GAHCHO KUÉ PROJECT

ENVIRONMENTAL IMPACT STATEMENT

SECTION 11.10

SUBJECT OF NOTE: CARNIVORE MORTALITY

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11.10 SUBJECT OF NOTE: CARNIVORE MORTALITY

11.10.1 Introduction

11.10.1.1 Context

This section of the Environmental Impact Statement (EIS) for the Gahcho Kué Project (Project) consists solely of the Subject of Note: Carnivore Mortality. In the *Terms of Reference for the Gahcho Kué Environmental Impact Statement* (Terms of Reference) issued on October 5, 2007, the Gahcho Kué Panel (2007) noted that potential mortality of carnivores was an important issue in previous assessments of diamond mines, including the Snap Lake Mine.

This subject of note includes a detailed assessment of impacts on carnivores, including grizzly bear (*Ursus arctos*), wolverine (*Gulo gulo*), wolf (*Canis lupus*), and fox. Carnivore mortality is directly related to two other Subjects of Note:

- Traffic and Road Issues (Section 11.8); and
- Waste Management and Wildlife (Section 11.9).

The in-depth analysis of carnivore mortality due to waste management, and traffic and roads, is presented in this subject of note along with an in-depth analysis of other sources of mortality. Substantive summaries of the results of this analysis are provided in the two Subjects of Note: Waste Management (Section 11.9) and Wildlife, and Traffic and Road Issues (Section 11.8).

Wolverine and grizzly bear are species at risk. The primary substantive assessment of impacts to these species is presented in this subject of note. However, a summary of the effects from the Project on these species is presented in the Subject of Note: Species at Risk and Birds (Section 11.12).

Because carnivores are predators, a decrease in their population due to mortality may have indirect effects on prey species such as caribou (*Rangifer tarandus groenlandicus*) and other ungulates (e.g., muskoxen [*Ovibos moschatus]* or moose [*Alces alces*]). Potential effects of the Project on carnivore mortality will also have an indirect effect on the following socio-economic Subjects of Note:

- Tourism Potential and Wilderness Character (Section 12.7.3);
- Proposed National Park (Section 12.7.4); and
- Culture, Heritage, and Archaeology (Section 12.7.5).

Where there is overlap between this subject of note and another key line of inquiry or subject of note, information will be provided in both locations as required in the Terms of Reference.

11.10.1.2 Purpose and Scope

The purpose of the Subject of Note: Carnivore Mortality is to meet the Terms of Reference for the EIS issued by the Gahcho Kué Panel on October 5, 2007. The table of concordance for the terms of reference for this subject of note are shown in Table 11.10-1. The entire Terms of Reference document is included in Appendix 1.I and the complete table of concordance for the EIS is in Appendix 1.II of Section 1, Introduction of the EIS.

This subject of note includes experience from existing diamond mines in the impact assessment of carnivore mortality, as well as mitigation practices and policies, and adaptive management plans. Specific consideration was given to the proximity of the Project to the tree line in the assessment of the potential interactions between boreal carnivores and furbearer species and the Project.

11.10.1.3 Study Area

11.10.1.3.1 General Location

The Project is located at Kennady Lake in the barrenlands of the Slave Geological Province (SGP) at Longitude 63° 26' North and Latitude 109° 12' West. It is located within an area that is transitional from boreal to tundra conditions (Scott 1995; Bliss 2000). The Project site is about 140 kilometres (km) northeast of the nearest community, Łutselk'e, and about 280 km northeast of Yellowknife, Northwest Territories (NWT) as shown at the beginning of Section 11 (Figure 11.1-1).

11.10.1.3.2 Study Area Selection

To assess the potential effects of the Project on carnivore mortality, it is necessary to define appropriate spatial boundaries. The geographic study area for this subject of note was identified in the final Terms of Reference as follows:

> *"The geographical scope for this Subject of Note includes the development area and all related access routes. In the cumulative context for species with larger ranges, this must include evaluations of the impacts in consideration of the full range used by each species."*

Table 11.10-1 Terms of Reference Pertaining to Carnivore Mortality

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
3.1.3 Existing Environment: Mammals (Excluding Caribou)	Describe species present, and for each describe:	
	- abundance, distribution, seasonal movements, habitat requirements	11.10.1.3, 11.10.2.1, 11.10.2.2, 11.10.2.3, 11.10.2.4
	- areas of specific habitat use at various life stages (e.g., denning)	11.10.2.2, 11.10.2.3
	- any sensitive time periods or habitat	11.10.2.2, 11.10.2.3
	- any other relevant sensitivities or limiting factors, such as behaviours or territory requirements	11.10.2.2, 11.10.2.3
	Describe key species used during traditional harvesting activities	11.10.2.3
	Describe any known issues currently affecting wildlife (excluding caribou) in the development area, (e.g., contamination of food sources, parasites, disease)	11.10.2.4
5.2.3 Biophysical Subjects of Note: Carnivore Mortality	General requirements pertaining to carnivore mortality include:	
	- the EIS must evaluate the experiences with carnivore mortality and related mitigation measures at existing and developing diamond mines, including Ekati, Diavik, and Snap Lake	11.10.2.4, 11.10.3,
	- in addition to an evaluation of the mitigation measures prescribed in earlier assessments, as well as any adaptive management activities, the EIS must provide improvements over the methods applied at existing developments	11.10.2.4, 11.10.3
	- the EIS must address any differences in impact predictions resulting from the proposed development's proximity to the tree line	11.10.3.2, 11.10.4.2, 11.10.4.3, 11.10.5.1, 11.10.5.2
	Specific information needs pertaining to carnivore mortality include:	
	- potential attraction to wolves, foxes, bear, and wolverines to attractants such as garbage, the creation of habitat in the camp, mine rock storage, etc.	11.10.2.4, 11.10.3.2, 11.10.4.3, 11.10.4.5; 11.10.5.2
	- development components that may cause a sensory disturbance to wolves, foxes, bear, and wolverines	11.10.3.2, 11.10.4.3, 11.10.5.2
	- effects on movement and hunting success from linear development components such as the ice road	11.10.3.2, 11.10.4.3, 11.10.5.2, 11.10.5.4
	- increased carnivore mortality resulting from creating access into a previously largely inaccessible area	11.10.3.2, 11.10.4.3, 11.10.4.4, 11.10.5.2, 11.10.5.4
	- impacts on prey species including small mammals	11.10.3.2, 11.10.4.5, 11.10.5.3
	- effective habitat loss	11.10.3.2, 11.10.4.2, 11.10.4.3, 11.10.5.1, 11.10.5.2
	- measures that may be taken to avoid or reduce these impacts	11.10.3.1, 11.10.3.2,11.10.7.2, 11.10.10

Table 11.10-1 Terms of Reference Pertaining to Carnivore Mortality (continued)

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
7 (7-1) Wildlife Issues	Remaining wildlife issues pertaining to carnivores include:	
	- carnivore attraction	11.10.2.4, 11.10.4.3, 11.10.4.4, 11.10.5.2,
	- human/bear encounters	11.10.2.4, 11.10.4.3, 11.10.4.4, 11.10.4.6
	- increased carnivore mortality	11.10.2.4, 11.10.4.4, 11.10.6, 11.10.7.2
	- noise/sensory impacts	11.10.4.3, 11.10.5.2
	- key habitat loss in eskers	11.10.4.2, 11.10.4.3, 11.10.5.1, 11.10.5.2
	- loss of prey sources for grizzly bears	11.10.4.5, 11.10.6.1
	Remaining wildlife issues pertaining to changing water levels include:	
	- drawdown impacts on habitat	11.10.3.2, 11.10.4.2, 11.10.4.3, 11.10.6.1, 11.10.7.2, 11.10.8.2
	- downstream impacts	11.10.3.2, 11.10.4.2, 11.10.4.3, 11.10.6.1, 11.10.7.2, 11.10.8.2
	- wildlife impacts from freeze- and break-up timing changes	11.10.3.2, 11.10.4.2, 11.10.4.3, 11.10.6.1, 11.10.7.2, 11.10.8.2, 11.13

Table 11.10-1 Terms of Reference Pertaining to Carnivore Mortality (continued)

Final Terms of Reference Requirements		Applicable EIS Sub-section
Section	**Description**	
3.2.7 Follow-up Programs	The EIS must include a description of any follow up programs, contingency plans, or adaptive management programs the developer proposes to employ before, during, and after the proposed development, for the purpose of recognizing and managing unpredicted problems. The EIS must explain how the developer proposes to verify impact predictions. The impact statement must also describe what alternative measures will be used in cases were a proposed mitigation measure does not produce the anticipated result.	11.10.10
	The EIS must provide a review of relevant research, monitoring and follow up activities since the first diamond mine was permitted in the Slave Geological Province to the extent that the relevant information is publicly available. This review must focus on the verification of impact predictions and the effectiveness of mitigation measures proposed in previous diamond mine environmental impact assessments. In particular the developer must make every reasonable effort to verify and evaluate the effectiveness of any proposed mitigation measures that have been used, or are similar to those used at other diamond mining projects in the Mackenzie Valley.	11.10.10
	The EIS must include a proposal of how monitoring activities at the Gahcho Kué diamond mine can be coordinated with monitoring programs at all other diamond mines in the Slave Geological Province to facilitate cumulative impact monitoring and management. This proposal must also consider reporting mechanisms that could inform future environmental assessments or impact reviews. The developer is not expected to design and set up an entire regional monitoring system, but is expected to describe its views on a potential system. The developer must also state its views on the separation between developer and government responsibilities.	11.10.10

Source: Terms of Reference (Gahcho Kué Panel 2007).

EIS = Environmental Impact Statement.

Baseline studies were completed before the Terms of Reference were issued. The boundaries for most of the wildlife field work, including carnivore studies, were based on the expected extent of the Project-related effects (i.e., the boundaries were set so that the expected effects would lie within the boundaries) as well as the life history attributes of carnivore species potentially inhabiting the area surrounding the Project. The baseline studies for all wildlife species were conducted within the following spatial boundaries:

- Regional Study Area (RSA);
- Local Study Area (LSA); and
- Winter Access Road Study Area.

The wildlife baseline LSA was selected to assess the immediate direct and indirect effects of the Project on individual animals and wildlife habitat. The wildlife baseline RSA was selected to capture any effect that may extend beyond the LSA and subsequently influence the abundance and distribution of populations. Wildlife baseline survey intensity varied within each spatial boundary, with broader studies completed within the RSA to assess seasonal distribution, and detailed studies completed within the LSA to assess direct habitat changes for these carnivores.

The Winter Access Road Study Area was included in the wildlife baseline to identify potentially sensitive habitat within the associated rights-of-way. The spatial area included for this study area was the 120 km winter access from the existing Tibbitt-to-Contwoyto Winter Road, to the Project site at Kennady Lake. A corridor width of 3 km on either side of the road centre line was used for grizzly bear, wolf, wolverine, and fox.

The effects analysis and assessment for carnivore mortality was completed on study areas that were larger than the study areas used for the wildlife baselines to meet the final Terms of Reference requirement to include the full range for each species. Distinct study areas were delineated for each of grizzly bear, wolverine, wolf, and fox. The study areas for grizzly bear, wolverine, wolf, and fox are described in turn below.

11.10.1.3.3 Grizzly Bear Study Area

The grizzly bear study area includes those portions of the SGP for which landscape classifications exist (Figure 11.10-1). Like wolves, the life history and annual home range of grizzly bears in this area are closely tied to the Bathurst caribou herd. However, unlike wolves, these grizzly bears typically do not travel below the treeline. The grizzly bear study area is therefore based approximately on the SGP as well as the portions of the Bathurst caribou range that occur above the treeline, during the northern caribou migration in the spring and the southern migration in the fall. Defining the study area for grizzly bears this way makes ecological sense as bears are emerging from hibernation in the spring and begin hibernation in the fall in synchrony with these caribou migration periods. Incorporating the SGP boundaries into the grizzly bear study area is appropriate since much of the existing data for grizzly bears was collected in this area. The study area includes other developments, such as the Jericho Diamond Mine, Ekati Diamond Mine, Diavik Diamond Mine, and the Snap Lake Mine. The SGP includes the RSA and the Winter Access Road, but not the entire Tibbitt-to-Contwoyto Winter Road. It has an area of approximately 200,000 square kilometres (km^2).

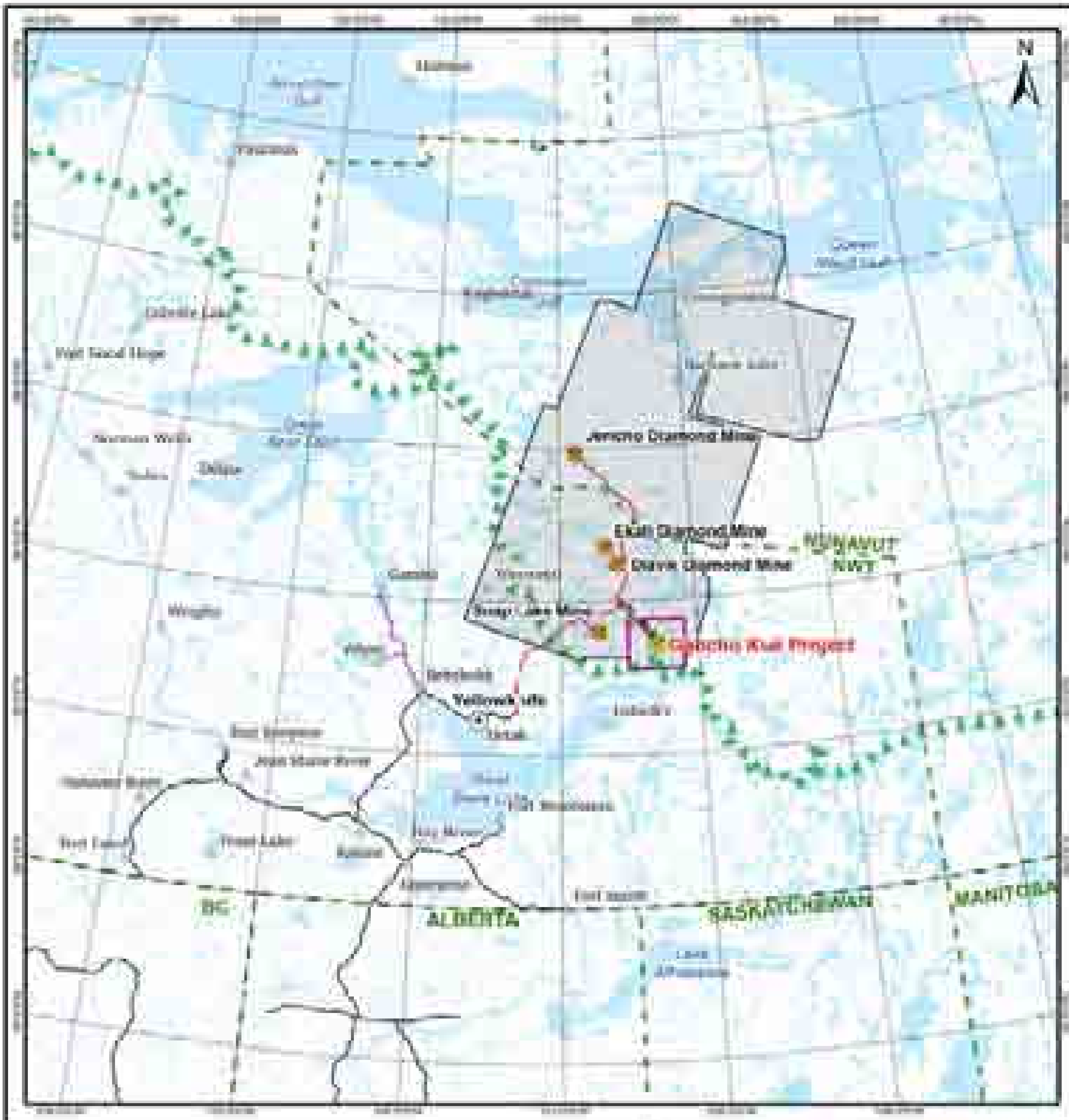
11.10.1.3.4 Wolverine Study Area

The study area used for wolverine is the same as that used for grizzly bear. It corresponds approximately to the SGP boundaries (Figure 11.10-1). The rationale for selecting this study area is based on a number of factors. Most of the existing information on wolverine has been conducted within the SGP (Johnson et al. 2005; Boulanger and Mulders 2007; Mulders et al. 2007). Although wolverines are wide-ranging, they have smaller home range sizes relative to wolves and grizzly bears; they are generally not migratory, but long distance movements are made by transient individuals. Wolverine subpopulations in the RSA for the Project are likely influenced very little by other diamond mines in the Lac de Gras region (Golder 2007, 2008a).

The study area captures the diversity of habitats that support the seasonal requirements of wolverines, and includes other developments within the SGP, such as the Jericho Diamond Project, Ekati Diamond Mine, Diavik Diamond Mine, and the Snap Lake Mine. The SGP includes the RSA and the Winter Access Road, but not the entire Tibbitt-to-Contwoyto Winter Road.

11.10.1.3.5 Wolf Study Area

The wolf study area was selected to encompass the annual range of the Bathurst caribou herd, and is approximately 400,000 km^2 (Figure 11.10-2). This study area was selected due to the large home range sizes of the wolf, and the fact that their life history and annual home range are tied to caribou. Using the annual range to define study areas for caribou and wolf is appropriate because they include all of the natural factors, and human activities and developments that can produce cumulative effects on these species. The study area includes the Project, three operating diamond mines (Snap Lake, Diavik, and Ekati), and the Tibbitt-to-Contwoyto Winter Road. Several communities in the NWT are also within the study area (e.g., Łutselk'e, Yellowknife, Behchokǫ̀, Whatì, Wekweètì, and Gamètì).



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Proposed Winter Access Road
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Grizzly Bear and Wolverine Study Areas
- Regional Study Area

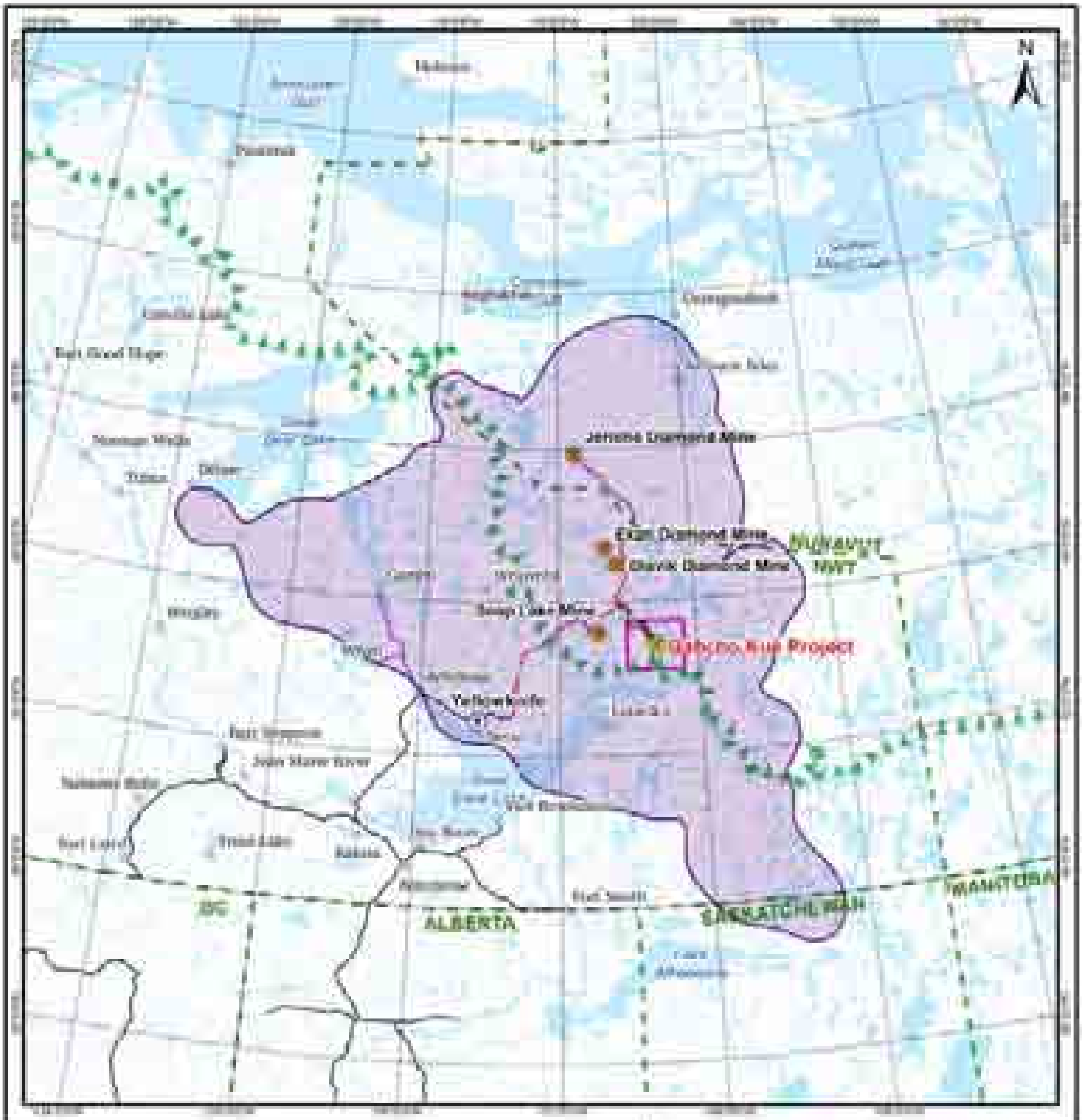
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Grizzly Bear and Wolverine Study Area

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE No: SON-11.9-004-GIS	DATE: October 28, 2010
JOB NO: 09-1365-1004	REVISION NO: 2
OFFICE: GOLD-SAS	DRAWN: ANK; CHECK: JV

Figure 11.10-1



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Regional Study Area
- Wolf Study Area

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Wolf Study Area

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
Scale 1:8,000,000			
FILE No: SON-11.9-005-GIS		DATE: October 28, 2010	
JOB No: 09-1365-1004	REVISION No: 2		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	**Figure 11.10-2**

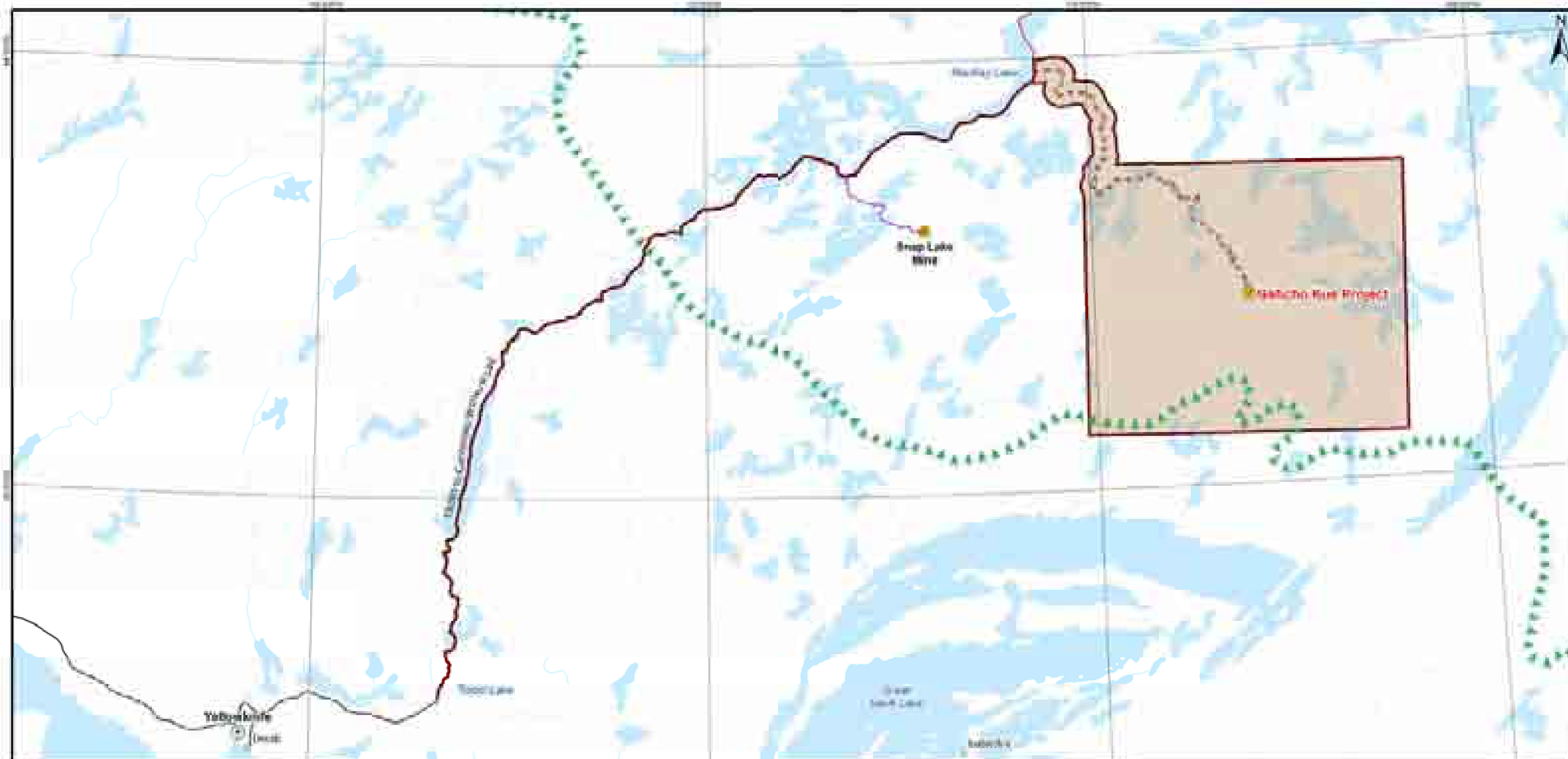
11.10.1.3.6 Fox Study Area

The fox study area comprises the RSA and the Winter Access Road Study Area as used for the wildlife baseline studies, with the addition of the portion of the Tibbitt-to-Contwoyto Winter Road from Tibbitt Lake to MacKay Lake (Figure 11.10-3). The wildlife baseline RSA boundary is delineated approximately by the following lakes: Reid Lake in the northwest, MacLellan Lake in the southwest, Cook Lake in the southeast, and Fletcher Lake in the northeast. The wildlife baseline RSA encompasses part of the treeline within the Taiga Shield Ecozone and the SGP (Ecological Stratification Working Group 1995). The term taiga refers to the northern edge of the boreal conifer forest. In northern Canada, much of this forest occurs on the bedrock of the Canadian Shield and just south of the tundra. At its closest point, the treeline is about 20 km south of Kennady Lake and extends across the southern portion of the RSA.

11.10.1.4 Content

Section 11.10 provides details of the impact analysis and assessment related to carnivore mortality. The headings in this section are arranged according to the sequence of steps in the assessment. The following briefly describes the content under each heading of this subject of note.

- **Existing Environment** summarizes relevant baseline information for select carnivore species (grizzly bear, wolverine, wolf and fox), including the general environmental setting in which the Project occurs, and methods and results for baseline studies (Section 11.10.2).
- **Pathway Analyses** identifies all the potential pathways by which the Project could affect carnivores, and traditional and non-traditional uses of carnivores, and provides a screening level assessment of each identified pathway after applying environmental design features and mitigation that reduce or eliminate Project-related effects (Section 11.10.3).
- **Grizzly Bear and Wolverine** explains the scientific methods that were used to predict changes to grizzly bear and wolverine populations as a result of the Project, identifies the effects of the Project's activities on populations (including effects on habitat quantity and quality, behaviour and distribution, and survival and reproduction), and identifies the effects that flow to people as a result of the effect of the Project's activities on grizzly bear and wolverine (Section 11.10.4).
- **Wolf** explains the scientific methods that were used to predict changes to wolf populations as a result of the Project, identifies the effects of the Project on wolf populations (including effects on habitat quantity and quality, behaviour and distribution, and survival and reproduction), and identifies the effects that flow to people as a result of the effect of the Project on wolf populations (Section 11.10.5).



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Existing Winter Road
- Tibbitt to Contwoyto Winter Road
- Winter Access Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Fox Study Area

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Fox Study Area

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Figure 11.10-3

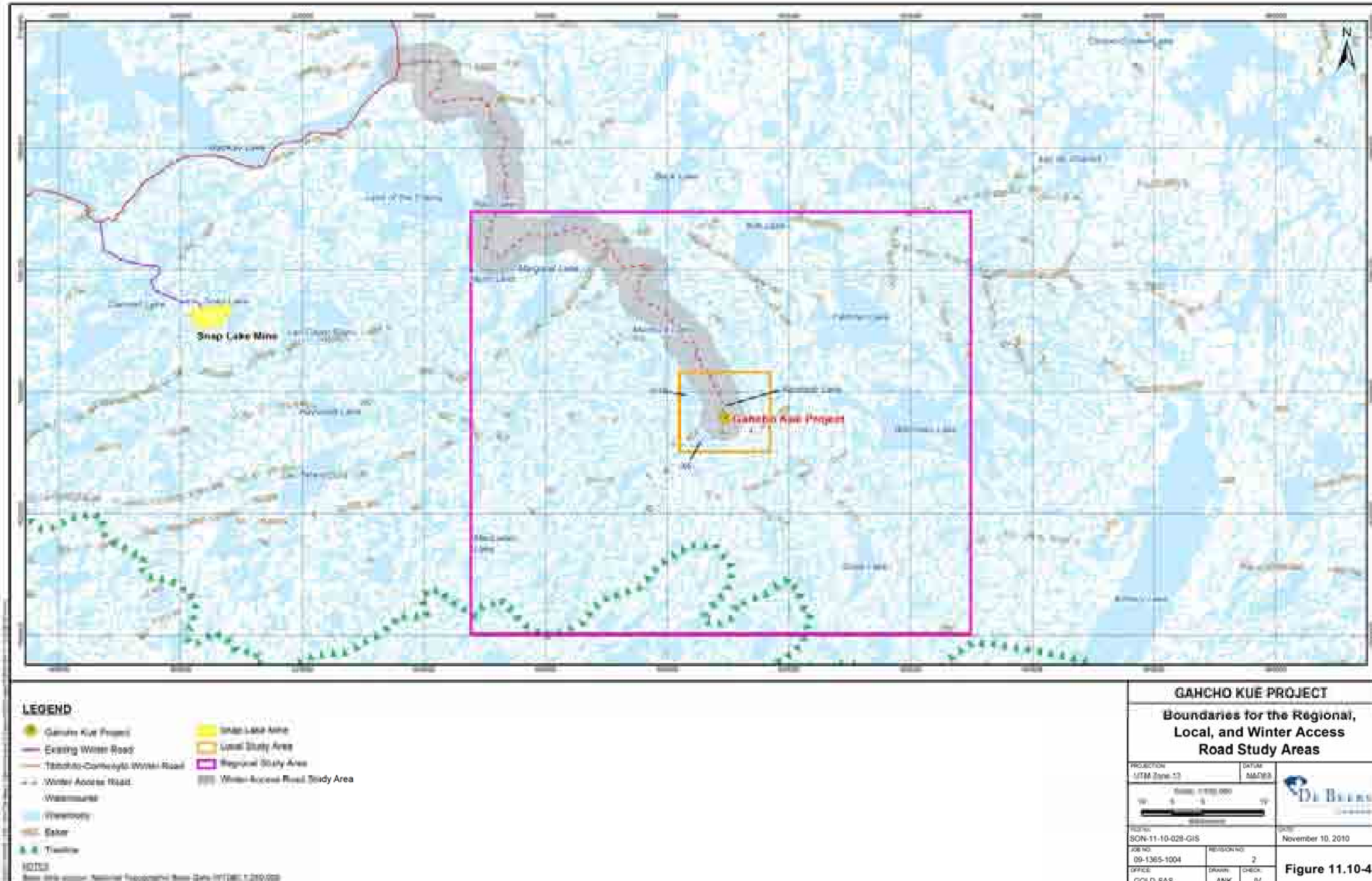
- **Residual Effects Summary** summarizes the effects on grizzly bear, wolverine, and wolf populations and related effects on people that are predicted to remain after all environmental design features and mitigation to eliminate or reduce these effects have been incorporated into the Project design (Section 11.10.6).
- **Residual Impacts Classification** describes methods used to classify residual effects and summarizes the classification results (Section 11.10.7).
- **Environmental Significance** summarizes the overall impacts from the Project on other carnivores, and considers the entire set of pathways to evaluate the significance of impacts from the Project on carnivores (Section 11.10.8).
- **Uncertainty** discusses sources of uncertainty surrounding the predictions of effects on carnivores (Section 11.10.9).
- **Monitoring and Follow-up** describes recommended monitoring programs, contingency plans, or adaptive management strategies related to carnivore mortality (Section 11.10.10).
- **References** lists all documents and other material used in the preparation of this section (Section 11.10.11).
- **Glossary, Acronyms, and Units** explains the meaning of scientific, technical, or other uncommon terms used in this section. In addition, acronyms and abbreviated units are defined (Section 11.10.12).

11.10.2 Existing Environment

11.10.2.1 General Setting

The Project is located at Kennady Lake (63^{o} 26’ North; 109^{o} 12’ West), a headwater lake of the Lockhart River watershed in the NWT. Kennady Lake is approximately 280 km northeast of Yellowknife, and 140 km northeast of the Dene Community of Łutselk’e on the East Arm of Great Slave Lake. The Project is 84 km east of the Snap Lake Mine, the only other active mine in the Lockhart River watershed. The Diavik Diamond Mine and Ekati Diamond Mine are located about 127 and 158 km northeast of Kennady Lake, respectively, in the Coppermine River watershed.

The RSA, approximately 5,700 km^2 in size, was defined to capture the indirect effects of the Project on wildlife valued components (VCs) (Figure 11.10-4). The Project is within the transition zone between the tundra and the treeline, and species that are characteristic of both ecozones may occur within the RSA.



Snap Lake Mine
Gahcho Kué Project
LEGEND
Gahcho Kué Project
Existing Winter Road
Tibbitt-to-Contwoyto Winter Road
Winter Access Road
Watercourse
Waterbody
Esker
Treeline
Snap Lake Mine
Local Study Area
Regional Study Area
Winter Access Road Study Area
GAHCHO KUE PROJECT
Boundaries for the Regional, Local, and Winter Access Road Study Areas
PROJECTION
UTM Zone 12
DATUM
NAD83
SON-11-10-028-GIS
November 10, 2010
JOB NO.
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Figure 11.10-4

Shrubs of willow (*Salix* sp.) and birch (*Betula* sp.) occur in drainages, and in some areas may reach over 2 metres (m) in height. Heath tundra covers most upland areas, and coniferous stands occur in patchy distribution above the treeline, in lowland sheltered areas, and riparian habitats. Conifer stands are found within the RSA as far north as Kirk Lake.

An extensive esker system stretches from Margaret Lake in the northwest, across the northern portion of the RSA, and beyond the eastern boundary. Numerous smaller esker complexes and glaciofluvial deposits such as kames and drumlins are scattered throughout the RSA. Habitat types within the RSA were based on the broad-scale Ecological Landscape Classification (ELC) developed by Matthews et al. (2001) for the SGP (Section 11.7).

The LSA encompasses the Project, which includes the proposed development of the anticipated core mine footprint (Figure 11.10-4). The LSA is approximately 200 km^2, centred on Kennady Lake. The LSA was designed to assess direct effects from the mine footprint (e.g., habitat loss) and small-scale indirect effects on individuals from Project activities (e.g., changes in habitat quality resulting from dust deposition). The LSA contains habitat that is characteristic of regional habitat conditions, including eskers and other glaciofluvial deposits, wetlands, riparian habitats, lakes, and vegetation that is typical of the tundra.

Terrain is less varied within the LSA, and habitat is characterized primarily by low relief with rolling hills, boulder fields, and a few bedrock outcrops. The dominant waterbodies are Kennady Lake, Lake N16, and Lake X6. Water covers 20% to 30 percent (%) of the LSA, and a major esker complex stretches across its southern portion. Small conifer stands are located in the southern portion of the LSA. Habitat types within the LSA were based on the broad-scale ELC developed by Matthews et al. (2001) for the SGP, and finer-scale ecosystem units (Section 11.7).

The Project is accessed in the winter by a 120-km-long Winter Access Road that extends from the Tibbitt-to-Contwoyto Winter Road at MacKay Lake to Kennady Lake (Figure 11.10-4). The Winter Access Road to Kennady Lake crosses Reid, Munn, Margaret, and Murdock lakes as well as several smaller lakes and streams. Northwest of the RSA boundary, habitat conditions along the Winter Access Road resemble the undulating terrain of the barren tundra. Within a 6 km right-of-way (corridor) along the Winter Access Road, water covers about 37% of the corridor area (approximate corridor area = 700 km^2). Within a 2 km corridor, about 48% of the Winter Access Road is comprised of water (approximate corridor area = 238 km^2).

Rocky terrain is less common farther north along this route and a few minor esker systems are present. The tundra landscape along the Winter Access Road is characterized by low-growing vegetation such as lichens, mosses, and stunted shrubs. Closer to Munn Lake and Margaret Lake, the habitat becomes more varied with extensive boulder fields, steep cliffs, and esker complexes.

Baseline studies on wildlife species and wildlife habitat were completed in the RSA, LSA, and along the proposed Winter Access Road from 1996 to 2007. Additional surveys for grizzly bear, wolf, and wolverine were completed in 2010 (Annex F, Addendum FF). Ground and aerial surveys were designed to provide estimates of the natural variation in wildlife presence, abundance, distribution, and movement within the RSA, LSA, and along the Winter Access Road. The sections below summarize the baseline data collected on wildlife species identified as VCs, specifically grizzly bear, wolf, fox, and wolverine. Data on all carnivores and other wildlife are provided in Annex F. Table 11.10-2 lists all the carnivore species or sign that were observed during the baseline studies, and are expected to be present based on species distribution.

Table 11.10-2 Carnivore Species That May Occur or Were Observed in the Regional Study Area

Common name	Latin Name	Presence
Barren-ground grizzly bear	*Ursus arctos*	observed
Black bear	*Ursus americana*	not observed, but hair detected at sampling station
Wolverine	*Gulo gulo*	observed
Grey wolf	Canis *lupus*	observed
Arctic fox	*Alopex lagopus*	not observed
Red fox	*Vulpes vulpes*	observed
Marten	*Martes americana*	observed
Ermine	*Mustela erminea*	observed
River otter	*Lontra canadensis*	sign observed
Lynx	*Lynx lynx*	sign observed

11.10.2.2 Methods

The following section integrates a historical and regional perspective on carnivore populations from available literature and existing knowledge. Baseline survey data were supplemented with ecological information from other baseline studies, published and unpublished scientific literature, discussions with wildlife experts, and traditional knowledge (TK). Secondary source TK information was obtained using various, previously completed reports on experiences and expertise of the Elders from each of the potentially affected Aboriginal communities (Annex M). Results of regional effects monitoring and research programs in the NWT and Nunavut (e.g., the Diavik Diamond Mine, the Ekati Diamond Mine, and the Snap Lake Mine) are also included. Information obtained from each of these data sources is used for the assessment of potential effects on carnivores from the Project, and provide a basis for developing wildlife mitigation and monitoring plans.

11.10.2.2.1 Gahcho Kué Project Baseline Study

Grizzly Bear

A baseline study was completed to determine grizzly bear distribution and den sites within the RSA. Caribou aerial surveys completed from 1999 to 2005, recorded bear observations and bear den locations within the RSA, LSA, and along the Winter Access Road. Survey efforts also focused on all mapped and many unmapped esker complexes and glaciofluvial deposits to locate active carnivore den sites. Additional esker surveys were completed in 2007 to document grizzly bear sign on esker and esker complexes identified as potential sources of gravel material for the Project. Habitat ground surveys completed in 2005 and 2007 assessed the natural variation in the relative use of seasonally preferred habitat by grizzly bears within the RSA.

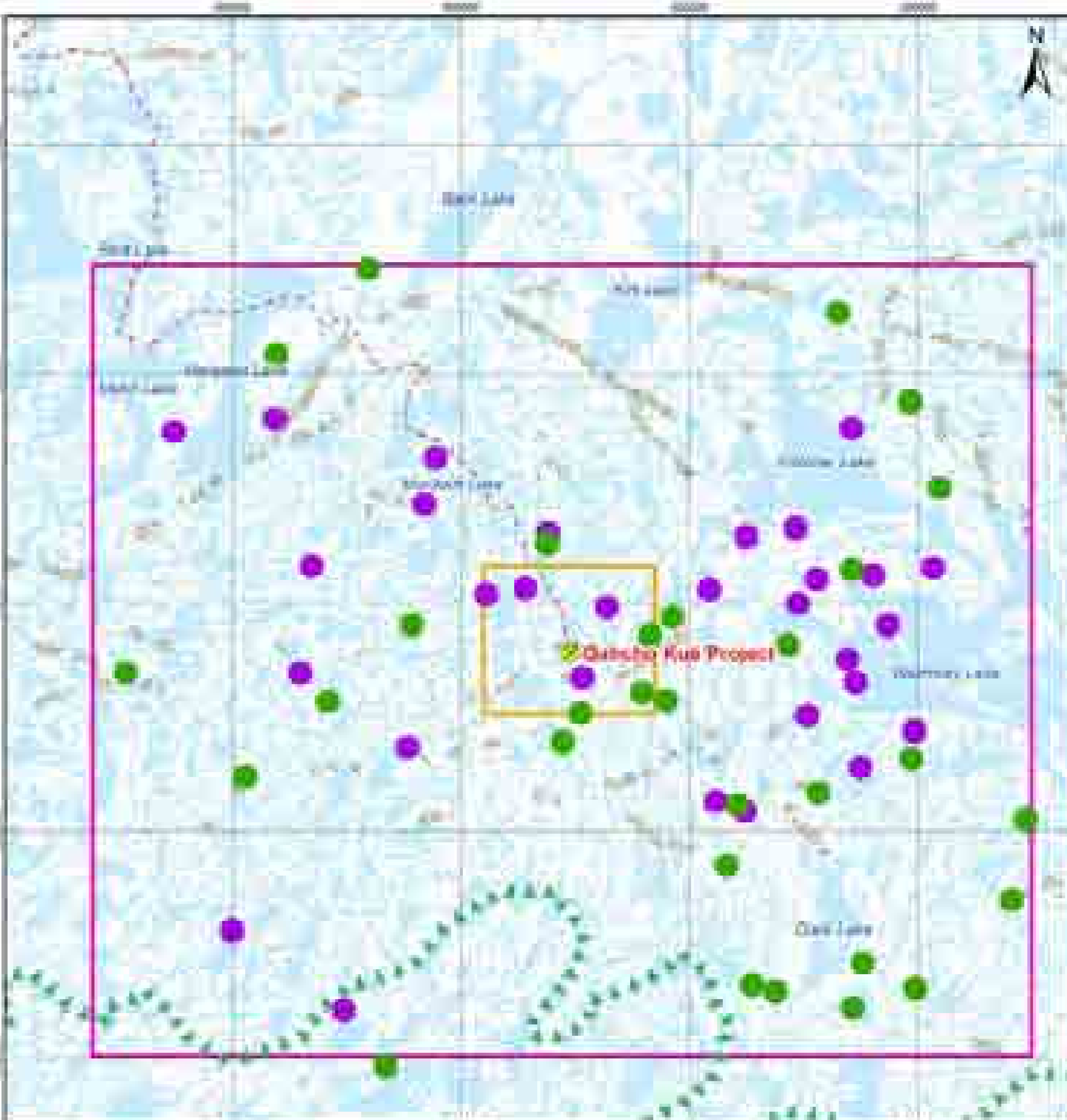
The objectives of the baseline study were to:

- document the natural range of variation in the occurrence and distribution of grizzly bears within the RSA;
- identify den sites used for winter hibernation within the RSA; and
- assess the importance of potential den habitats within the LSA.

Habitat Surveys

The presence of bear sign within and adjacent to seasonal high-quality (i.e., preferred) habitats has been used as an index of relative activity by grizzly bears within study areas for several projects in the NWT and Nunavut (Golder 2005; BHPB 2007; DDMI 2007; De Beers 2007; Miramar 2007, Tahera 2007a, internet site).

Habitat surveys were completed in 2005 and 2007 to determine the natural variation in the relative use of seasonally preferred habitat by grizzly bears in the RSA. Surveys focused on ground searches for bear sign in plots within sedge wetlands and riparian habitats (Figure 11.10-5). In 2005, searches were completed within 30 sedge wetlands plots from June 14 to 22, and within 30 willow-riparian/birch seep plots from August 22 to 28. Habitat surveys completed from August 22 to 28, 2007, involved re-sampling the 30 riparian plots established in 2005. Study design and survey protocols followed the methods used at the Diavik Diamond Mine, Ekati Diamond Mine, and the Snap Lake Mine in the NWT, and the Jericho Diamond Mine and Doris North Project in Nunavut (BHPB 2007; DDMI 2007; Miramar 2007; Tahera 2007a, internet site; Golder 2008a).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- June Plot
- August Plot
- Local Study Area
- Regional Study Area

NOTES

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Barren-Ground Grizzly Bear Habitat Surveys 2005 and 2007

PROJECTION: UTM Zone 13	DATUM: NAD83		
FILE No: SON-11-10-029-GIS			DATE: November 10, 2010
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV	**Figure 11.10-5**

The number of recent dens, digs, tracks, beds, scat, hair, and prey remains were recorded for each plot. Only sign from bear activity that had occurred in the year of the survey (i.e., since spring den emergence) was included in the analysis. To gauge potential historic use of the RSA, older bear sign was noted. Incidental observations or sign of grizzly bears within the RSA was also recorded.

The total number of each sign type (i.e., dens, digs, rubs, hair, scat, or tracks), as well as any bears present were summarized by habitat type. The probability of grizzly bear sign occurrence by habitat with confidence intervals (based on a binomial distribution) was also calculated. Data collected from the baseline studies completed within the RSA were also compared to regional data collected at the Snap Lake Mine and the Ekati and Diavik diamond mines. Current collar data for grizzly bears located within or adjacent to the RSA are not available, thus the estimate of collared bear distribution is based on studies completed from 1995 to 1999 (McLoughlin et al. 1999).

Recent analyses of long-term data from bear sign surveys at other mine developments in the NWT have had limited success at detecting changes in bear presence over time and across the study areas. As a result, pilot hair snagging study designs were implemented at the Project, the Snap Lake Mine, Ekati Diamond Mine, and the Diavik Diamond Mine in 2010. These pilot studies were implemented to assess the efficiency and logistics of using hair snagging techniques to determine the relative occurrence and distribution of bears in the study areas. Forty hair snagging stations were established in the Project RSA from May 24 to 27, 2010. Three surveys documenting the presence of bear hair occurred from June 6 to 8, June 17 to 18, and June 27 to 28, 2010 (Annex F, Addendum FF). Surveys were completed by two field staff, including a community technician from Łutselk'e (Pete Enzo).

Esker Surveys

Eskers are linear structures of loose sand and gravel, formed by glacial rivers, and provide critical habitat for carnivores and ungulates in the Arctic (Cluff et al. 2002). Esker aerial surveys were completed in 1998, 1999, 2001, and 2004 to identify historic and active grizzly bear and carnivore dens in the RSA (Figure 11.10-6). Bear dens were also recorded during aerial surveys for caribou, and during non-systematic aerial searches of select areas deemed to have high potential for bear den habitat (1998 to 2005). Surveys for grizzly bear sign along eskers and esker complexes that were identified as possible sources of gravel material within 35 km of the Project were completed in 2007 (Figure 11.10-6).

LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Esker Surveyed
- Local Study Area
- Regional Study Area

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Eskers and Glaciofluvial Deposits Surveyed in the Regional Study Area

PROJECTION	UTM Zone 13
DATUM	NAD83
Scale	1:500,000 (Kilometres)
FILE No.	SON-11-10-030-GIS
DATE	November 10, 2010
JOB NO.	09-1365-1004
REVISION NO.	3
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

De Beers Canada

Figure 11.10-6

Ground reconnaissance surveys completed on June 23, 29, and 30, 1998 investigated the main esker along the southern portion of the LSA, as well as another prominent esker located about 12 km southeast of Kennady Lake (Jacques Whitford 1998). On August 15, 25, and 26, 1998, the main esker in the LSA was surveyed again, which focused on the portion of the esker proposed for excavation of borrow materials.

In July 1999, all mapped and unmapped eskers identified within a 30-km radius of Kennady Lake were flown to locate grizzly bear and carnivore den sites and other evidence of activity (EBA and Jacques Whitford 2000). All potentially active dens and sign of unknown origin were examined more closely from the ground. Additional esker surveys were completed southeast of Kennady Lake in the spring of 2001.

Esker surveys completed from May 28 to June 1, 2004 were timed to occur after the emergence of grizzly bears from den sites, which occurs from about mid-April through mid-May (McLoughlin 2000). Snow cover during the 2004 survey was between 70 and 80%, and the base of most eskers remained covered. Although the snow cover prevented finding older grizzly bear den sites, active den sites were more easily detected. All potentially active bear dens were checked on the ground during the snow-free season in late July for verification of overwinter occupancy (i.e., fresh dirt and bedding material). During the survey, den site locations were recorded with global positioning system (GPS), as were incidental observations of grizzly bears and grizzly bear sign. On July 25 and 26, 2004, 17.5 km of the main esker within the LSA was ground-surveyed to identify any den sites that were missed during the June aerial survey.

Esker aerial and ground surveys were also completed between July 21 and 23, 2007 along eskers identified as possible sources for gravel material for the Project (Figure 11.10-6). Eskers and esker complexes within 35 km of the Project camp were surveyed to document use (i.e., foraging, denning, and transportation corridors) by grizzly bears. A local trapper and member of the Łutselk'e Dene First Nation (LKDFN), provided direction and guidance for the surveys. Follow-up surveys were completed on the ground where grizzly bear sign was observed. The relative use of eskers was estimated for grizzly bears by calculating the sign per kilometre surveyed.

Wolverine

A baseline study was completed to determine the natural variation in the relative annual activity, abundance, and distribution of wolverine within the RSA. Observations of wolverine and wolverine sign within the RSA, LSA, and along the Winter Access Road were recorded during aerial surveys completed for other wildlife species from 1999 to 2005. Incidental observations were also recorded during the esker surveys completed in 2007.

Objectives of the baseline study were to:

- document the natural range of variation in the presence and relative activity levels of wolverine in the RSA and LSA;
- determine the number of wolverine with home ranges that overlap the RSA based on deoxyribonucleic acid (DNA) analysis;
- identify the location of existing den sites in relation to the Project site; and
- assess the importance of potential den habitats in the LSA.

Ground-based winter track count surveys were completed in 2004 and 2005 to determine wolverine presence in the LSA. A DNA hair snagging study was also completed in 2005 and 2006 to estimate the number of wolverines within a sampling grid in the RSA. The grid study area covered the LSA and part of the RSA.

Winter Track Count Surveys

In 2004 and 2005, winter track count surveys were completed within the LSA over a 200 km^2 study area, centred on Kennady Lake (Figure 11.10-7). The surveys included seventeen, 13-km-long transects spaced 1 km apart, covering a total distance of 237 km. The surveys were completed by snowmobile during three periods over two years:

- May 7 to 10, 2004;
- March 29 to 31, 2005; and
- April 21 to 22, 2005.

Observers collected the following information on wolverines and other mammal species during track count surveys:

- number of tracks encountered;
- direction of travel;
- habitat type; and
- location (recorded with a Global Positioning System [GPS] unit) of each track.

LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Contour (10m interval)
- Esker
- Survey Transect
- Local Study Area

NOTES
Base data source: National Topographic Base Data (NTDB) 1:50,000

GAHCHO KUÉ PROJECT

Winter Track Count Survey Transects in the Local Study Area 2004 and 2005

PROJECTION: UTM Zone 11	DATUM: NAD83
Scale 1:100,000	
FILE No.: SON-11-10-031-GIS	DATE: October 28, 2010
JOB NO.: 09-1365-1004	REVISION NO.: 2
OFFICE: GOLD-SAS	DRAWN: MGD / CHECK: JV

De Beers

Figure 11.10-7

A track density index (expressed as tracks per kilometre per day [TKD]) was calculated as the number of tracks per km of distance travelled per number of days since snowfall. These calculations were completed to determine the relative abundance of wolverines in the LSA for each survey period. Track density was also calculated for other wildlife species detected during the 2004 and 2005 winter track count surveys (e.g., wolf, fox).

A Chi-square test was used to examine if the proportion of habitats where tracks were observed was equal to the proportion of habitats available. The proportion of wolverine tracks observed in each habitat in each year was compared to availability of habitats. Habitat calculations were based on a 10-m transect width. Pooling of habitat categories (Table 11.10-3) was required as the observed counts within all habitats were too few for analyses. The analysis compared the proportion of tracks observed in each pooled habitat to the expected proportion of tracks in each pooled habitat, based on the amount of habitat available.

Table 11.10-3 Comparison between the Amount of Available Habitat and Sampled Habitat in Each Pooled Category

Habitat Type	Area (ha)	% of Total Area Available	Transect Area (ha)	% of Total Area Surveyed
Rock (heath bedrock, heath boulder, and bedrock association)	3,458	17.7	42.8	18.0
Heath tundra	2,886	14.8	34.7	14.6
Esker	47	0.2	0.5	0.2
Water (deep water and shallow water)	5,667	29.1	66.0	27.9
Lowland (peat bog, sedge wetlands, and tussock hummock)	3,252	16.7	40.6	17.1
Spruce forest	697	3.6	9.2	3.9
Riparian (tall shrub and birch seep)	2,243	11.5	27.8	11.7
Other (unclassified)	1,249	6.4	15.5	6.5
Total	19,499	100.0	237.0	100.0

ha = hectares; % = percent.

In 2010, snow track surveys for wolverine were completed along transects of equal length distributed within the RSA. The study design and sampling method is similar to that currently used at the Snap Lake and Diavik mine sites. The study design includes 51 transects, 4 km in length and at varying distances of up to 25 km from the Project site (Annex F, Addendum FF). Each transect was surveyed by two observers driving parallel on snowmobiles at a maximum speed of 15 km/h and spaced 25 m apart. Surveys occurred during March and April. The number and location of wolverine tracks encountered were recorded. The data provide an initial baseline to determine the effect of the Project on the annual relative presence (activity) and distribution of wolverines in the RSA.

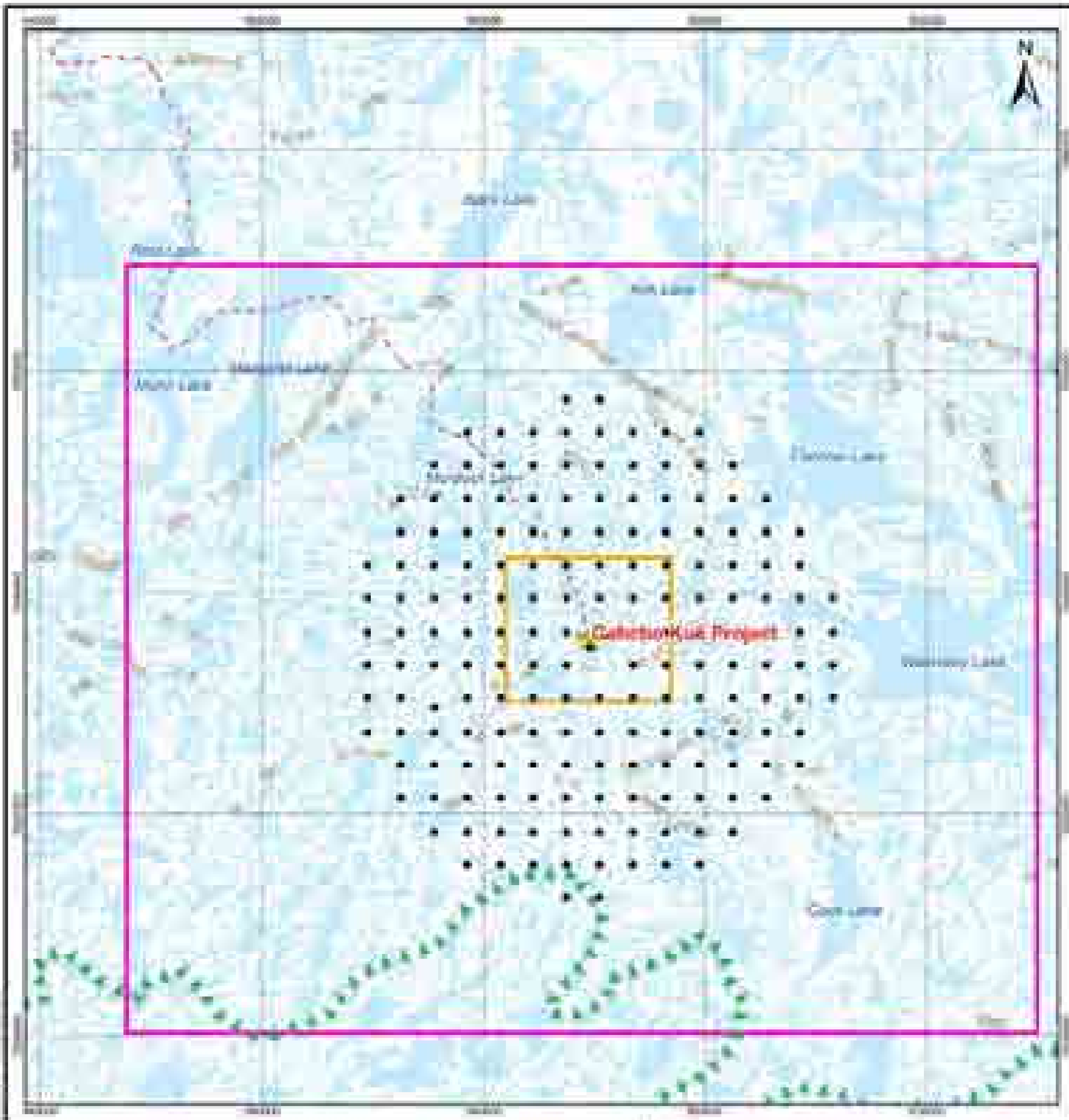
DNA Hair Snagging

It is important to acknowledge that the snow track method is not designed to estimate the annual changes in abundance of wolverines in a study area. Currently, the Department of Environment and Natural Resources (ENR) has developed and implemented a successful program for estimating the abundance, density, and demographic parameters of wolverine at several mining projects in the NWT (Boulanger and Mulders 2007; Mulders et al. 2007). The study design used baited posts, arranged in a sampling grid, to capture wolverine hair, which are then analyzed using DNA finger printing techniques. The method has been incorporated into the wildlife effects monitoring programs for the Ekati Diamond Mine and the Diavik Diamond Mine in the NWT, and the Jericho Diamond Mine and Doris North Project in Nunavut.

A wolverine DNA hair snagging program was completed within a circular 1,600 km^2 study area centred on the Project camp from April 16, 2005 to May 8, 2005 (Figure 11.10-8). Two crews, each including an Aboriginal assistant and a wildlife biologist, installed 175 baited posts within the sampling grid that covered the LSA and part of the RSA. Scent posts were wrapped in barbed wire and positioned within a 3 by 3 km grid cell, based on similar protocols used for the Ekati Diamond Mine and the Diavik Diamond Mine. Following the initial set-up period, each post was sampled twice during two 10-day sessions. Hair samples collected from the barbed wired were submitted for DNA analysis. In 2006, the program was repeated in the RSA, in conjunction with programs completed at Daring Lake, the Ekati Diamond Mine, and the Diavik Diamond Mine (Boulanger and Mulders 2007).

Wolf

A baseline study was completed to determine the natural variation in the distribution, and occupancy of wolf dens within the RSA. Aerial and ground surveys, completed between 1999 and 2005, determined the presence of wolves and wolf den locations within the RSA, LSA, and the Winter Access Road. Survey efforts focused on all mapped and unmapped esker complexes and glaciofluvial deposits to locate traditional and alternate natal den sites. Surveys for wolf sign along eskers identified as possible sources for gravel material within 35 km of the Project were completed in 2007 (Figure 11.10-6).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Wolverine DNA Hair Snagging Station
- Local Study Area
- Regional Study Area

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Wolverine DNA Hair Snagging Stations in the Regional Study Area 2005 and 2006

PROJECTION: UTM Zone 12	DATUM: NAD83		
FILE No: SON-11-10-032-GIS		DATE: October 28, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV	**Figure 11.10-8**

The objectives of the baseline study were to:

- document the natural range of variation in the occurrence and distribution of wolves and wolf dens within the RSA;
- identify important traditional natal den sites and potential alternate den locations within the RSA, LSA, and Winter Access Road; and
- assess the importance of potential den habitats within the LSA.

Esker surveys were completed in 1998, 1999, 2001, and 2004, to identify historic and active wolf dens in the RSA (Figure 11.10-6). Wolf dens were also recorded during aerial surveys for caribou, and during non-systematic aerial searches of select areas deemed to have high potential for wolf den habitat (1998 to 2005). Incidental observations of wolves in the RSA, LSA, and along the Winter Access Road also were recorded.

The esker surveys (May 28 to June 1, 2004), documented wolf dens in the RSA, LSA, and along the Winter Access Road. When active wolf dens were identified during the aerial and ground surveys, an attempt was made to revisit each site between late July and August, 2004, to record pup production. Ground surveys of 17.5 km along the main esker in the LSA were completed on July 25 and 26, 2005. One person walked the top portion of the esker, while two others walked each side of the esker. The purpose of the ground survey was to identify any den sites that were missed during the aerial survey.

Esker aerial and ground surveys were also completed between July 21 and 23, 2007 along eskers identified as possible sources for gravel material for the Project (Figure 11.10-6). Eskers and esker complexes within 35 km of the Project camp were surveyed to document use (i.e., denning and transportation corridors) by wolves. Follow-up surveys were completed on the ground where wolf sign was observed. The relative use of eskers was estimated for wolves by calculating the sign per kilometre surveyed.

In 2010, historic dens (n = 25) discovered at esker complexes in the RSA in 1999 and 2005 were surveyed to measure wolf activity and distribution. Known dens were visited by helicopter. Each den was inspected by two observers for fresh sign (e.g., animals, tracks, scat, fur, or prey bones) as evidence of active use (Annex F, Addendum FF). Surveys were completed by a trained biologist and a community technician (Pete Enzoe from Łutselk'e). The objective of the 2010 wolf den survey was to provide information to ENR on the annual relative activity and distribution of wolves in the RSA.

Fox

A baseline study was completed to determine the natural variation in the distribution, and occupancy of fox dens within the RSA. Aerial and ground surveys, completed from 1999 to 2005, determined the presence of foxes and fox dens within the RSA, LSA, and along the Winter Access Road. Survey efforts focused on all mapped and unmapped esker complexes and glaciofluvial deposits to locate den sites.

The objectives of the baseline study were to:

- document the natural range of variation in the occurrence and distribution of Arctic and red fox, and fox dens within the RSA;
- identify traditional natal dens within the RSA; and
- assess the importance of potential fox den habitats in the LSA.

Esker surveys completed for grizzly bears and wolves in 1998, 1999, 2001, 2004, and 2007, also identified historic and active fox dens in the RSA (Figure 11.10-6). Fox dens were also recorded during aerial surveys for caribou, and during non-systematic aerial searches of select areas deemed to have high potential for fox den habitat (1998 to 2005). Incidental observations of foxes in the RSA, LSA, and along the Winter Access Road also were recorded. The relative use of eskers during the 2007 surveys was estimated for foxes by calculating the sign per kilometre surveyed.

Other Carnivores

As outlined in Table 11.10-2, there have been sightings of other carnivores or their sign within the study area. These include ermine, marten, river otter, and lynx. Although no black bears or obvious black bear sign were observed, it is likely that black bears are present within the study area, given its proximity to the treeline and the frequent black bear observations made at Snap Lake. These other carnivore species were not considered VCs during baseline studies. The Project is located near the northern extent of most species range. Subsequently, no specific surveys were conducted to document the abundance, distribution, or habitat associations of these species.

11.10.2.2.2 Regional Effects Monitoring and Research Programs

Information obtained from wildlife effects monitoring programs was used to estimate the frequency of interactions and mortality of carnivores associated with mine sites. Sources include reports from the Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Mine, and the Snap Lake Mine. Systematic surveys are not conducted to monitor wildlife mortalities. Rather, all wildlife incidents and mortalities are investigated by a site environmental technician, reported to the territorial government, and summarized in annual wildlife reports. Through this investigation and reporting mechanism, the number of carnivore mortalities is monitored at each development.

11.10.2.2.3 Traditional Knowledge and Resource Use

Further information was obtained from TK studies and a review of existing information on resource use of carnivores. The TK information was obtained from the research, experience, and expertise of the Elders from each of the potentially affected Aboriginal communities (Annex M).

11.10.2.3 Results

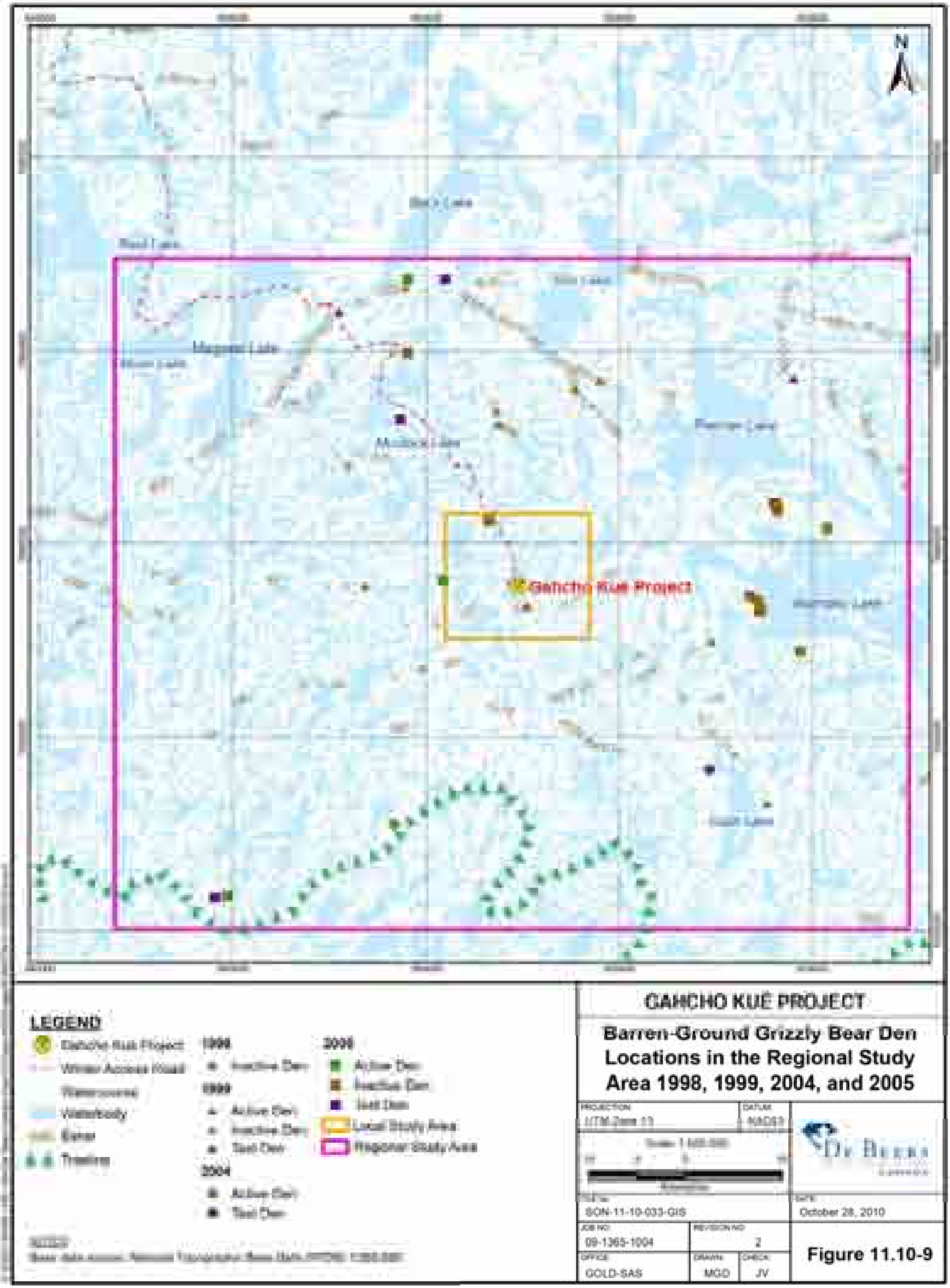
11.10.2.3.1 Grizzly Bear

Habitat Use

Grizzly bear habitat selection will vary spatially and temporally depending on the availability and quality of den locations and foraging resources. Proportionate to areas of availability, grizzly bears will select home ranges that contain more riparian habitat, habitats that support upland tundra vegetation growth, sedge wetlands, and esker habitat (McLoughlin et al. 1999, 2002). Gau et al. (2002) concluded that barren-ground grizzly bears lead a predominantly carnivorous lifestyle and are effective predators of caribou. Caribou was a predominant diet item during spring, mid-summer and fall. During early summer grizzly bears foraged primarily on green vegetation. Berries increased in dietary importance in late summer.

Surveys for grizzly bear sign along eskers completed in the RSA in 1999 located 14 grizzly bear den sites (13 inactive and one active) on eskers, while the majority of the 24 dens sites (19 inactive; three active, and two test dens) recorded during the 2004 and 2005 surveys were located adjacent to an esker (Figure 11.10-9). Of the four active dens recorded since 1999, one was located in heath tundra, one in tussock-hummock, one in heath-boulder, and one adjacent to the esker. The test den identified in 2004 was located in tussock-hummock, while the test den located in 2005 was found in a small glaciofluvial deposit located adjacent to a lake.

Esker use surveys completed in the RSA in 2007 documented 59 observations of grizzly bear sign on eskers, resulting in 0.76 sign per km surveyed (Figure 11.10-10). The finding that grizzly bears select eskers for dens supports traditional knowledge (LKDFN 2001a). Traditional knowledge indicates that grizzly bears use the dwarf birch on the sides of eskers as shade in the summer, and place their dens on the more windy west-facing slopes of eskers.



Gahcho Kué Project
LEGEND
Gahcho Kué Project
Winter Access Road
Watercourse
Waterbody
Esker
Treeline
1998
Inactive Den
1999
Active Den
Inactive Den
Test Den
2004
Active Den
Test Den
2005
Active Den
Inactive Den
Test Den
Local Study Area
Regional Study Area
GAHCHO KUÉ PROJECT
Barren-Ground Grizzly Bear Den Locations in the Regional Study Area 1998, 1999, 2004, and 2005
PROJECTION
UTM Zone 11
DATUM
NAD83
SON-11-10-033-GIS
October 28, 2010
JOB NO.
09-1365-1004
REVISION NO.
2
OFFICE
GOLD-SAS
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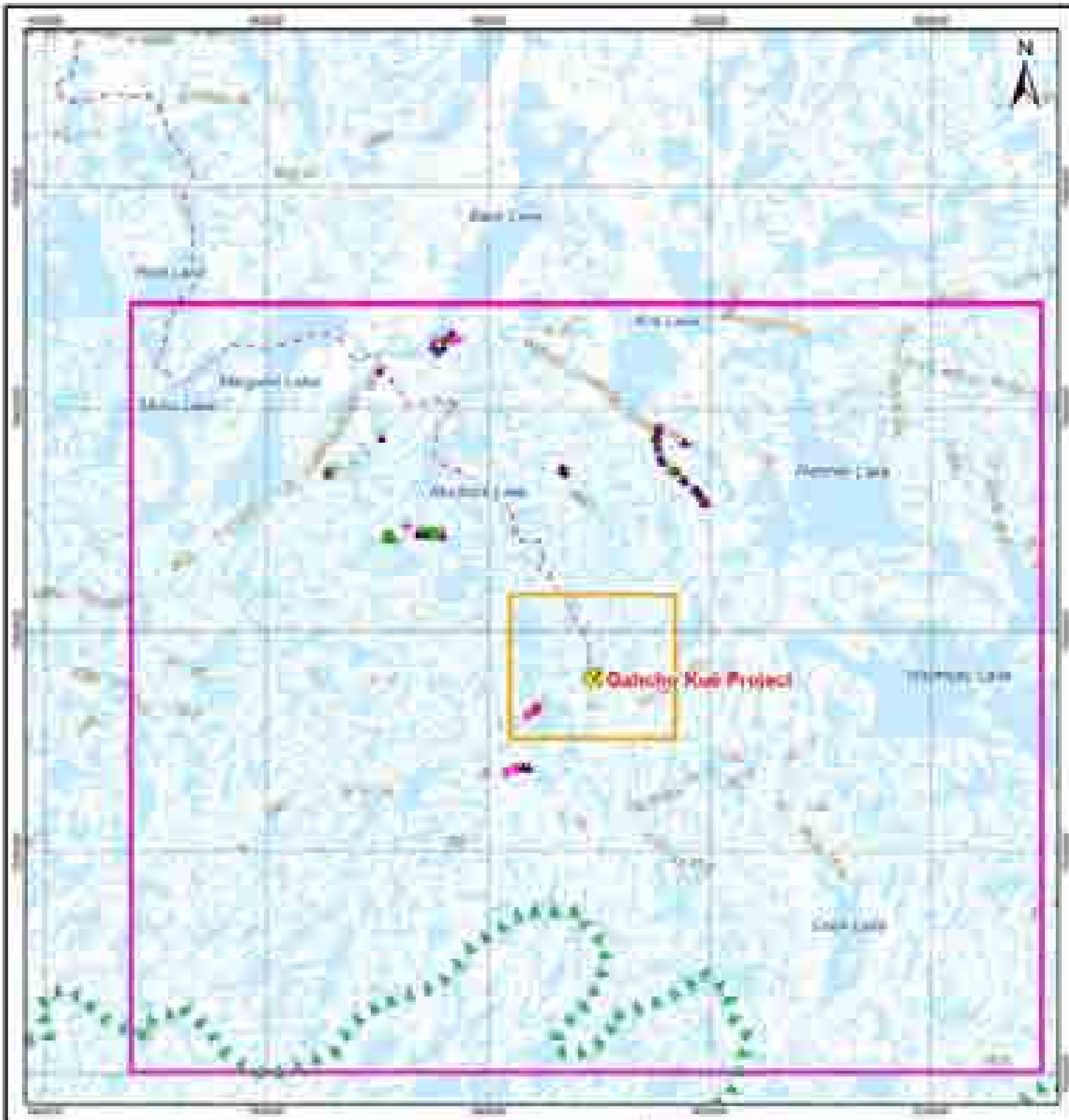
Figure 11.10-9



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Day Bed
- Dig
- Scat
- Track
- Local Study Area
- Regional Study Area

NOTES

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Esker Surveys for Barren-Ground Grizzly Bear Sign in the Regional Study Area 2007

Scale 1:500,000

FILE No.	SON-11-10-034-GIS
DATE	October 28, 2010
JOB NO.	09-1365-1004
REVISION NO.	2
OFFICE	GOLD-SAS
DRAWN	MGO
CHECK	JV

Figure 11.10-10

The number of bear signs per plot in the RSA, calculated from habitat surveys completed in 2005 and 2007, was slightly lower in riparian habitats (0.80 and 0.77) as compared to sedge wetland plots (1.07). Grizzly bear sign per plot during baseline studies completed at the Snap Lake Mine averaged 0.71 and 0.83 sign per plot in sedge wetlands and riparian plots, respectively. For 2005 to 2007 (i.e., during Snap Lake Mine construction), the number of bear signs per plot, ranged from 0.25 to 0.48 and 0.30 to 0.77 for sedge wetlands and riparian plots, respectively (Golder 2008a). At the Diavik mine, bear sign per plot ranged from 0.53 to 1.17 in wetlands plots, and between 0.37 and 1.61 in riparian habitats (Golder 2008b).

In 2005, the occurrence of grizzly bear sign in sedge wetland plots ranged from 23% to 60% and from 12% to 46% in riparian plots in the RSA. In 2007, the proportion of riparian plots with sign increased to 31% to 69%.

Monitoring studies completed at the Diavik and Ekati mine sites in the Lac de Gras region (2000 to 2007 [combined study area = 2,800 km^2]) found that, from 42% to 55% of all bear plots surveyed had evidence of recent habitat use by grizzly bears (Golder 2008b). During the construction phase, the proportion of plots with bear sign were roughly equal in riparian and sedge wetland habitats (48% and 45%, respectively). During the operation phase, the proportion of sedge wetland plots with bear sign (42%) was significantly lower the proportion of riparian plots with bear sign (55%).

At the Snap Lake Mine (study area = 3,000 km^2), the proportion of plots with bear sign was also higher in riparian habitats (46% and 31% for baseline and construction, respectively) than in sedge wetland habitats (38% and 25% for baseline and construction, respectively) (Golder 2008a). Further analyses completed for the Ekati Diamond Mine (study area = 1,600 km^2) from 2000 through 2006 found 33 to 66% of wetlands plots and 27 to 83% of riparian plots contained recent bear sign (BHPB 2007).

Grizzly bear hair was observed at 23% (9 of 40) of the stations during the 2010 pilot hair snagging study. Black bear hair was identified at two stations during the third survey (Annex F, Addendum FF).

Behaviour and Distribution

The annual home range for barren-ground grizzly bears is the largest reported for brown bears in North America. In the SGP, McLoughlin et al. (2002) found the mean annual range of adult male grizzly bears was 7,245 km^2 and the mean annual range of females was 2,000 km^2. The larger home range size for males is likely due to higher energy requirements and wandering to search for females for mating (McLoughlin et al. 2003a). No differences in annual or seasonal range size were found between females with or without cubs (McLoughlin et al. 2003a). Grizzly bears are inactive during the winter, when they den and enter a dormant state, approximately from October to April (McLoughlin et al. 2002).

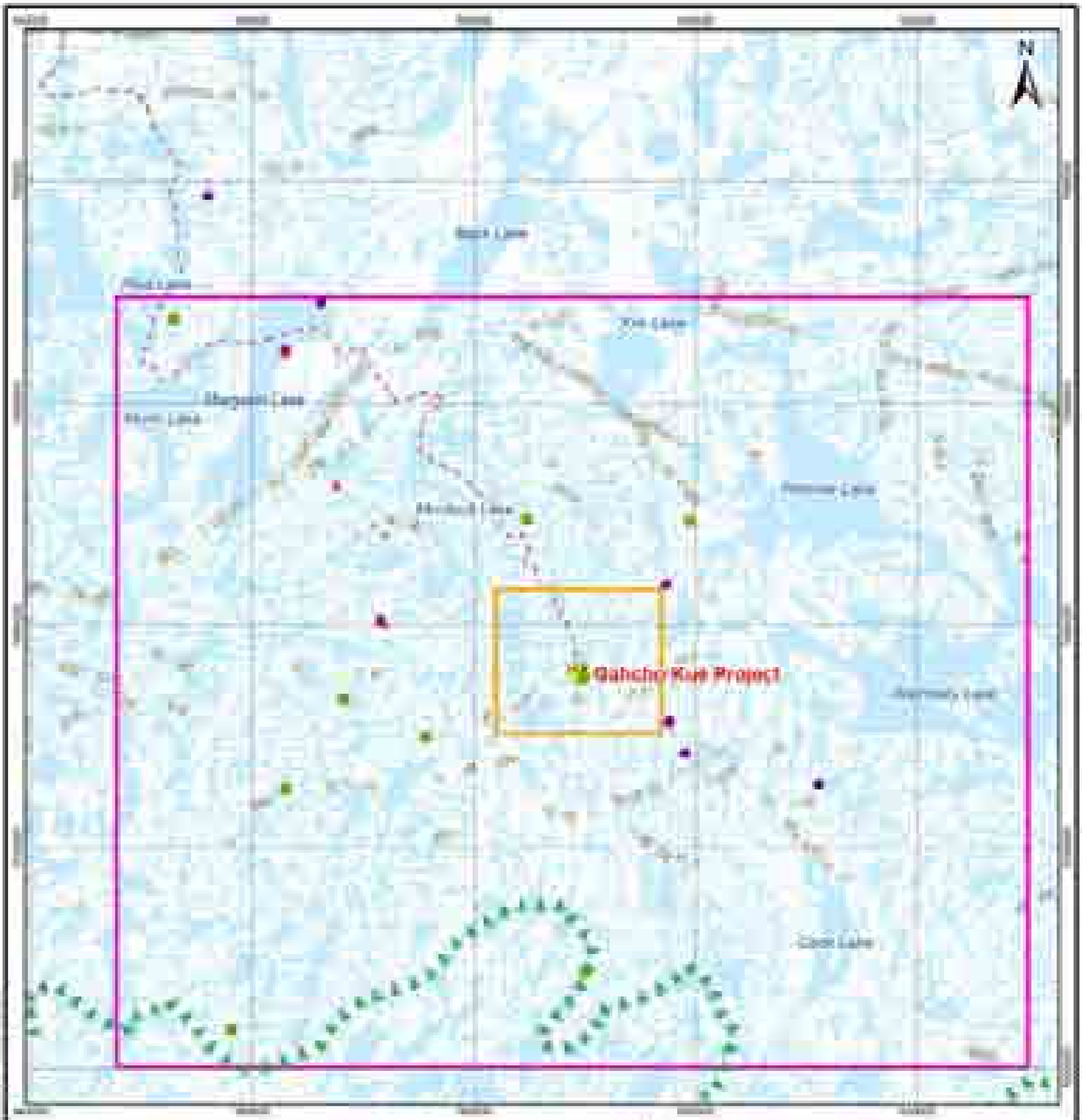
Recent GPS collar data for grizzly bears located within or adjacent to the RSA is not available, therefore the estimation of collared bear distribution was based on studies completed from 1995 to 1999 (McLoughlin et al. 1999). Based on the GPS-collared grizzly bear data, two grizzly bears maintained home ranges and den sites close to the RSA. Based on density estimates of 3.5 bears per 1,000 km^2 (McLoughlin and Messier 2001), up to 20 individual bears may inhabit portions of the RSA (including sows with dependant cubs).

Grizzly bears and bear sign have been documented in the RSA from 1999 through 2005 (Figure 11.10-11). Although no bears were observed within the RSA in 1998 or 1999, three sets of grizzly bear tracks were identified in 1999. In 2004, eight different grizzly bears (five adults and three cubs) were observed within the RSA and a minimum of six different grizzly bears were present in 2005. In the RSA, most sightings occurred during the spring, with observations decreasing during the late summer and fall. No negative encounters with exploration personnel or field survey crews occurred.

In the Snap Lake Mine study area, 13 incidental observations of grizzly bears were made from 1999 through 2006 (De Beers 2007). Environment personnel at the Diavik Diamond Mine recorded 33 individual bears on 21 separate occasions in 2006 (DDMI 2007). Incidental observations of grizzly bears in the vicinity of the Ekati Diamond Mine collected since 2001 ranged from 36 in 2001 to 76 in 2005 (BHPB 2007).

Population Characteristics

Grizzly bears in the NWT are listed as sensitive (NWT General Status Ranking Program 2010, internet site), and as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2009, internet site). The population of barren-ground grizzly bears was estimated at 800 ± 200 (standard error [SE]) individuals within an approximate area of 235,000 km^2, which is roughly the area of the SGP (McLoughlin et al. 2003a). The population appeared stable, but increased losses associated with illegal hunting or the killing of nuisance bears may place the population at risk of decline (McLoughlin et al. 2003a).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Caribou Kill Site
- Grizzly Bear Observation, 2004
- Grizzly Bear Observation, 2005
- Local Study Area
- Regional Study Area

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Incidental Observations of Barren-Ground Grizzly Bear in the Regional Study Area 2004 and 2005

PROJECTION: UTM Zone 12	DATUM: NAD83		
FILE No: SON-11-10-035-GIS		DATE: October 28, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV	**Figure 11.10-11**

It is estimated that about 13.4 bears were removed per year from 1958 to 2000, primarily to protect human lives and property (McLoughlin et al. 2003b). About 3 to 4 bears were removed each year as problem bears. However, this estimate may be much lower than the actual rate of problem bear kills. For example, about eight "problem" grizzly bears were reported killed each year from 1995 to 2002 in the Northwest Territories (unpublished data, Robert Mulders, Territorial Biologist, Yellowknife, NWT).

Barren-ground grizzly bears also may be at risk of population decline because they have low reproduction rates and live in areas of low forage productivity and extreme environmental conditions. McLoughlin et al. (2003b) estimated vital rates from data collected on 81 bears with satellite collars between May 1995 and June 1999. In their study, survival rates for cubs of both sexes were 0.737 (0.118 [standard deviation; SD]), and for yearlings of both sexes were 0.683 (0.145 [SD]). Survival rates for subadults were similar from year 2 to 5 for males, as well as for females; however survival rates were slightly lower for females (0.831 ±0.29 [SD]) than for males (0.833 ±0.294 [SD]) during this life stage. As adults, female survival rates were 0.979 (0.024 [SD]) and slightly lower than those of male bears, which were 0.983 (0.033 [SD]).

Factors other than adaptation to natural conditions appear to govern the life history of central Arctic populations, such as harvest biased towards male bears (McLoughlin et al. 2000), and limited ability for range expansion because of increased human development (McLoughlin et al. 1999). Further, there are nine grizzly bear tags issued each year among the Nunavut communities of Bathurst Inlet and Kugluktuk for sport and commercial use (Atatahak 2008, pers. comm.). A further unmanaged Aboriginal subsistence harvest of 1 to 2 grizzly bears per year occurs in the community of Kugluktuk (Atatahak 2008, pers. comm.). The population size and distribution of barren-ground grizzly bears may be affected by the annual sport hunt and human activities. Johnson et al. (2005) estimated a 21% decrease in good quality habitats for bears in autumn and 18% decrease in good quality habitats in late summer from existing development in the SGP.

Traditional and Non-Traditional Use

The Deninu Kué traditionally harvested bears using traps in the late summer through the fall, when the berries are ripe (Fort Resolution Elders 1987). The people used to travel all together when they hunted and they would help each other. They used to hunt for everything, bears too. In the late summer, towards fall, they would set traps for bears (Elder HB in Fort Resolution Elders 1987: 29).

Grizzly bears in the NWT are classified as a big game species and a furbearer. Hunting of grizzly bears in the SGP is not permitted, although there are quotas for other populations in the NWT (such as the Mackenzie Mountains). There remains a small harvest of grizzly bears, mostly due to problem bears, but also including some illegal harvests (McLoughlin and Messier 2001). Between 1958 and 2000, this harvest has totalled 265 bears, or an average of about six per year (McLoughlin and Messier 2001).

During the hunting season of 2006/2007, one grizzly bear hide was submitted to ENR from Yellowknife hunters, and none from Łutselk'e (ITT 2008), suggesting this species does not have a significant level of traditional or non-traditional use in the region.

11.10.2.3.2 Wolverine

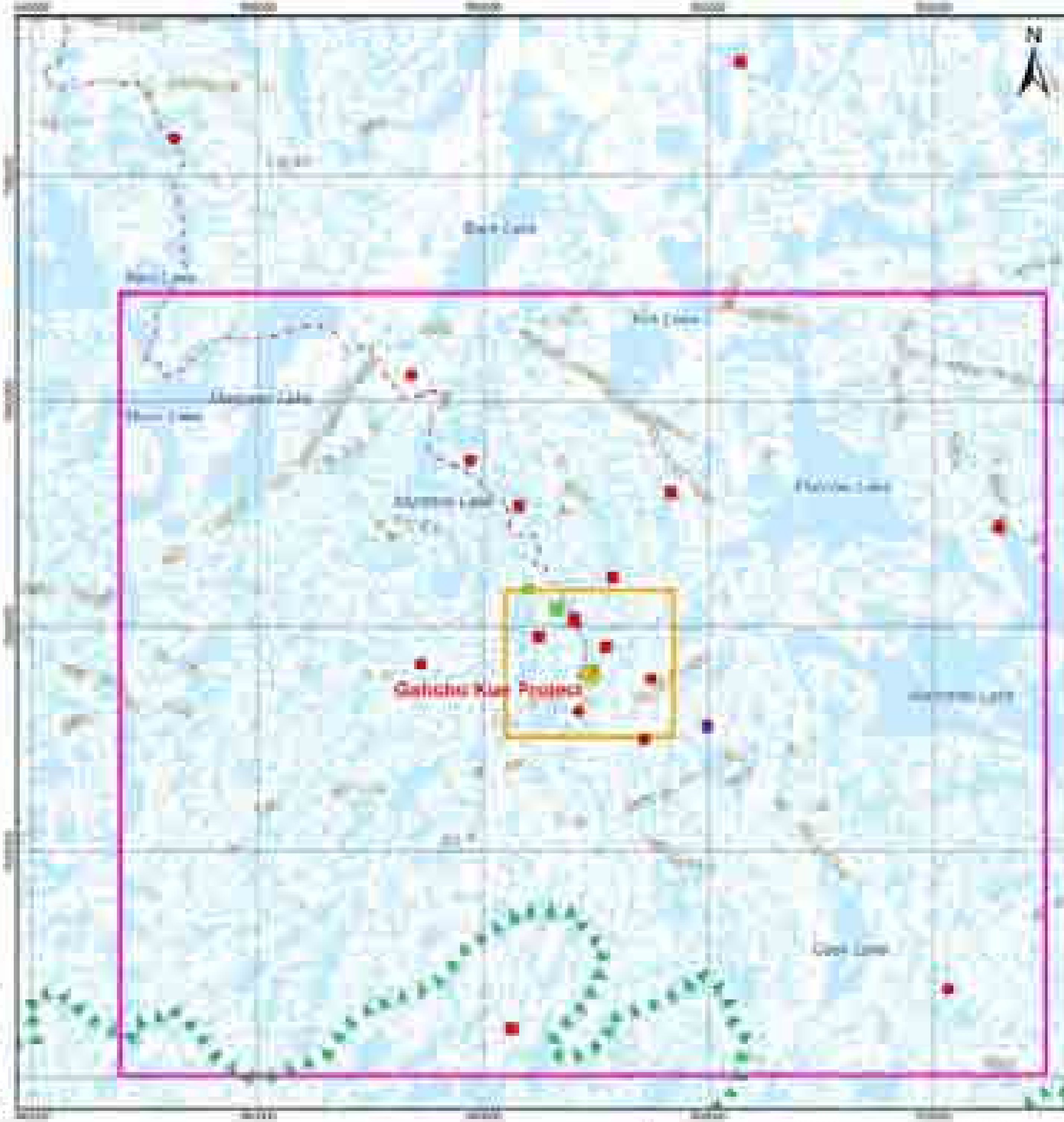
Habitat Use

Wolverines are highly adaptable animals that can alter their location and distribution over time, but often occur with large ungulate populations. Recent concerns regarding the potential cumulative direct and indirect effects on wolverine populations from human development, hunting, and trapping have resulted in an increase in conservation efforts and planning for wolverine in northern Canada (Johnson et al. 2005).

Satellite-collared wolverine studies on the central Canadian Arctic barrens estimated that adult female wolverines have a home range of 126 km^2, while the home range of adult males was 404 km^2 (Mulders 2000). Populations generally exhibit low densities. For example, Boulanger and Mulders (2007) estimated that, on average, male densities were 2.64 (1.2 [SD]) per 1,000 km^2 and female densities were 4.19 (1.29 [SD]) per 1,000 km^2 in the Northwest Territories during 2005 and 2006. These densities result in an estimated total population size of 1,298 wolverine for a 190,000 km^2 study area (approximate size of SGP).

Habitat use typically depends on adequate food resources and den site availability. In tundra habitats, the availability and quality of reproductive den sites is not likely a limiting factor in wolverine production. Wolverine dens can vary from simple resting sites to complex natal dens with extensive tunnel networks that are frequently associated with rocky outcrops and deep snowdrifts. Traditional knowledge also suggest that wolverines make their dens in rough terrain (LKDFN 2001a).

Habitat within the RSA appears to provide adequate availability of potential den locations. Bedrock outcrops are relatively common, particularly farther south and west in the RSA. During spring, areas of deep snow are available along the base of eskers, in conifer stands, and in terrain depressions. The LSA is less varied in terrain features; however, den habitats do not appear to be limiting in this area. From 1999 to 2005, four wolverine dens were located within the RSA, ranging from 7 to 15 km from the Project camp (Figure 11.10-12).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Wolverine, 2004
- Wolverine, 2005
- Feeding Den, 1999
- Potential Den, 2005
- Rock Den, 2004
- Snow Den, 2004
- Local Study Area
- Regional Study Area

NOTES

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Incidental Observations of Wolverine and Wolverine Den Locations in the Regional Study Area 1999, 2004, and 2005

SON-11-10-036-GIS	October 28, 2010
JOB NO. 09-1365-1004	REVISION NO. 2
OFFICE GOLD-SAS	DRAWN MGD / CHECK JV

Figure 11.10-12

Studies of wolverine stomach contents indicated that caribou are their primary source of food. Caribou was found in the stomach contents of 62% of the 277 wolverine sampled from the SGP between 1995 and 1999 (Mulders 2000). Muskoxen and Arctic ground squirrel (*Spermophilus parryii*) were the next most common items, at 11% and 5%. Other items found included moose, small mammals, Arctic hare, fox, ermine, ptarmigan, and fish. Vegetation was found in 6% of the stomachs, although it was not clear if this was purposeful or inadvertent (Mulders 2000).

Den site fidelity is not well understood, although wolverines have been observed to reoccupy den sites or habitats for consecutive years. One active den site located in the RSA showed signs of long-term use with an abundance of feeding sign, including scattered caribou antlers that were of varying ages and stages of decay.

Traditional knowledge suggests that wolverines are known as scavengers, but are also known to kill caribou or smaller animals such as mice. Wolverines are described in the reviewed sources as thieves that are mischievous and strong, but slow (LKDFN 1999). If there are ample resources for the wolverines they will be fat. In the summer they have their young. Summer is also a time when the wolverines will eat minnows that can be found along the shore lines (LKDFN 1999). The North Slave Métis Alliance (NSMA) report that wolverine are long-distance travelers and can travel up to 40 miles in one day looking for food (NSMA 1999, Ziemann 2007, internet site). The wolverine diet includes ptarmigan, lemming, ground squirrel, and mouse, as well as dead animals left by wolves. They are described by NSMA member Peter Arychuk as being “very, very cautious like a wolf”, but if there is food available “they are very bold” (NSMA 1999, Ziemann 2007, internet site).

Behaviour and Distribution

In the RSA, 21 wolverines and sign were documented from 1998 through 2005 (Figure 11.10-12). Wolverine activity and frequency of sightings coincided with the major spring and fall caribou migrations. There were 23 incidental observations of wolverine reported at the Ekati Diamond Mine in 2006, which decreased from 128 observations in 2005 (BHPB 2007). Incidental observations of wolverine in and around the Diavik Diamond Mine were similar to the Ekati Diamond Mine, with 31 sightings reported in 2006 (DDMI 2007).

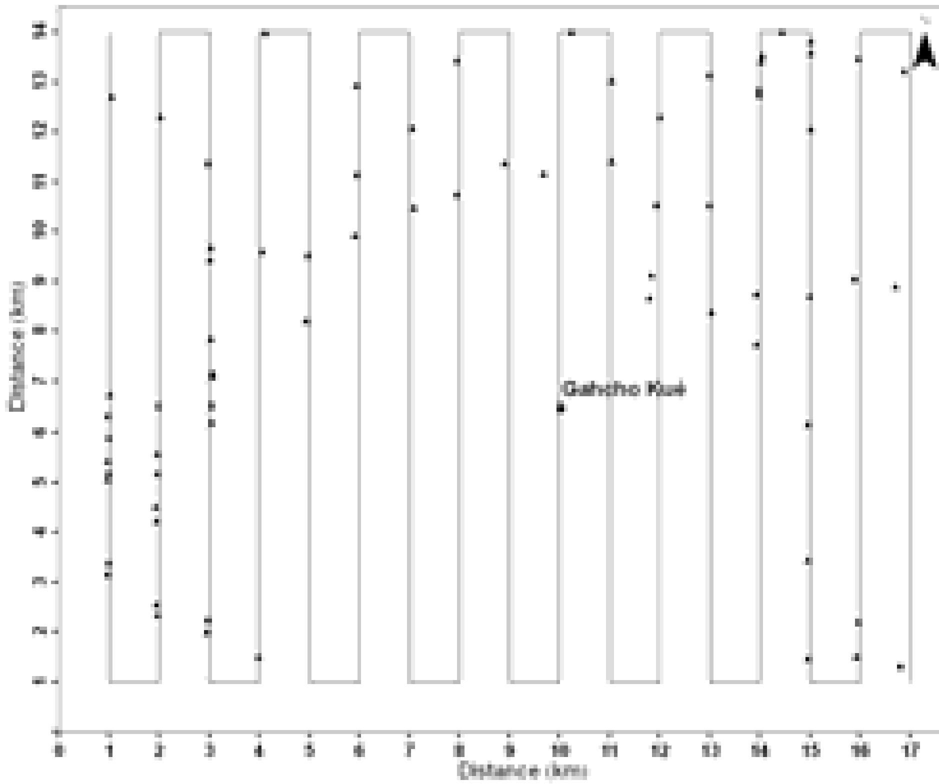
Population Characteristics

Wolverine, the largest member of the weasel family, has a circumpolar distribution in the tundra, taiga, plains, and boreal forests of North America (Weir 2004). The animals are a cultural and economic resource for people of the NWT.

Traditional knowledge indicates that wolverines were harvested primarily for their fur, although historically, they were sometimes killed as an emergency food source. Wolverines are annual residents in the RSA, and are listed as a species of special concern by COSEWIC (2009, internet site) and sensitive by the NWT General Status Ranking Program (2010). This species currently has no status under the *Species at Risk Act* (SARA 2009).

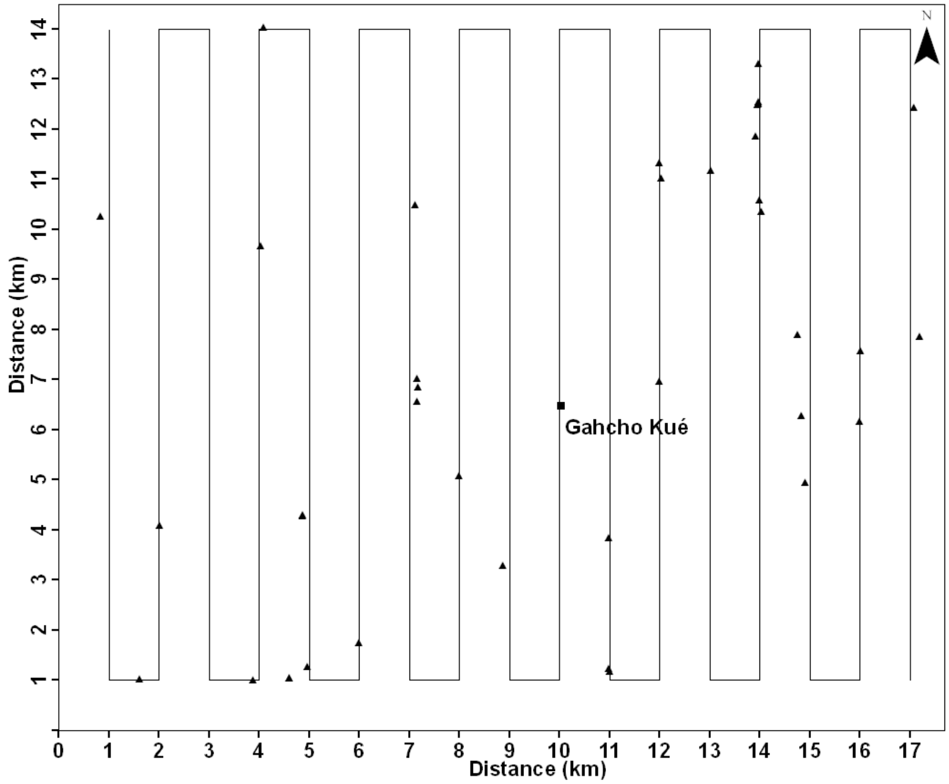
Wolverine snow track data were used to provide an annual index of relative abundance within the LSA, and to determine if annual changes in wolverine distribution around Kennady Lake could be detected. Track count surveys completed in May 2004 recorded 73 wolverine tracks over 237 km (Figure 11.10-13). Standardized (normalized for days since last snowfall) track density was 0.08 wolverine TKD. In March 2005, poor weather conditions prevented completion of all survey transects. Wind and snow resulted in seven wolverine track observations over 195 km. Wolverine track density in 2005 was 0.01 and 0.12 TKD for March and April (Figure 11.10-14), respectively. In 2004, fewer tracks were located near the Project than in 2005 suggesting an annual change in distribution around the Project. In neither year was there evidence that the wolverine tracks appeared in habitats in a different proportion than expected. Habitat use in the LSA also was similar between the two years. In 2010, thirteen wolverine tracks were detected on 14% (7 of 49) transects surveyed, and an additional four wolverine tracks were recorded incidentally (Annex F, Addendum FF).

Figure 11.10-13 Transects Surveyed During the May 2004 Winter Track Counts and the Distribution of Wolverine Tracks



km = kilometre.

Figure 11.10-14 Transects Surveyed During the April 2005 Winter Track Counts and the Distribution of Wolverine Tracks



km = kilometre

The results from the track counts completed in May 2004 and April 2005 are similar to track count density reported during baseline and monitoring studies at the Snap Lake Mine. From 1999 through 2004, the mean annual TKD reported at the Snap Lake Mine varied from 0.04 to 0.23, for an overall average of 0.14 ± 0.03 (1 SE) (De Beers 2007). In recent years, TKD at Snap Lake ranged from 0.09 ± 0.07 (2SE) in 2007 to 0.15 ± 0.08 (2SE) in 2005. From 2003 to 2007, the proportion of transects with fresh wolverine tracks ranged 67% in 2003 to 31% in 2007, and appears to be declining over the years (Golder 2008a).

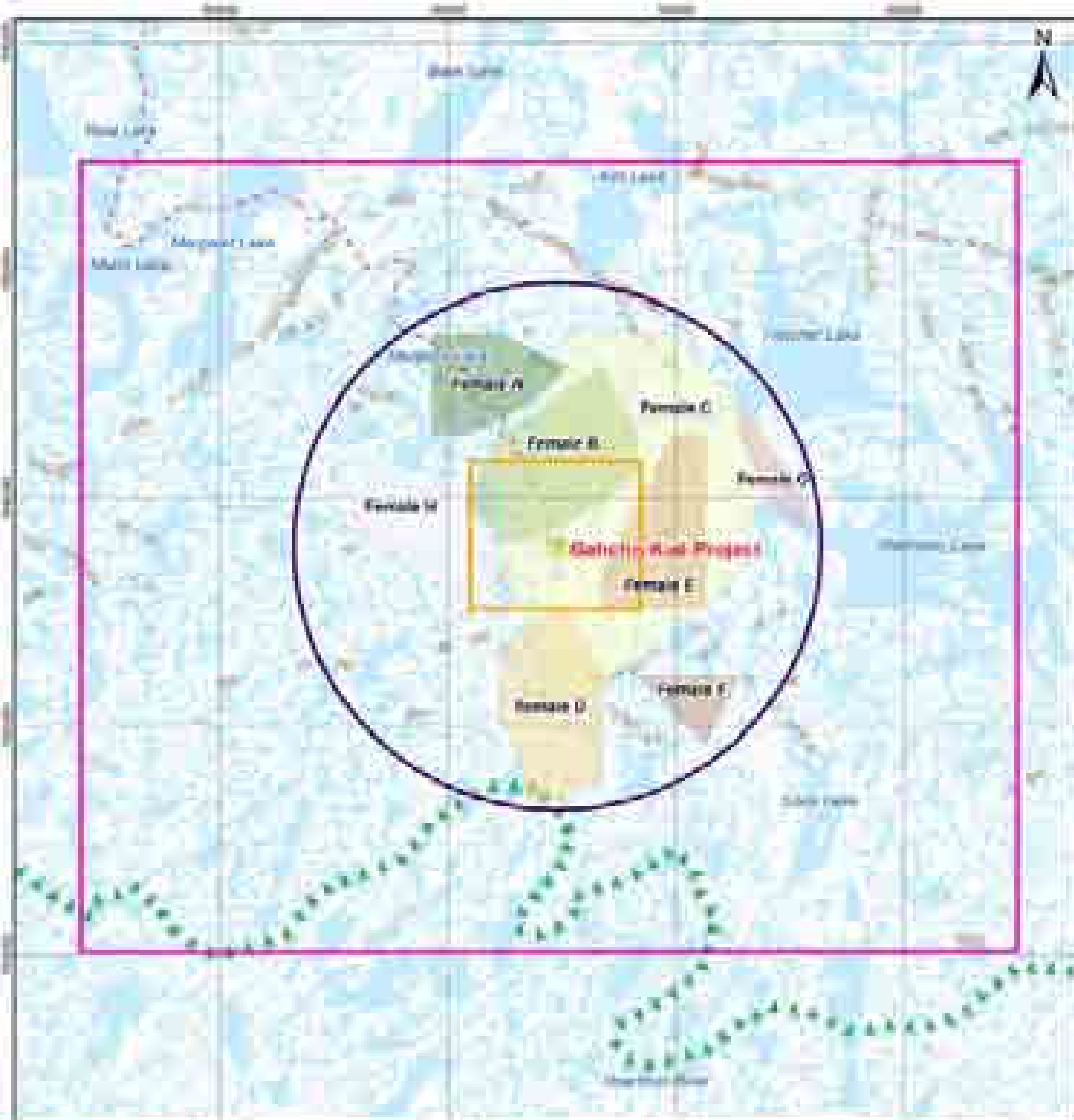
Monitoring studies at the Diavik Diamond Mine and Ekati Diamond Mine also generated similar estimates of wolverine activity using snow track methods. From 2003 through 2006, average annual TKD in the Diavik study area ranged from 0.05 to 0.07 (Golder 2007). In the Ekati study area, wolverine track density ranged from 0.04 to 0.13 TKD from 1997 through 2003 (BHPB 2004).

Survival rates of wolverine have been synthesized for North America wolverines in Krebs et al. (2004). Survival estimates were based on pooled data from tundra, boreal, and montane ecological zones, rather than tundra only because of low sample sizes and relatively few studies conducted in this region. In untrapped areas of North America, survival rates for adult females = 0.88 (0.127 [SD]), adult males = 0.87 (0.186 [SD]), subadult females = 0.85 (0.161 [SD]), and subadult males = 1.0 (0 [SD]). It is important to note that these rates do not account for hunting pressure.

In areas that are used for trapping (trapped areas), survival rates for adult females = 0.73 (0.149 [SD]), adult males = 0.74 (0.122 [SD]), subadult females = 0.69 (0.157 [SD]), and subadult males = 0.45 (0.172 [SD]). Among harvested wolverine populations in trapped areas in North America, nearly half of all mortalities were related to humans or development. Typically, young males are the most susceptible to such mortality sources. Based on a Scandinavian study, it is assumed that 54% of adult female wolverine can successfully reproduce in any given year, and that the average wolverine litter size is 1.9 kits (Persson 2003).

The use of genetic markers (DNA and allozymes) to study wolverine populations in the NWT has provided insight into the distribution and connectivity of these populations (Kyle and Strobeck 2002). Wolverine DNA hair snagging completed near Daring Lake in 2004 identified 53 individual wolverine in a 2,500 km^2 study area for a population estimate of up to 37 males and 24 females. Results from Daring Lake in 2005 and 2006 detected 38 wolverines (17 females, 21 males) and 33 wolverines (16 females, 17 males), respectively (Boulanger and Mulders 2007). Similar studies at the Diavik Diamond Mine and Ekati Diamond Mine each sampled an area of 1,300 km^2 in 2005 and identified 24 wolverines (13 females and 11 males) and 21 wolverines (9 females and 12 males), respectively. In 2006, 22 wolverines (14 females, 8 males) were identified at the Diavik Diamond Mine, and 14 wolverines (9 females, 5 males) were detected at the Ekati Diamond Mine (Boulanger and Mulders 2007).

Similar studies were completed for the Project in 2005 and 2006 within a 1,600 km^2 sampling area that covered the LSA and part of the RSA. In 2005, nine female and eight male wolverines were identified. Results from 2006 detected 17 individuals (11 females, 6 males) (Boulanger and Mulders 2007). For 2005, the estimated area of movement for female and male wolverines in the hair sampling grid within the RSA is presented in Figures 11.10-15 and 11.10-16, respectively. Population estimates for the Project suggest that the number of wolverine in the region of the Project is lower than the Lac de Gras region. Results also indicated that movement of individuals, particularly males, among study areas in the Lac de Gras region was common. Movement of individuals between the Lac de Gras region and the region of the Project was not detected (Boulanger and Mulders 2007).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Hair Sampling Grid
- Local Study Area
- Regional Study Area

NOTES

Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Estimated Area of Movement of Female Wolverine 2005

PROJECTION	UTM Zone 12
DATUM	NAD83
FILE No.	SON-11-10-037-GIS
DATE	October 28, 2010
JOB NO.	09-1365-1004
REVISION NO.	2
OFFICE	GOLD-SAS
DRAWN	MGD
CHECK	JV

Figure 11.10-15

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Estimated Area of Movement of Male Wolverine 2005

PROJECTION: UTM Zone 11	DATUM: NAD83	
TITLE: SON-11-10-038-GIS		DATE: October 28, 2010
JOB NO: 09-1365-1004	REVISION NO: 2	
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV

Figure 11.10-16

Traditional and Non-Traditional Use

Wolverines are prized by Aboriginal cultures for their fur, which provides excellent insulation and protection from the wind when used on clothing. Wolverine fur is used by both Inuit and Dene as trim on hoods and sleeves. Traditionally, the Denesǫłıne people travelled to the barrenlands to harvest wolf, white fox, and wolverine, particularly in the area east of Kennady Lake (LKDFN 1999).

Harvest kill rates through sport hunting and trapping of non-problem wolverine for subsistence are much higher than that for problem wolverine. For example, based on the reported number of wolverine tags issued to sport hunting outfitters in the North Slave Region (data from 1995 to 2002, and 2005, and 2006), the minimum number of tags issued during a year was 63 wolverine, whereas the maximum number of tags issued during a year was 451 wolverine (Carriere 2007 in Berens 2007, internet site). Further, annual subsistence trapping may range from 56 to 175 wolverine based on the reported number of wolverine pelts sold in the NWT from 1995 to 2002 (Statistics Canada 2008). During the winter of 2006/2007, 19 wolverine hides were submitted to ENR from Yellowknife residents, and a further 7 from Łutselk'e (ITT 2008).

However, harvesting pressure on NWT wolverines has been increasing. In some northern communities, the price for a wolverine pelt has risen to as high as $500. The use of snow machines has made it easier to hunt and trap wolverines. Residents can harvest one or more wolverine in accordance with the number of tags obtained (July 25 to April 30). Non-residents can harvest one wolverine (December 1 to March 15, and August 15 to October 31) (ENR 2010a, internet site).

The estimated wolverine harvest to Yellowknife hunters showed an increase from eight in the 1992/1993 season to peaks of 23 in both the 1995/1996 and 1997/1998 seasons. From those peaks, the numbers trended downward to three in the 2005/2006 season. Prior to the 1992 season, estimated harvests were six in 1984/1985 and one in 1985/1986. Other hunting seasons show either zero harvests or no data. For the North and South Slave regions, the estimated harvest levels for wolverine were quite low. Most years estimated no harvest, and in those years in which harvests were estimated, the numbers ranged between two and four. No data are available for the license years 1987/1988 to 1990/1991 inclusive (Carriere 2007 in Berens 2007, internet site). Yearling wolverines constitute the largest proportion of harvested individuals (Mulders 2000). Increased movement by subadults and subsequent nutritional stress could lead to in increased vulnerability that is reflected in the harvest.

A component of conservation planning has been the implementation of effective waste management programs at industrial development sites, such as that used at the Diavik Diamond Mines Inc. (Golder 2007). Based on reported mine-related mortalities for Ekati, Diavik and two of the winter road camps, the problem wolverine removal rate was about 2 individuals per year from 1998 to 2001 (BHPB 2002). Traditional knowledge sources indicated concern about wolverine attracted to mine sites, because of garbage attractants or because people are feeding animals (NSMA 1999, Ziemann 2007, internet site).

11.10.2.3.3 Wolf

Habitat Use

At the local scale, wolves select areas with suitable den habitat, such as eskers, kames, and other glaciofluvial deposits (Johnson et al. 2005). Eskers comprise only 1 to 3% of the Arctic tundra ecosystem (Mueller 1995; Cluff et al. 2002), so the availability of suitable den sites, rather than the availability of food resources, may limit wolf populations in the central Canadian Arctic (McLoughlin et al. 2004).

Wolves arrive at the summer ranges from late March to about mid-May, and den sites may be occupied as early as the first week of May (Cluff et al. 2002). Historically, wolves travelled together in a pack of ten; however, recent traditional knowledge indicates that one or two wolves are typically observed together (LKDFN 2002). From late May through August, most wolf sightings are typically associated with a nearby natal den site. Wolf pups usually leave the natal den in early August, but do not leave the summer range on the tundra for below the treeline until October. Few wolves are likely to occur in the RSA during winter, as wolves typically follow the caribou into the boreal forest.

Wolves and wolf sign have been documented in the RSA since 1999. A total of 46 wolves and 9 pups were recorded from 1999 to 2007. Most observations occurred in 2004 and 2005 during aerial surveys for caribou and esker surveys for natal den sites (Figure 11.10-17). During a 1999 Project site visit by First Nations, the participants sighted a wolf or wolves on three occasions as well as a wolf kill (caribou carcass) that was along the eastern shore of Kennady Lake (LKDFN 1999). Monitoring results from the Ekati Diamond Mine recorded 47 incidental observations of wolves in 2006 (BHPB 2007) and 54 to 58 wolves in other years (2002 to 2005) (BHPB 2007).

LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Wolf Observation, 2004
- Wolf Observation, 2005
- Wolf Observation, 2007
- Local Study Area
- Regional Study Area

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Incidental Observations of Wolf in the Regional Study Area 2004, 2005, and 2007

PROJECTION: UTM Zone 11	DATUM: NAD83	De Beers
Scale 1:600,000	Kilometres	
TITLE: SON-11-10-039-GIS		DATE: October 28, 2010
JOB NO: 09-1365-1004	REVISION NO: 2	**Figure 11.10-17**
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV

Similar to grizzly bears, wolves also use eskers for den sites, foraging, and travel (LKDFN 2001b, internet site). Wolf sign surveys were completed in 2007 on eskers within 35 km of the Project (Figure 11.10-18). A total of 77.5 km of esker complexes were surveyed during the summer season. A total of 34 observations of wolf sign were recorded on the eskers, resulting in 0.44 sign per kilometre surveyed. A lone wolf and active den complex with several large entrance holes was discovered during the surveys.

Although considered a habitat generalist, wolves in the tundra appear to select habitat based on the availability of food resources and den site locations. Wolves occur seasonally in the RSA from March through October, coinciding with the caribou movements through the region. During the spring, wolves follow the caribou herds north of the treeline and choose den sites south of the caribou calving grounds (Parker 1973; Heard and Williams 1992). This strategy likely optimizes the availability of food resources for rearing pups (Heard and Williams 1992). Caribou will remain on the calving grounds until late June before migrating south and arriving closer to the treeline in July and August. This coincides with the time when the nutritional demands of wolf pups are greatest (Kelsall 1968; Parker 1973; Fancy et al. 1989; Heard and Williams 1992).

Wolves that den on the tundra are thought to do so almost exclusively in eskers, kames, and drumlins (Williams 1990; Mueller 1995). Traditional knowledge indicates that "*eskers are the main places where wolves make their dens"* (LKDFN 2001b, internet site). The sandy composition of these deposits provides suitable habitat for excavation of dens in a landscape that is dominated by bedrock, boulders, standing water, and permafrost (Mech and Packard 1990; Mueller 1995).

Active wolf den sites within the RSA ranged from 6 to 38 km from the Project camp (Figure 11.10-19) (Annex F, Addendum FF). None of the dens surveyed in June 2010 had evidence of active occupancy by wolves. Esker material does not have to be extensive. Active wolf dens may be located in slightly raised and well-drained mounds of sand and gravel (Cluff et al. 2002). Wolf dens located in the RSA during baseline surveys were established on eskers or other glaciofluvial deposits such as kames. Dens associated with eskers were often on terraces, side deposits, or esker ends rather than on the top of the esker. Wolf dens identified in the Snap Lake Mine study area (3,000 km^2) during baseline studies (1999 to 2004) were also associated with eskers or other sandy glacial deposits (De Beers 2006).

LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline
- Active Den
- Day Bed
- Inactive Den
- Scat
- Track
- Wolf
- Local Study Area
- Regional Study Area

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Esker Surveys Completed for Wolf Sign in the Regional Study Area 2007

UTM Zone 12

Scale 1:500,000

De Beers Canada

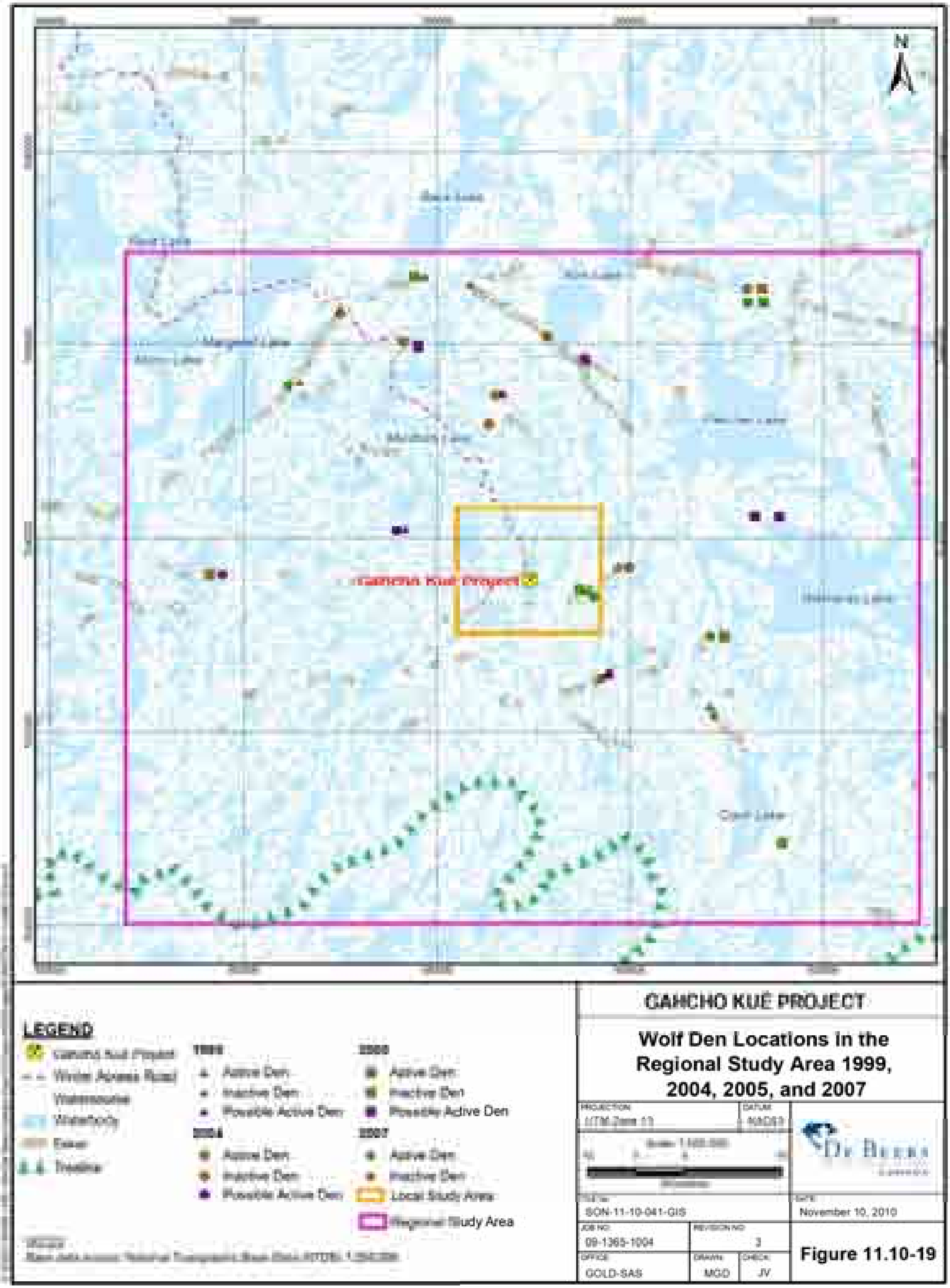
SON-11-10-040-GIS

October 28, 2010

JOB NO.	REVISION NO.
09-1365-1004	2

OFFICE	DRAWN	CHECK
GOLD-SAS	MGD	JV

Figure 11.10-18


N
Gahcho Kué Project
LEGEND
Gahcho Kué Project
Winter Access Road
Watercourse
Waterbody
Esker
Treeline
1999
Active Den
Inactive Den
Possible Active Den
2004
Active Den
Inactive Den
Possible Active Den
2005
Active Den
Inactive Den
Possible Active Den
2007
Active Den
Inactive Den
Local Study Area
Regional Study Area
GAHCHO KUÉ PROJECT
Wolf Den Locations in the Regional Study Area 1999, 2004, 2005, and 2007
PROJECTION
UTM Zone 11
DATUM
NAD83
SON-11-10-041-GIS
DATE
November 10, 2010
09-1365-1004
3
GOLD-SAS
MGD
JV
Figure 11.10-19

Wolves may use more than one den site in a season, and several alternate den locations may be present within the summer range. Adult wolves will frequently relocate pups from the natal den to an alternate site (Cluff et al. 2002). When the pups are more mobile, or about two months of age, the adults and pups may travel to a rendezvous or rest area. Many of the den sites found in the RSA may be alternative den locations that have been composed of older functional burrows, or burrows that were partially collapsed. The older den sites are important indicators of potential or alternate den sites because wolves will re-excavate old burrows. Several of these sites showed evidence of long-term use, such as numerous deeper burrows and attempted shallower excavations.

Increased demand for esker material by non-renewable resource interests may create conflict with wolves in the Canada's Central Arctic (Cluff et al. 2002; McLoughlin et al. 2004). However, Mueller (1995) found that esker granular material used at den sites by wolves is smaller than that generally required by industry for mine site development. McLoughlin et al. (2004) recommended that disturbance of esker habitat should be limited to within 2 to 3 km of active wolf dens to avoid den abandonment.

Behaviour and Distribution

At the regional scale, home ranges are established based on food availability (McLoughlin et al. 2004). As predators of migratory caribou, wolves in the Arctic have larger home ranges and less territorial behaviour than other wolves of North America (Walton et al. 2001). According to traditional knowledge, wolves typically have large territories and travel in pairs (NSMA 1999, internet site).

Wolves restrict movements to smaller summer ranges near the den site from parturition in mid-to-late May (when they give birth), until the pups can travel with the adults in September or October (Kuyt 1972; Heard and Williams 1992; Cluff et al. 2002). Male and female wolves differ in their movements in summer, but not during other times of the year. The summer range for females is between 500 and 1,000 km^2, while males will range over 2,000 km^2 (Walton et al. 2001; Cluff et al. 2002). This difference is likely a result of different parental roles. Males allocate more time searching for food, while females remain closer to the den.

When prey are scarce (e.g., when the caribou are at the calving grounds) wolves may occasionally expand their search for food to areas beyond their normal summer range (Cluff et al. 2002). These excursions are typically of short duration and occur frequently in a northern direction presumably in an attempt to intersect the first caribou herds migrating south from the calving grounds. Depending on the area and the time of year, a wolf's diet may also include Arctic hare, fox, Arctic ground squirrel, lemmings and voles, ptarmigan, and water birds and their eggs (ENR 2010b, internet site). Muskoxen, which occur in a patchy distribution in the NWT, are also hunted by wolves when available (Cluff et al. 2002). Prey items identified at natal den sites during baseline studies at the Diavik Diamond Mine included caribou, ptarmigan, geese, small birds, Arctic ground squirrel, Arctic hare (*Lepus arcticus*), and fish (DDMI 1998).

The differences between male and female movements typically ends when the pack leaves the den and travels together, presumably following caribou in the fall and winter (Cluff et al. 2002). Walton et al. (2001) found that annual movements covered ranges over 60,000 km^2. The winter movements of wolves may depend on the distribution of caribou and not on the location of traditional wintering areas. Walton (2000) found that collared wolves would winter in different areas from year-to-year in response to caribou movements. The straight-line distances from the den site of wolves to the most distant winter location averaged 500 km (Walton 2000; Cluff et al. 2002).

The wolf is an opportunistic hunter, primarily targeting weak, young, or old animals. However, wolves are capable of bringing down healthy prey. In northern habitats, caribou are the only ungulate species that occurs at densities sufficient to support wolves (Williams 1990; Walton et al. 2001). Wolves that occupy these regions feed almost exclusively on caribou (Kuyt 1972; Stephenson and James 1982). Caribou were the dominant prey item found in scats collected at natal den sites in tundra habitats (Williams 1990; Banci and Moore 1997). Traditional knowledge describes the wolf as being shy and adaptive, and state that they will generally avoid humans (NSMA 1999, internet site).

Population Characteristics

Grey wolves are distributed over most of the NWT, and populations are considered to be ‘secure’ in the NWT (NWT General Status Ranking Program 2010, internet site). Federally, the grey wolf is ‘not at risk’ (COSEWIC 2009, internet site), and is not listed under SARA (SARA 2009). However, potential risks for the local population may arise from habitat removal and human disturbance (Clarke et al. 1996).

Since 1999, nine active wolf dens were identified in the RSA, some of which were used in consecutive years. Repeated use of den sites is common and many of these sites may be considered traditional dens because of their historical use by wolves (Cluff et al. 2002). Historic natal den sites in the Arctic and sub-Arctic may be used annually or intermittently for hundreds of years (Mech and Packard 1990). Determining den site fidelity is difficult because many wolves may be harvested or perish naturally during their long-distance winter movements (Cluff et al. 2002). Walton et al. (2001) found that a few wolves returned to use the same den as the previous year, while most wolves returned to within 25 km of the same den area. One active den site located in the RSA is believed to be a historic natal den as baseline surveys have documented its continued use in 1999, 2004, and 2005. A total of seven wolf dens were identified in the Snap Lake study area (3,000 km^2) during baseline studies from 1999 to 2004, and the frequency of individual den site re-occupancy ranged from zero to two years from 2000 to 2004 (De Beers 2006).

Traditional and Non-traditional Use

Traditionally, wolves have been harvested for their pelts. The Denesǫłıne people travelled to the barrenlands to harvest wolf, along with other furbearing species, particularly in the area between Fletcher Lake and Walmsley Lake east of Kennady Lake (LKDFN 1999). From 2003 to 2005, there has been a sizeable increase in the percentage of Denesǫłıne adults and youth who are trapping (LKDFN 2005, internet site). According to the review of existing information, the Denesǫłıne primarily harvest wolves for their fur but have also killed them for bounties that the government offered. During the 2006/2007 hunting season, no hides were submitted to ENR from Yellowknife residents, but three were submitted from Łutselk'e (ITT 2008).

Wolves in the NWT are classified as both a big game species and a furbearer. Wolves are managed mostly by controlling the hunting season for resident and non-resident hunters. Residents are allowed to harvest any number of wolves in accordance with the number of tags held. Non-residents must hunt with a licensed outfitter and only in specific areas (ENR 2010a, internet site).

The estimated wolf harvests to Yellowknife hunters increased from 19 in 1991/1992 to a peak of 81 in 1994/1995. From that point, the numbers trended downward to four in 2000/2001. Estimated harvests rose to 31 in 2001/2002 and declined to 14 in 2005/2006 (Carriere 2007 in Berens 2007, internet site). In the North and South Slave region, the estimated harvest levels for wolf went through a cycle that rose from 44 in 1983/1984 to 61 in 1984/1985, and declined to 13 in 1986/1987. From 1991/1992 to 2005/2006, the estimated harvests were lower. Although there were estimated harvests of 14 and 12 for the years 1994/1995 and 1997/1998, respectively, other years reported estimates of seven or less, with several years reporting zero harvests. No data are available for the licence years 1987/1988 to 1990/1991 inclusive (Carriere 2007 in Berens 2007, internet site).

The fur of wolf pelts from the NWT are considered superior quality. The price of individual wolf pelts have varied little over the last decade, with an average price of $215 each. The value of the annual wolf fur harvest has ranged from $10,000 to over $30,000 and is on average worth $22,200 (ENR 2010b, internet site).

11.10.2.3.4 Fox

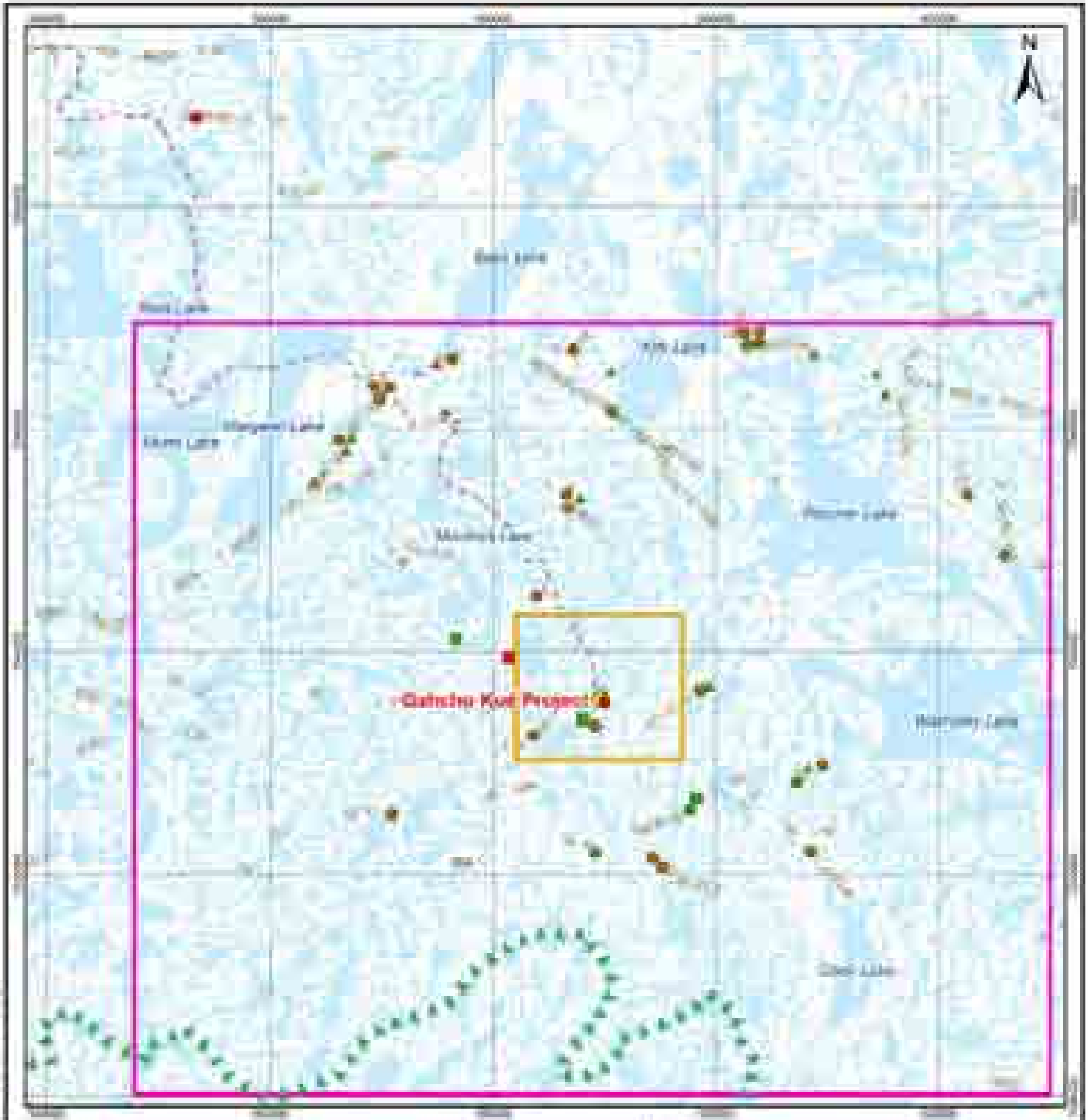
Habitat Use

The Project is within the range of both the Arctic and red fox. The Project is, however, at the southern extent of the Arctic fox range, and no animals were observed during baseline studies. Both the Arctic and red fox occur in a wide range of habitats. Although information regarding general habitat requirements is limited, the physical characteristics of den sites and their surrounding areas have been used to identify critical fox habitat requirements in the Arctic tundra (Prestrud 1992; Smits and Slough 1993; Anthony 1996). The number of natal dens per unit area is believed to be an appropriate and direct index of habitat productivity (Smits and Slough 1993). Habitat quality can also depend on resource availability because foxes are opportunistic predators (Jones and Theberge 1982; Anthony 1997; Elmhagen et al. 2002; Jepsen et al. 2002).

Fox dens are most often found in well-drained upland terrain, which are typically associated with eskers, hummocks, or moraines (Jones and Theberge 1982; Garrott et al. 1983; Smits et al. 1988; Smits and Slough 1993; Anthony 1996). These observations support traditional knowledge, which contends that "you can find fox and ground squirrel holes in eskers" (LKDFN 2001b, internet site). In particular, dens were found near the big eskers, where there were little narrow eskers, which were sand only and no rocks (LKDFN 2001b, internet site).

Between 1999 and 2007, 24 active fox dens were identified in RSA, all of which were established on eskers or other glaciofluvial deposits such as kames. Mean distance of den sites from the Project from 1999 to 2005 was 23.5 km (minimum = 2 km; maximum = 38 km) (Figure 11.10-20). Baseline studies completed for the Snap Lake Mine in 1999 and 2000 recorded eight active fox dens in the study area (3,000 km^2) (De Beers 2002). Den sites ranged from 8 to 30 km from the Snap Lake camp.

Eskers comprise only 1 to 3% of the Arctic tundra ecosystem (Mueller 1995; Cluff et al. 2002). Therefore limited den habitat may influence the distribution and productivity of foxes (Smits and Slough 1993; Anthony 1996). Limiting terrain factors include depth to permafrost and soil type (Garrott et al. 1983; Smits et al. 1988; Anthony 1996). These characteristics are typically limited to localized elevated areas, such as eskers, where permafrost is sufficiently deeper and soil is not too compacted to allow burrowing (Garrott et al. 1983; Prestrud 1992). The ice-free substrate of sand and gravel provides excellent den sites where digging of extensive burrows is relatively easy (Matthews et al. 2001). A south-oriented den entrance is usually selected to favour microclimate conditions (Garrott et al. 1983; Prestrud 1992; Smits and Slough. 1993).



LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Esker
- Treeline

1999
- Active den
- Inactive den
- Fox

2004
- Active den
- Inactive Den
- Fox

2005
- Active den
- Fox

- Local Study Area
- Regional Study Area

NOTES
Base data source: National Topographic Base Data (NTDB) 1:250,000

GAHCHO KUÉ PROJECT

Incidental Observations of Fox and Fox Den Locations in the Regional Study Area 1999, 2004, and 2005

PROJECTION: UTM Zone 12		DATUM: NAD83	DE BEERS
FILE No: SON-11-10-042-GIS			DATE: November 10, 2010
JOB NO: 09-1365-1004		REVISION NO: 3	**Figure 11.10-20**
OFFICE: GOLD-SAS	DRAWN: MGD	CHECK: JV	

Both fox species often select historically favoured den locations and den site fidelity is high (Garrott et al. 1983; Smits and Slough 1993; Anthony 1996; Landa et al. 1998). Some evidence suggests that individual den sites have been used for decades and even centuries (Smits et al. 1988; Anthony 1996; Landa et al. 1998). Long-term use of den sites may alter the composition of vegetation around the dens. The presence of species, such as lush grasses and sedges, may have resulted from fertilizing by prey remains and feces deposition, which in turn may help distinguish older dens from those constructed more recently (Garrott et al. 1983; Smits et al. 1988; Anthony 1996).

New burrows are dug each year, which expands the complexity of the den site (Garrott et al. 1983; Prestrud 1992; ENR 2010b). Fox dens may be of natal and non-natal types (Anthony 1996; Smits and Slough 1993). Natal dens are usually larger (greater than five entrances) and more complex than non-natal dens (Smits and Slough 1993). Reports have shown that natal dens are composed of numerous entrances, with entrances in excess of 40 (Garrott et al. 1983; Smits et al. 1988; Smits and Slough 1993). Non-natal dens are used primarily for resting, feeding, and shelter (Banfield 1974; Smits et al. 1988; Smits and Slough 1993). Natal dens are usually located in eskers or river banks, while dens used for shelter are found in other areas such as rock crevices (Prestrud 1992).

Behaviour and Distribution

Red fox were found to be abundant, and were observed throughout the year. There are two distinct movement periods for both species of fox on the tundra: fall (August to late September) and winter through spring (January to March) (Eberhardt et al. 1982, 1983; Jones and Theberge 1982). The fall movement is related to the dispersal of young from natal dens, while the late winter and spring movement is related to the establishment of a breeding territory. Adult males have been recorded travelling in excess of 2,000 km from their natal home range (Eberhardt et al. 1983; ENR 2010b). Traditional knowledge suggests that Arctic fox migrate in a pattern similar to the caribou and these species' populations are interrelated (LKDFN 1999).

The home range size of a fox will vary, and is usually smaller when prey densities are high because of reduced foraging effort (Anthony 1997). Arctic and red fox have similar home range sizes, generally up to 35 km^2 (ENR 2010b, internet site); however, males of both species may occupy larger ranges up to 49 km^2 (Eberhardt et al. 1982; Jones and Theberge 1982; Anthony 1997; Landa et al. 1998). The only factor that appears to affect the shape of the fox's home range is their breeding status. Solitary animals generally occupy long, narrow territories as they search for prey (Jones and Theberge 1982). Home ranges of breeding individuals appear to be centred on the den site or a series of dens, and are smaller during the denning season compared to the rest of the year (Landa et al. 1998).

The Arctic fox's usual southern limit of distribution is the treeline, although they may venture into the boreal forest when prey densities on the tundra are limited (ENR 2010b, internet site). While the red fox does not penetrate into the high Arctic, Voight (1987) estimated densities of red fox in the tundra at one fox per square kilometre, with higher densities reported throughout the remainder of North America (Elmhagen et al. 2002; ENR 2010b). Interspecific competition between these species will influence distribution, as Arctic fox are less likely to occur where red fox are common (Elmhagen et al. 2002).

Both fox species are non-specific predators and efficient scavengers (Hiruki and Stirling 1989; Jepsen et al. 2002). This strategy results in a wide seasonal and regional variation in diet. Through much of the year microtine species constitute as much as 50% of the diet. The red fox prefers tundra voles (*Microtus oeconomus*), while the Arctic fox prefers collared lemmings (*Dicrostonyx groenlandicus*) (Kennedy 1980; Smits et al. 1989; Elmhagen et al. 2002). Fox are highly dependent on microtine species in both summer and winter, to the extent that fox populations cycle in synchrony with this prey (Smits and Slough 1993; Carriere 1999; Jepsen et al. 2002). In areas of human development, fox may use food wastes as an additional food resource (Eberhardt et al. 1982; BHPB 2007; DDMI 2007; De Beers 2007). Carrion is also important, especially during the winter (Kennedy 1980; Smits et al. 1989; Anthony et al. 2000).

During the summer the fox diet is often more varied. In addition to carrion, the fox may consume invertebrates, small mammals, birds, eggs, and fruits (Smits et al. 1989; Anthony et al. 2000; Elmhagen et al. 2002; ENR 2010b). Traditional knowledge also states that white fox will hunt hare, ptarmigan, mice, lemmings, eggs, insects, and carrion (LKDFN 1999). During this time of abundant supply both species of fox will cache any food surplus (Whitaker 1980; ENR 2010b).

Although less is known about the winter diet of fox in the Arctic tundra, their diet is likely less diverse because many food resources are absent (Smits et al. 1989; Elmhagen et al. 2002). Microtine species make up the majority of prey (Chesemore 1968; Anthony et al. 2000); however, fox species also consume birds, squirrels, hares, and caribou in the winter months (when available) (Chesemore 1968; ENR 2010b). Elders in the LKDFN (1999) describe the Arctic fox as not being a "scared" animal, as "they will go after a caribou carcass as soon as the hunter leaves".

Population Characteristics

The Arctic fox and red fox are the most abundant carnivores in the Arctic tundra; however, there is little information on the ecology and behaviour of these species in the SGP. Both species are considered ‘secure’ in the NWT (NWT General Status Ranking Program 2010, internet site) although no discrete population estimates are available for either species. Neither of the fox species are listed federally (COSEWIC 2009, internet site; SARA 2009).

In the Arctic tundra, the distribution and population dynamics of fox is highly dependent on the spatial distribution and density of their prey (Anthony 1997; Jepsen et al. 2002). Fox populations in northern tundra environments fluctuate in response to the three- to four-year population cycle in microtine species (Hiruki and Stirling 1989; Smits and Slough 1993; Carriere 1999; Jepsen et al. 2002). Traditional knowledge holders stated that the Arctic fox population has declined (LKDFN 1999). Some traditional knowledge holders suggested that the decline of the Arctic fox population was a result of natural fluctuation, while other sources believed poison set to kill wolves was the cause (LKDFN 1999). Elders believed that mining activity was not likely affecting the Arctic fox populations (LKDFN 1999).

Winter track counts were used to provide data on winter activity levels and to detect species presence. Track count surveys completed within the LSA in May, 2004 recorded 114 fox tracks over a total distance of 237 km. Track density was standardized to days since last snowfall, and was calculated to be 0.13 TKD. In March 2005, 68 fox tracks were recorded over 195 km for a density of 0.14 TKD. One red fox was observed. All transects were surveyed in April 2005 and 41 tracks were recorded over 237 km for a density of 0.11 TKD. Because historical survey data in the region are not available, it is not possible to compare these results to other baseline studies.

Traditional and Non-traditional Use

Arctic and red fox are an important furbearer, and an important source of income for the community of Łutselk’e (LKDFN 1999). Fox harvest levels are monitored through pelts turned in to the Government of the Northwest Territories (GNWT) for fur auctions (INAC 2007). During the winter of 2006/2007, there were 21 red fox hides and one cross fox were submitted to ENR from Yellowknife residents, and two silver and one Arctic fox hides from Łutselk’e (ITT 2008), suggesting that the use of this furbearer has declined in recent years. As stated above, only red fox have been observed in the RSA.

Between 1991 and 2003, red fox pelts have averaged $29 per pelt, ranging from $17 to $39 (ENR 2010b, internet site). The number of red fox harvested in the

NWT has ranged from 218 (in 2002/2003) to a high of 1,171 (in 1997/1998). The overall value of this harvest has averaged $15,974 (ranging from $5,668 to $29,914). The average value of Arctic fox pelts was slighter lower than red fox ($27), but more Arctic fox are harvested, ranging from 37 to 2,241 per year (annual average of 795). The annual value of Arctic fox furs was on average $19,000 over the last decade (ranging from to $1,100 to $39,000) (ENR 2010b, internet site).

11.10.2.3.5 Other Carnivores

Black Bear

Black bears are solitary carnivores that inhabit coniferous and deciduous forest, and are often found near swamps and berry patches (ENR 2010b, internet site). Black bears are considered ‘secure’ in the NWT (NWT General Status Ranking Program 2010, internet site), and are not listed federally (COSEWIC 2009, internet site; SARA 2009). No black bears or obvious black bear sign was observed during the baseline studies at the Project, but they are observed within the Snap Lake Mine study area. The black bear population in the Northwest Territories is unknown, but conservatively estimated at 10,000 (ENR 2010b, internet site).

Black bears are omnivorous and eat a wide range of food items. They will eat twigs, leaves, insects, berries, nuts, as well as any animals they can catch such as hare, fish, birds, squirrels, or young moose (Banfield 1974). They are distributed throughout the prairies, mountains, and forested areas of Canada, but are not frequently observed beyond the treeline. Black bears are inactive during the winter, when they den and enter a dormant state, approximately from October to April (Banfield 1974).

Black bears are classified as both a big game species and furbearer in the NWT. Black bears are managed mostly by controlling the hunting season for resident and non-resident hunters. All sport hunters are limited to one adult bear per year that is not accompanied by a cub. General Hunting Licence holders (including all natives, most Métis, and a few long-time non-native residents) may hunt during any season. Non-resident hunters must hunt with a licensed outfitter. On average, non-residents purchase 11 tags each year. At an average cost of about $2,300 Canadian per hunt, the black bear trophy harvest is worth about $24,000 per year to the NWT.

Fewer than 200 black bears are estimated to be harvested in the NWT annually. Although there are no exact figures for the subsistence harvest, fewer than 100 bears are thought to be taken by subsistence harvesters each year. Many bears are also killed every year when they become problems in camps, towns or around food caches. It is estimated that about 30 bears are destroyed annually in defence of human life or property across the western NWT.

The estimated black bear harvest by Yellowknife hunters has fluctuated annually. Generally, estimated harvest levels show around 10 or fewer bears, although harvest estimates rose above 20 for the 1989/1990, 1990/1991 seasons and for the 1993/1994 to 1996/1997 seasons inclusive. The estimated harvest for 2005/2006 was 19 (Carriere 2007 in Berens 2007, internet site). In the North and South Slave regions, the estimated harvest levels for black bear between 1983/1984 and 1994/1995 varied between a high of 16 and a low of four (with zero harvest estimated for 1992/1993). From 1995/1996 in which there was an estimated harvest of nine, to the current year, harvest levels were five or less (Carriere 2007 in Berens 2007, internet site). Only one black bear pelt was submitted to ENR during the 2006/2007 hunting season from Łutselk'e, and none from Yellowknife (ITT 2008), suggesting the black bear is not an important furbearer, or at least is generally only used domestically.

Marten

Marten are considered 'secure' in the NWT (NWT General Status Ranking Program 2010, internet site), are not listed federally (COSEWIC 2009, internet site; SARA 2009). The marten is a forest-dwelling weasel, and is common throughout the forested areas of the NWT (Banfield 1974). Although there are occasional patches of forest in the RSA, most of the habitat is typically tundra. There was one incidental observation of marten during baseline studies.

Although wide-ranging, marten select features that are associated with mature forests (such as wide-diameter snags, Porter et al. 2005) and display a degree of selection against burn areas (Latour et al. 1994). They are present throughout the northern boreal forests of Canada (Banfield 1974).

Marten prey on a range of animals, including red squirrel, snowshoe hair, voles, birds, and insects, but are not dependent upon a particular species. Their diet can fluctuate widely with changes in prey densities (Banfield 1974). Marten harvest totals in Canada are synchronized with those of snowshoe hares (Bulmer 1975), although one study in the NWT found marten to prefer voles (Douglass et al. 1983).

For trappers in the boreal Taiga Shield ecozone, marten are economically the most important fur-bearing species in the NWT (Latour et al. 1994). During the winter of 2006/2007, there were 308 marten hides submitted to ENR from Yellowknife residents, and a further 275 from Łutselk'e (ITT 2008), indicating that this species is important to traditional economies.

Harvest levels are affected by natural population cycles and the market value of the pelts. The harvest season for marten in the NWT is November 1 to early or mid-March, varying slightly by region. Prime pelts are harvested between November and mid-January when the marten's fur is at its highest quality. The darkest fur is most popular and most valuable. By late February or March the fur is past prime (ENR 2010b, internet site).

Between 1992 and 2004, there were an average of 8,086 marten pelts submitted to ENR, ranging from a high in 1994/1995 of 11,584 to a low in 1993/1994 of 4,703 pelts (ENR 2010b, internet site). The average price per pelt over this time was $53, ranging from $40 to $64. The overall annual value of the marten harvest ranged from approximately $250,000 to over $600,000, and on average is worth $434,000 (ENR 2010b, internet site). During the winter of 2006/2007, there were 46 marten hides submitted to ENR from Yellowknife residents, but only two from Łutselk'e (ITT 2008).

Ermine

Ermine are considered 'secure' in the NWT (NWT General Status Ranking Program 2010, internet site), and are not listed federally (COSEWIC 2009, internet site; SARA 2009). Ermine occupy a wide range of habitats, and are distributed throughout Canada (Banfield 1974). They are found in mixed forest or climax conifer forests, as well as riparian, tundra, and alpine areas. The ermine is a small weasel, measuring up to 300 millimetres (mm) long. One individual was observed during the baseline studies at the Project.

Ermine populations are linked to those of mice and voles, their main prey. Ermine will also prey upon hare, porcupine, birds, squirrels, and fish. Ermine are in turn hunted by larger animals such as fox, hawks, and owls. Their population size in the NWT is unknown (ENR 2010b, internet site).

River Otter

River otter are considered 'secure' in the NWT (NWT General Status Ranking Program 2010, internet site), and are not listed federally (COSEWIC 2009, internet site; SARA 2009). The river otter is an amphibious weasel, usually found in fish-bearing river systems. Close to the treeline, they are typically only associated in winter with rapids or falls where there is year-round open water. Although no otter have been observed in the RSA, otter slides have been observed in snow near river rapids within the Snap Lake and Project study areas.

Otter are social and intelligent animals. They are agile swimmers, and on snow they will move with a series of bounds followed by a belly-slide. Otter slides are frequently seen near open water in the winter. Their food is predominantly fish caught underwater, but they will also search along the bottom for invertebrates. They have also been known to consume amphibians and other mammals such as muskrat, beaver, and voles (Banfield 1974). Their population within the NWT is unknown (ENR 2010b, internet site). During the winter of 2006/2007, no otter hides were submitted to ENR from either Yellowknife or Łutselk'e (ITT 2008).

Lynx

Lynx are considered 'secure' in the NWT (NWT General Status Ranking Program 2010, internet site), and are considered "not at risk" by COSEWIC (2009, internet site). Lynx are a medium-sized cat, found in the boreal forest. No lynx were observed in the RSA during baseline studies. Lynx or lynx sign also have not been observed in the adjacent Snap Lake study area.

Lynx are solitary hunters that select dense climax coniferous forests, although they have been known to venture to the tundra when food is scarce (Banfield 1974). Their main source of food is the snowshoe hare. Lynx are also known to eat ptarmigan and other birds, voles, fox and carrion. Their population in the NWT is roughly estimated to cycle between 8,000 and 90,000 individuals (ENR 2010b, internet site). Lynx harvest levels are monitored through pelts turned into the GNWT for fur auctions (INAC 2007). During the winter of 2006/2007, 26 lynx hides were submitted to ENR from Yellowknife residents, but only one from Łutselk'e (ITT 2008).

The lynx harvest is important to NWT fur harvesters located below the treeline. Lynx are harvested from November 1 to March 15 in the NWT, with their fur becoming prime in late November and at its highest quality during December and January (ENR 2010b, internet site). Trappers focus their efforts during this prime time to acquire top-quality pelts for sale at auction.

The value of lynx pelts fluctuates because fashion trends and the number of pelts available affect the fur industry. With changing supply and demand, highest prices for pelts often correspond with the low in the lynx cycle. The price of a lynx pelt has varied from $66 to $175 and was on average $98. An average of 817 lynx are harvested annually in the NWT, and the average revenue from furs is approximately $75,000 (ENR 2010b, internet site).

11.10.2.4 Mine-related Carnivore Incidents and Mortality

Since 1996, carnivore incidents and mortalities have occurred at the Diavik, Ekati, Jericho, and Snap Lake mines (Table 11.10-4). Incidents include all occasions when there was an interaction between the mine and the carnivore, and some action was required (e.g., deterrent, re-location, or report of damage). Here, an incident does not include mortality. The cause of wildlife mortality is clear for cases where problem wildlife are deliberately destroyed, or when an accidental event was witnessed (such as the wolf pup that was struck by a vehicle at Ekati in 2002). However in other cases, such as when an animal is found dead within the mine property with no physical injury, the cause of death (natural or mine-related) may not be known.

Table 11.10-4 Carnivore Incidents and Mortality at the Ekati, Diavik, Jericho, and Snap Lake Diamond Mines, 1996 to 2009

Site	Year	Phase	Species	Incidents[a]	Mortalities		
					Intentional[b]	Non-intentional[c]	Found Dead[d]
Diavik	1996 - 1999	exploration	wolverine	1	1	-	-
	2000	construction	-	-	-	-	-
	2001	construction	wolverine	2			1
	2001	construction	grizzly bear	3	-	-	-
	2002	construction	-	-	-	-	-
	2003	production	grizzly bear	1	-	-	-
	2004	production	grizzly bear	20	1	-	-
	2005	production	grizzly bear	43	-	-	-
	2005	production	wolverine	5	-	-	-
	2006	production	grizzly bear	21	-	-	-
	2006	production	wolverine	2	-	-	-
	2007	production	grizzly bear	20	-	-	-
	2007	production	wolverine	1	-	-	-
	2008	production	-	-	-	-	-
	2009	production	-	-	-	-	-
Ekati	1998-2001	construction-production	wolverine	3	2	-	
	2000	production	grizzly bear	-	1	-	-
	2001	production	fox	-	9	-	-
	2001	production	wolverine	7	2	-	-
	2002	production	wolf	-	-	1	-
	2002	production	fox	-	1	1	-
	2003	production	grizzly bear	5	-	-	-
	2004	production	wolf	4	-	-	-
	2004	production	wolverine	3	-	-	-
	2004	production	grizzly bear	3	-	-	-
	2005	production	fox	6	-	1	-
	2005	production	grizzly bear	18	2	-	-
	2005	production	wolverine	23	1	-	1

Table 11.10-4 Carnivore Incidents and Mortality at the Ekati, Diavik, Jericho, and Snap Lake Diamond Mines, 1996 to 2009 (continued)

Site	Year	Phase	Species	Incidents[a]	Mortalities		
					Intentional[b]	Non-intentional[c]	Found Dead[d]
	2005	production	wolf	5	-	-	-
	2006	production	grizzly bear	15	-	-	-
	2006	production	wolf	4	-	-	1
	2006	production	fox	13	-	-	-
	2007	production	fox	-	6	-	2
	2008	production	wolf	5	1	-	-
	2008	production	fox	2	-	-	4
	2008	production	grizzly bear	15	-	-	-
	2008	production	wolverine	4	-	-	-
	2009	production	wolf	1	-	-	-
	2009	production	fox	11	-	1	1
	2009	production	grizzly bear	19	-	-	-
Jericho	2000 - 2004	exploration	-	-	-	-	-
	2005	construction	wolverine	-	1	-	-
	2006	production	-	-	-	-	-
	2007	production	wolverine	1	-	1	-
Snap Lake	1999 - 2003	exploration	-	-	-	-	-
	2004	exploration	fox	1	-	-	-
	2005	construction	fox	1	-	-	-
	2005	construction	grizzly bear	1	-	-	-
	2006	construction	wolverine	2	-	-	-
	2006	construction	fox	41	-	-	-
	2007	construction	fox	36	-	-	-
	2007	construction	black bear	2	-	-	-
	2008	production	-	-	-	-	-
	2009	production	wolverine	-	-	1	-
	2009	production	fox	-	-	-	1

Sources: BHPB 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010; De Beers 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010; DDMI 1998, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010; Golder 2008a; Tahera 2000, 2006, 2007a, 2007b, 2008).

(a) Each occasion where animals are deterred, relocated, or a damage report was filed. General observations and mortalities are not included. The number of different individuals involved may not be known.

(b) Animal intentionally destroyed by mine or government personnel.

(c) Accidental mine-related mortality (e.g., vehicle collision).

(d) Animal found dead, mortality could not be directly linked to mine activities.

- = no incident or mortality

Some of the carnivore incidents and mortalities have been directly associated with waste management. One source of attraction that has been problematic for wildlife is the feeding of wildlife by mine staff, which has occurred deliberately and accidentally. For example, at the Ekati mine in 1997, lunch bags were found at a local fox den on several occasions, and staff reported seeing fox travelling with food scraps. In 1999, a fox became habituated to staff at the Ekati truck shop, presumably due to availability of food scraps. The fox was live-captured and relocated. The most effective means of managing the negative interaction between carnivores and projects is through continuing education of mine staff, and providing garbage cans labelled for food waste in areas where people eat.

Carnivore Incidents

Three hundred and seventy incidents have been recorded at the Ekati, Diavik, Jericho, and Snap Lake mines from 1998 through 2009. Although the definition of a wildlife incident varies, this statistic generally includes all occasions where there was some kind of direct interaction between an animal and the mine. Examples include the use of deterrents, wildlife gaining access to areas where they present a risk to themselves or to humans and are re-located, or causing damage to property. There were 45 total recorded mortalities on all 4 mine sites from 1998 to 2009.

Less than 5% of the incidents reported at mine sites involved wolves. Most of the recorded incidents have involved grizzly bears, probably because the presence of a bear is considered more of a threat than other carnivore species. The predominance of grizzly bear incidents at Diavik is likely due to the location of the mine on an island, which makes deterring animals away from the mine particularly difficult. There have also been relatively high numbers of grizzly bear and wolverine incidents at Ekati, and fox incidents at Snap Lake. In some cases, the frequency of incidents appears cyclic (i.e., periods associated with a high number of incidents interspersed with years with fewer incidents). This may be indicative of cycles in populations of the carnivores or their prey. Associated with the 370 incidents recorded, there have been 34 confirmed mine-related mortalities of various causes, suggesting a ratio of one mine-related mortality for every 11 recorded incidents.

Carnivores Intentionally Destroyed

Wildlife species that have been intentionally destroyed at existing diamond mines primarily include wolverine, grizzly bear, and fox (Table 11.10-4). Of the 28 individuals destroyed, four were grizzly bear, seven were wolverine, 16 were fox, and one was a wolf. Grizzly bear kills included one cub of unknown sex in 2000, a 3-year-old male and 13-year old male in 2005 at Ekati, and an adult male at Diavik in 2004. Ninety percent of the foxes were destroyed in 2001 at Ekati. All of these removals occurred with the permission of ENR, usually following an extended period of habituation to the site and multiple deterrent attempts with the same individual animal. No wildlife has been intentionally destroyed at the Snap Lake Diamond Mine from 1999 through 2009 (exploration through current operation).

Carnivores Accidentally Destroyed

All six occasions where wildlife was accidentally destroyed at a project, and where the cause of death was clearly attributable to the mine, were a result of vehicle collisions. Three fox and one juvenile wolf were killed by vehicles at the Ekati Diamond Mine. On October 9, 2002 a wolf pup carcass was found on the Misery road, 5 m from the shoulder. Fog and blowing snow resulted in poor visibility at the time. A necropsy revealed that cause of death was due to a blow to the back of the head, which broke the skull. A red fox mortality was reported in 2002 due to a vehicle collision on the Misery road. A fox pup and adult mortality occurred at Ekati in 2005 and in 2009, respectively, which was due to a vehicle collision. A wolverine was accidentally hit by a vehicle at Jericho in 2005. A wolverine was accidentally hit by a vehicle at Snap Lake in 2009.

Carnivores Found Dead

There have been 11 carnivores (two wolverine, one wolf and eight fox) found dead among the four mines (Table 11.10-4). This category includes wildlife found dead, and for which the cause of death could not be directly linked to mine activities. For example, a wolf apparently died from starvation at Ekati in 2006. The carcass was found underneath a building at Misery Camp. A wolverine was found dead at Ekati in 2005, and the cause of death was not determined. One fox was found dead at each of the Snap Lake and Ekati sites during 2009.

11.10.3 Pathway Analysis

11.10.3.1 Methods

Pathway analysis identifies and assesses the issues and linkages between the Project components or activities, and the correspondent potential residual effects on carnivores. Pathway analysis is a three-step process for determining linkages between Project activities and environmental effects that are assessed in Sections 11.10.4 to 11.10.8. Potential pathways through which the Project could influence carnivores were identified from a number of sources including:

- the Terms of Reference (Gahcho Kué Panel 2007) and the Report of Environmental Assessment (MVEIRB 2006);
- a review of the Project Description and scoping of potential effects by the environmental assessment and Project engineering teams for the Project; and
- consideration of potential effects identified for the other diamond mines in the NWT and Nunavut.

The first part of the analysis is to produce a list of all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on carnivores. This step is followed by the development of environmental design features and mitigation that can be incorporated into the Project to remove the pathway or limit (mitigate) the effects to carnivores. Environmental design features include Project designs and environmental best practices, and management policies and procedures. Environmental design features were developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects. Proposed mitigation will be used to reduce effects after the disturbance or problem has occurred (e.g., spill response and cleanup plan, stopping traffic while animals are on Project roads).

Knowledge of the ecological system and environmental design features and mitigation is then applied to each of the pathways to determine the expected amount of Project-related changes to the environment and the associated residual effects (i.e., after mitigation) on carnivores. For an effect to occur there has to be a source (Project component or activity), a change in the environment, and a correspondent effect on carnivores.

Project activity → change in environment → effect on VC

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment, and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on carnivores. Pathways are determined to be primary, secondary (minor), or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and, therefore, no residual effects to a VC relative to baseline or guideline values;
- secondary - pathway could result in a measurable and minor environmental change, but would have a negligible residual effect on a VC relative to baseline or guideline values; or
- primary - pathway is likely to result in a measurable environmental change that could contribute to residual effects on a VC relative to baseline or guideline values.

Primary pathways require further effects analysis and impact classification to determine the environmental significance from the Project on the persistence of carnivore populations, and continued opportunity for traditional and non-traditional use of carnivores. Pathways with no linkage to carnivore populations or that are considered minor are not analyzed further or classified in Sections 11.10.4 to 11.10.8 because environmental design features and mitigation will remove the pathway (no linkage) or residual effects can be determined to be negligible through a simple qualitative evaluation of the pathway (secondary). Pathways determined to have no linkage to carnivores or those that are considered secondary are not predicted to result in environmentally significant effects on the persistence of carnivore populations and continued opportunity for traditional and non-traditional use of carnivores. Primary pathways are assessed in more detail in Sections 11.10.4 to 11.10.8.

11.10.3.2 Results

Pathways potentially leading to effects on carnivores include direct and indirect changes to habitat, and survival and reproduction (Table 11.10-5). These changes may ultimately affect the persistence of carnivore populations, and continued opportunity for traditional and non-traditional use of carnivores. Evaluation of effects on carnivores also considers changes to hydrology, water quality, air quality, soil quality, and vegetation during the construction, operation, and closure of the Project, as well as effects remaining after closure.

Because potential pathways are based primarily on public concerns identified during the Mackenzie Valley Environmental Impact Review Board (MVEIRB) scoping process (MVEIRB 2006). Many environmental design features were incorporated during the development of the Project to address these issues by reducing or eliminating potential effects. Also, preliminary analysis may have shown that potential effects considered during issue scoping are so small that they are not relevant. Other potential pathways are considered to be primary and are included in the effects analysis. The following sections discuss the potential pathways relevant to carnivores.

Table 11.10-5 Potential Pathways for Effects to Carnivores

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Project Footprint (e.g., pits, Fine PKC Facility, Coarse PK Pile, mine rock piles, Winter Access Road and Tibbitt-to-Contwoyto Winter Road)	• direct loss and fragmentation of wildlife habitat from the physical footprint of the Project may alter carnivore movement and behaviour	• backfilling the mined-out pits with PK and mine rock will decrease the on-land Project footprint • compact layout of the surface facilities will limit the area disturbed at construction and increase site operations efficiency	Primary
	• physical hazards from the Project may increase the risk of injury/mortality to individual animals, which can affect carnivore population sizes	• mine rock will be used as the source of aggregate production, thereby , reducing the need for separate quarries • blasting in pits will be carefully planned and controlled to maintain a safe workplace and reduce the throw of ore bearing materials • where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms • to the extent practical, the total amount of area disturbed by Project activities at any one time will be reduced through the use of progressive reclamation • ramps to facilitate the access and egress of carnivores from the mine rock pile will be constructed during closure • culverts or stream-crossing structures will be removed and natural drainage re-established • at closure, transportation corridors and the airstrip will be scarified and loosened to encourage natural revegetation, and re-contoured where required • at closure, the entire site area will be stabilized and contoured to blend with the surrounding landscape • conditions will be monitored over time to evaluate the success of the Closure and Reclamation Plan and, using adaptive management and newer proven methods as available, adjust the Plan, if necessary • De Beers will actively liaise with other mine operators in the Canadian Arctic to understand the challenges and successes they have encountered with respect to reclamation	Secondary

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

<table>
<tr><th>Project Component/Activity</th><th>Effects Pathways</th><th>Environmental Design Features and Mitigation</th><th>Pathway Assessment</th></tr>
<tr><td rowspan="2">Construction and Operations
(e.g., equipment operation, aircraft/vehicles, airstrip, processing and storage facilities)
Winter Access Road and Tibbitt-to-Contwoyto Winter Road (continued)</td><td>• dust deposition may cover vegetation and decrease abundance of forage for prey species and carnivores (i.e., habitat quantity)</td><td rowspan="4">• a program of carbon and energy management will be implemented once the generators are commissioned
• generator efficiencies and equipment will be tuned for optimum fuel-energy efficiency
• load management will allow for the optimization of the load factors on the generators
• pumping circuits will be operated and efficiencies will be optimized to minimize noise disturbances
• power and heat use to reduce energy use, and therefore air emissions, will be reviewed on a regular basis
• piping will be insulated for heat conservation
• personnel arriving at or leaving the site will be transported by bus, therefore, reducing the amount of traffic between the airstrip and the accommodation complex
• compact layout of the surface facilities will reduce traffic, and therefore dust and air emissions, around the site
• watering of roads, airstrip, and laydown areas will facilitate dust suppression
• enforcing speed limits will assist in reducing production of dust</td><td>Secondary</td></tr>
<tr><td>• dust deposition may cover vegetation and change the amount of different quality habitats for prey species, and alter carnivore movement and behaviour</td><td>Primary</td></tr>
<tr><td></td><td>• dust deposition and air emissions may change the amount of different quality habitats for prey species (through chemical changes in soil and vegetation), and alter carnivore movement and behaviour</td><td>Secondary</td></tr>
<tr><td></td><td>• ingestion of soil, vegetation, and water, or inhalation of air that has been chemically altered by air emissions (including NO_X and PAI deposition) or dust deposition, may affect carnivore survival and reproduction</td><td>No Linkage</td></tr>
<tr><td></td><td>• sensory disturbance (e.g., presence of buildings, people, lights, smells, and noise) changes the amount of different quality habitats, and alters carnivore movement and behaviour, which can influence survival and reproduction</td><td>• compact layout of the surface facilities will limit the area disturbed at construction and reduce traffic around the site
• a minimum flying altitude of 300 m above ground level (except during takeoff, landing, and field work) will be maintained for cargo, passenger aircraft, and helicopter outside of the Project site
• limit the amount of noise from the Project site to the extent practical
• equipment noise sources will be limited by locating them inside buildings, to the extent possible</td><td>Primary</td></tr>
</table>

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and Operations (continued) Winter Access Road and Tibbitt-to-Contwoyto Winter Road (continued)	• sensory disturbance (e.g., presence of buildings, people, lights, smells, aircraft, and on-site vehicles) changes the amount of different quality habitats, and alters carnivore movement and behaviour, which can influence survival and reproduction (continued)	• downward directional and low impact lighting will be used to reduce light pollution • a minimum 200-m distance from wildlife will be maintained, when possible • environmental sensitivity training for personnel • at closure, the entire site area will be stabilized and contoured to blend with the surrounding landscape	Primary
	• aircraft/vehicle collisions may cause injury/mortality to individual animals	• personnel arriving at or leaving the site will be transported by bus, which will decrease the amount of traffic between the airstrip and the accommodations complex • speed limits will be established and enforced • wildlife will be provided with the “right of way” • levels of private traffic using the Project Winter Access Road will be monitored • the site will be designed to limit blind spots, where possible, to reduce the risk of accidental wildlife-human encounters • drivers will be warned when wildlife are moving through an area using signage and radio	Secondary
	• chemical spills (including de-icing fluid run off) may cause negative changes to health or mortality of individual animals	• processing of the kimberlite ore will be mechanical, with limited use of chemicals • hazardous, non-combustible waste and contaminated materials will be temporarily stored in the waste storage transfer area in sealed steel or plastic, wildlife-resistant drums, and shipped off-site for disposal or recycling • chemicals such as de-icing fluid, acids, solvents, battery acids, and laboratory agents will be collected in lined trays and drums, and stored in suitable sealed containers in the waste transfer area • the waste transfer storage area will include a lined and enclosed pad for the collection and subsequent return of hazardous waste to suppliers or to a hazardous waste disposal facility • emulsion materials will be stored at the emulsion plant where spills would be 100% contained within the building	No Linkage

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and Operations (continued) Winter Access Road and Tibbitt-to-Contwoyto Winter Road (continued)	• chemical spills (including de-icing fluid run off) may cause negative changes to health or mortality of individual animals (continued)	• all fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard and placed in a lined and dyked containment area to contain any potential fuel spills • aviation fuel will be stored in self-contained, Underwriters Laboratories Canada-rated envirotanks mounted on an elevated pad at the air terminal shelter • aviation fuel for helicopters will be stored in sealed drums inside a lined berm area near the airstrip • to prevent accumulation and/or runoff of de-icing fluids at the airstrip from aircraft de-icing operations, aircraft will be sprayed in a specific area that will be equipped with swales to collect excess fluids if necessary • puddles of de-icing fluids in the swales will be removed by vacuum truck and deposited into waste de-icing fluid drums for shipment to recycling facilities if necessary • an Emergency Response and Contingency Plan has been developed • spill containment supplies will be in designated areas • any spills will be isolated and immediately cleaned up by a trained spill response team consisting of on-site personnel who will be available at all times	No Linkage
Construction and Operations (e.g., equipment operation, aircraft/vehicles, airstrip, processing and storage facilities)	• attractants to site (e.g., food waste, oil products) may increase the risk of mortality to individual animals and affect carnivore population sizes	• separate bins will be located throughout the accommodations complex, processing plant, shops, and other facilities on-site for immediate sorting of domestic wastes • food wastes will be collected from the food waste bins in the accommodations complex, service complex, and other facilities and immediately placed and sealed in plastic bags; the plastic bags will be stored in sealed containers at each facility before transport directly to the incinerator storage area for incineration • chemicals such as de-icing fluid, acids, solvents, battery acids, and laboratory agents will be collected in lined trays and drums and stored in suitable sealed containers in the waste transfer area; chemicals that cannot be incinerated will be shipped off-site for disposal or recycling • incinerator ash from combustion of kitchen and office waste will go to the landfill • inert solid waste will be deposited into a small area of the mine rock piles or Fine PKC Facility • care will be taken to prevent the inclusion of wastes that could attract wildlife	Primary (grizzly bear and wolverine) Secondary (wolf)

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Construction and Operations (e.g., equipment operation, aircraft/vehicles, airstrip, processing and storage facilities) (continued)	• attractants to site (e.g., food waste, oil products) may increase the risk of mortality to individual animals and affect carnivore population sizes (continued)	• two dual-chambered, diesel-fired incinerators will be provided for the incineration of combustible waste, including kitchen waste; the incinerators will also be used to burn waste oil; Incinerator ash will be collected in sealed, wildlife-resistant containers and transported to the landfill • a fenced area will be established for the handling and temporary storage of wastes; fencing will be 2 m high, slatted-type, and partially buried to prevent animals from burrowing underneath • education and reinforcement of proper waste management practices will be required for all workers and visitors to the site • the efficiency of the waste management program and improvement through adaptive management will be reviewed as needed	Primary (grizzly bear and wolverine) Secondary (wolf)
Mine Rock Management	• leaching of PAG mine rock may change the amount of different quality habitats, and alter carnivore movement and behaviour	• mine rock used to construct the dykes will be non-acid generating (NAG) • any mine rock containing kimberlite will be separated from the tundra by at least 2 m of inert and kimberlite-free rock to prevent drainage with low pH • any PAG mine rock, as well as any barren kimberlite, will be sequestered within the interior of the mine rock piles in areas that will allow permafrost to develop or will be underwater when Kennady Lake is refilled • till from ongoing pit stripping will be used to cover PAG rock placed within the interior of the structure to keep water from penetrating into the portion of the repository • the PAG rock will be enclosed within enough NAG rock that the active frost zone (typically two metres) will not extend into the enclosed material and water runoff will occur on the NAG rock cover areas • to confirm the lower levels remain frozen, temperature monitoring systems will be placed in the mine rock piles as they are being constructed • minimal water is expected to penetrate to the PAG rock areas • only non-reactive mine rock will be placed on the upper and outer surfaces of the mine rock piles; the thickness of the cover layer is predicted to be sufficient so that the active freeze-thaw layer remains within the non-reactive mine rock • thermistors will be installed within the mine rock piles to monitor the progression of permafrost development; the upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are expected to remain permanently frozen • mine rock piles will not be covered or vegetated to limit attraction of wildlife to them after Project closure	No Linkage
	• ingestion of soil, vegetation, or water that has been chemically altered by leaching of PAG mine rock may affect carnivore survival and reproduction		No Linkage

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Site Water Management	• release of seepage and surface water runoff (including erosion) from the Fine PKC Facility, Coarse PK and mine rock piles may change the amount of different quality habitats, and alter carnivore movement and behaviour	• the performance of the dykes will be monitored throughout their construction and operating life; instrumentation monitoring together with systematic visual inspection will provide early warning of many conditions that can contribute to dyke failures and incidents. Additional mitigation will be applied, if required • a system of ditches and sumps will be constructed, maintained, and upgraded throughout the operation phase of the Project to manage groundwater from the open pits • site runoff will flow naturally to the dewatered areas of Kennady Lake that will act as a control basin for storage of water; within this basin, water flows can be managed where practical, natural drainage patterns will be used to reduce the use of ditches or diversion berms • no substantial runoff and seepage from the mine rock piles is expected • a soil-bentonite slurry cutoff wall through a till fill zone placed over the overburden and the overburden to the bedrock surface has been adopted as the main seepage control for the diversion dyke separating Areas 7 and 8 • the cut-off wall for the dyke separating Areas 7 and 8 will be protected by a downstream filter zone and mine rock shell zone • for the retention dyke that separates Areas 3 and 4, Areas 5 and 6, and Areas 4 and 6, a wide till core has been selected as the main seepage control • the water retention dyke separating Area 2 and Lake N7, as well as diversion dykes dealing with Lakes A3, A4, B1, N13, D2, E1, and E3 will have a liner keyed into the competent frozen ground or bedrock to control seepage • the curved filter dyke to retain the particles in the fine PK placed in Areas 1 and 2 will be construction material and will be free of roots, organics, and other materials not suitable for construction	No Linkage
	• ingestion of seepage and surface water runoff from the Coarse PK and mine rock piles, or ingestion of soil, vegetation, or water that has been chemically altered by seepage and runoff, may affect carnivore survival and reproduction		No Linkage
Site Water Management (continued)	• ingestion of seepage and surface water runoff from the Coarse PK and mine rock piles, or ingestion of soil, vegetation, or water that has been chemically altered by seepage and runoff, may affect carnivore survival and reproduction (continued)	• the PAG rock will be enclosed within enough NAG rock to prevent the active zone (typically 2 m) from extending into the enclosed material and water runoff will occur on the NAG rock cover areas • thermistors will be installed within the mine rock piles to monitor the progression of permafrost development; the upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are expected to remain permanently frozen • only non-reactive mine rock will be placed on the upper and outer surfaces of the mine rock pile; the thickness of the cover layer is predicted to be sufficient so that the active freeze-thaw layer remains within the non-reactive mine rock	No Linkage
	• release of seepage and surface water runoff (including erosion) from the Coarse PK and mine rock piles may change the amount of different quality habitats, and alter carnivore movement and behaviour (continued)		No Linkage

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Winter Access Road and Tibbitt-to-Contwoyto Winter Road	• road footprint decreases habitat quantity and may cause fragmentation, which can alter carnivore movement and behaviour	• low profile roads will be used so that they do not act as a barrier to movement for wildlife • winter road snow berms will be removed so that they do not act as a barrier to movement for wildlife	Primary
	• road footprint may cause changes to the amount of different quality habitats (e.g., degradation to vegetation), and alter carnivore movement and behaviour	• use of proven best practices for winter road construction	Secondary
	• increased access for traditional and non-traditional harvesting may alter carnivore movement and behaviour, which can affect survival and reproduction	• seasonal use of Winter Access Road • prohibit firearms of any type, bows, and crossbows at the Project • prohibit hunting, trapping, harvesting, and fishing by employees and contractors and enforce this prohibition	Secondary
Dewatering of Kennady Lake	• ingestion of exposed sediments and riparian/aquatic vegetation in the dewatered lakebed of Kennady Lake may affect carnivore survival and reproduction	• none	No Linkage
	• injury or mortality to individual animals getting trapped in sediments		Secondary
	• changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering of Kennady Lake may affect the quantity of riparian habitat, which could alter carnivore movement and behaviour	• Lake N11 is capable of accepting water at the proposed discharge rate without erosion damage to downstream watercourses	Secondary
	• dewatering may result in newly established vegetation on the exposed lakebed sediments and increase habitat quantity, which may alter carnivore movement and behaviour	• dykes will be constructed to divert fresh water from entering areas of Kennady Lake • the height of the diversion structures will be designed such that the excess water from the surrounding sub-watershed will remain in the original	Secondary

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Dewatering of Kennady Lake (continued)	• changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering Kennady Lake may cause injury/mortality to individual animals	N watershed • dewatering and operation discharges will be limited so that pumping will not increase discharges above the baseline two-year flood levels in downstream lakes and channels	No Linkage
	• changes in the timing of freeze and break-up downstream may alter carnivore movement and behaviour, and could cause injury/mortality to individual animals		No Linkage
Closure and Reclamation	• changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from the refilling of Kennady Lake may affect the quantity of riparian habitat, which could alter carnivore movement and behaviour	• mined-out pits will be backfilled with PK and mine rock to reduce the time required for filling these portions of Kennady Lake because less water is required to refill the partially backfilled pits • Kennady Lake will be refilled using natural runoff and supplemental water drawn from Lake N11 • while fine PK is being discharged in the mined-out pits (primarily Hearne, but potentially 5034) process water will not be reclaimed from the pits; instead the slurry discharge water will be used to accelerate the infill of the mined-out pits; the process will facilitate a more rapid re-filling and progressive reclamation of Area 6 within Kennady Lake • the 5034 Pit will be backfilled to the extent possible with mine rock and the remaining space will be eventually filled with water once mining in the Tuzo Pit is complete • the Tuzo Pit will be allowed to flood following the completion of the operations phase; natural watershed inflows will be supplemented by pumping water from Lake N11 • the pumping rates are anticipated to be managed such that the total outflow from Lake N11 does not drop below the 1 in 5-year dry conditions	Secondary

Table 11.10-5 Potential Pathways for Effects to Carnivores (continued)

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Assessment
Closure and Reclamation (continued)	• long-term seepage from the Coarse PK Pile and mine rock piles may cause local changes to habitat quality, and alter carnivore movement and behaviour	• the PAG rock will be enclosed within enough non-AG rock to prevent the active zone (typically 2 m) from extending into the enclosed material and water runoff will occur on the NAG rock cover areas • thermistors will be installed within the mine rock piles to monitor the progression of permafrost development The upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the PK and PAG rock sequestered below are expected to remain permanently frozen • the Coarse PK Pile will be shaped and covered with a layer of mine rock of a minimum 1 m to limit surface erosion • only non-reactive mine rock will be placed on the upper and outer surfaces of the mine rock piles; the thickness of the cover layer is predicted to be sufficient so that the active freeze-thaw layer remains within the non-reactive mine rock • no substantial runoff and seepage from the mine rock piles is expected	No Linkage

CCME = Canadian Council of Ministers of the Environment; m = metre; NAG = non-acid generating; NO_X = nitrogen oxide; PK = processed kimberlite; PKC = processed kimberlite containment; PAG = potentially acid generating; PAI = potential acid input.

11.10.3.2.1 Pathways with No Linkage

A pathway may have no linkage if the activity does not occur (e.g., effluent is not released), or if the pathway is removed by environmental design features so that the Project results in no detectable (measurable) environmental change and residual effects to carnivores. The following pathways are anticipated to have no linkage to carnivores, and will not be carried through the effects assessment.

Changes to Habitat Quality, Movement, and Behaviour

The pathways described in the following bullets have no linkage to habitat quality, movement, and behaviour of carnivores. To be conservative, it is assumed that habitats within the Project footprint that have not been used for construction or storage of material are available to wildlife but of no value.

- Leaching of potentially-acid generating (PAG) mine rock may change the amount of different quality habitats, and alter carnivore movement and behaviour.

Any PAG mine rock, as well as any barren kimberlite, will be sequestered within the interior of the mine rock piles in areas that will allow permafrost to develop or will be underwater when Kennady Lake is re-filled (Table 11.10-5). Overburden, including lakebed sediments, will be used to cover any areas in the core of the mine rock piles where PAG mine rock is sequestered. The overburden (including sediments), which consist mainly of till, will provide a low permeability barrier that will limit infiltration and encourage water to flow over the surface of the mine rock pile, rather than through it. Water quality will be monitored on site, and additional mitigation will be applied if required to limit changes to the environment.

Further, the PAG rock will be enclosed with enough non-acid generating (NAG) rock that the active zone (typically 2 m) will not extend into the enclosed material, and water runoff will occur on the NAG rock cover areas (Table 11.10-5). While all water will not be stopped completely from penetrating the till and NAG rock envelop, the amounts that may penetrate deeper into the pile are expected to be trapped in void spaces and likely freeze. Minimal water is expected to penetrate to the PAG rock areas. To confirm the lower levels remain frozen, temperature monitoring systems will be placed in the mine rock piles as they are being constructed (Table 11.10-5).

Experience at the Ekati Diamond Mine suggests that coarse kimberlite in direct contact with the naturally acidic tundra soils can lead to drainage with low pH. Therefore, barren kimberlite or mine rock mixed with kimberlite will not be placed directly on the tundra soils, and will be separated from the tundra by at least 2 m of inert and kimberlite-free clean rock (Table 11.10-5).

Progressive closure and reclamation of the mine rock piles will involve contouring and re-grading. The piles will not be covered or vegetated, consistent with the approaches at the Ekati Diamond Mine and Diavik Diamond Mine. Thermistors will be installed within the mine rock piles to monitor the progression of permafrost development (Table 11.10-5). The upper portion of the thick cover of mine rock over the waste repository will be subject to annual freeze and thaw cycles, but the processed kimberlite (PK) and PAG rock sequestered below are predicted to remain permanently frozen.

Overall, leaching of PAG mine rock is not expected to result in a detectable change to habitat quality relative to baseline conditions. Consequently, this pathway was determined to have no linkage to effects on the persistence of carnivore populations, and continued opportunity for traditional and non-traditional use of carnivores.

- Release of seepage and surface water runoff from PK and mine rock piles may change the amount of different quality habitats, and alter movement and behaviour.
- Long-term seepage from the Coarse PK Pile and mine rock piles may cause local changes to habitat quality, and alter movement and behaviour.

Water-borne chemicals can adversely affect habitat quality through surface water runoff and seepage. Environmental design features and mitigation have been incorporated into the Project to eliminate or reduce potential effects from surface water runoff and seepage (Table 11.10-5). Runoff and seepage from the Fine PKC Facility, Coarse PK Pile and mine rock piles will not be released to the environment outside of the Project footprint during construction and operations, with the exception of a monitored discharge to Lake N11. Runoff from the coarse PK and mine rock piles will be contained in the affected basins and drain to either Area 3 or to one of the mined-out pits using natural drainage channels (Table 11.10-5). Natural drainage channels will provide opportunities for monitoring runoff quality, and additional mitigation will be applied if required to limit changes to the existing environment outside of the footprint.

The Coarse PK Pile will not be designed to have a single point of release for seepage and runoff. Any runoff will flow through natural channels within the watershed and be retained in the controlled basin associated with Area 4, which in later years represents the Tuzo Pit area. Groundwater entering the open pits during mining will be routed by ditches to a series of sumps (Table 11.10-5). Groundwater inflows collected in the pit dewatering systems will be discharged to either Area 5 or the process plant where groundwater will be incorporated in the fine PK and pumped to the Fine PKC Facility.

As part of reclamation, the Fine PKC Facility will be covered with a 1 to 2 m layer of NAG mine rock (Table 11.10-5). The facility will be graded so that surface runoff will flow towards Area 3. The final geometry of the cover layer will be graded to limit ponding of water over the mine rock covered fine PK in Areas 1 and 2 of the Fine PKC Facility. Permafrost development in the Fine PKC Facility and underlying talik is expected to occur over time. Thermistors will be installed in the Fine PKC Facility to monitor the formation of permafrost in the solids. The Coarse PK Pile will also be shaped and covered with a layer of mine rock of approximately 1 m thick to limit surface erosion. Runoff will be directed to Area 4.

Overall, release of seepage and surface water runoff from the PK and mine rock piles, and long-term seepage from the Coarse PK Pile and mine rock piles is not expected result in a detectable change to habitat quality relative to baseline conditions. Consequently, this pathway was determined to have no linkage to effects on the persistence of carnivore populations, and continued opportunity for traditional and non-traditional use of carnivores.

Changes to Survival and Reproduction

The pathways described in the following bullets have no linkage to the survival and reproduction of carnivores.

- Ingestion of soil, vegetation, and water, or inhalation of air that has been chemically altered by air emissions (including NO_X and PAI deposition) or dust deposition, may affect carnivore survival and reproduction.
- Ingestion of soil, vegetation, or water that has been chemically altered by leaching of PAG mine rock may affect carnivore survival and reproduction.
- Ingestion of seepage and runoff from the PK and mine rock piles, or ingestion of soil, vegetation, or water that has been chemically altered by seepage and runoff, may affect carnivore survival and reproduction.
- Ingestion of exposed sediments and riparian/aquatic vegetation in the dewatered lakebed of Kennady Lake may affect carnivore survival and reproduction.

Carnivores within the RSA may be directly and indirectly exposed to airborne chemicals through fugitive dust and air emissions from the Project. Direct exposure to chemicals includes inhalation of fugitive dust and air emissions, drinking of water, inadvertent ingestion of soil while foraging or grooming, and ingestion of vegetation. Airborne chemicals may deposit directly onto the surface of plants or may deposit onto soils and be subsequently taken up through plant roots (vascular plants) or tissues (lichen). Therefore, carnivores may be indirectly exposed to chemicals from fugitive dust and air emissions by intentionally or inadvertently consuming vegetation that has accumulated chemicals through the soil or air.

There is a general concern that carnivores may drink from the collection ponds or associated containment ditches, which may result in negative changes to carnivore health. As such, environmental design features have been incorporated into the Project to eliminate or reduce potential effects from surface water runoff and seepage (Table 11.10-5). Runoff and seepage from the Fine PKC Facility, Coarse PK and mine rock piles will not be released beyond the Project footprint during construction and operations, with the exception of a monitored discharge to Lake N11. Runoff from the Coarse PK and mine rock piles will be contained and drain to either Area 3 or to one of the mined-out pits using natural drainage channels. Natural drainage channels will provide opportunities for monitoring runoff quality, and additional mitigation will be applied if required to limit changes to the existing environment outside of the footprint. Any runoff from the Coarse PK Pile will flow through natural channels within the watershed and be retained in the controlled basin associated with Area 4, which in later years represents the Tuzo pit area (Table 11.10-5).

Any PAG mine rock, as well as any barren kimberlite, will be sequestered within the interior of the mine rock piles. Overburden, including lakebed sediments, will be used to cover any areas in the core of the mine rock piles where potentially reactive mine rock is sequestered. Limited water is expected to penetrate to the PAG rock areas. To confirm the lower levels remain frozen, temperature monitoring systems will be placed in the mine rock piles as they are being constructed (Table 11.10-5). Experience at the Ekati Diamond Mine suggests that coarse kimberlite in direct contact with the naturally acidic tundra soils can lead to drainage with low pH. Therefore, barren kimberlite or mine rock mixed with kimberlite will not be placed directly on the tundra soils, and will be separated from the tundra by at least 2 m of inert and kimberlite-free clean rock.

As part of reclamation, the Fine PKC Facility will be covered with a 1 to 2 m layer of NAG mine rock. The facility will be graded to encourage surface runoff and limit infiltration. Progressive closure and reclamation of the mine rock piles will involve contouring and re-grading. The piles will not be covered or vegetated, consistent with the approaches at the Ekati Diamond Mine and Diavik Diamond Mine. Thermistors will be installed within the mine rock piles and Fine PKC Facility to monitor the progression of permafrost development (Table 11.10-5). The Coarse PK Pile will also be shaped and covered with a layer of mine rock of approximately 1 m thick to limit surface erosion and infiltration into the pile. The 5034 Pit will be backfilled to the extent possible with mine rock. All pits, including the 5034, Hearne, and Tuzo pits, will be allowed to flood following the completion of the operation phase.

While lake-bed sediments will be exposed following the dewatering of Kennady Lake, it is predicted they will form a hardpan crust and will not be a substantial source of dust (Section 11.7). However, dust from Project activities may settle on the exposed portion of the lake-bed sediments, and be inadvertently ingested by carnivores foraging in this area. Carnivores may be indirectly exposed to chemicals by consuming vegetation that has accumulated chemicals through the sediment.

An ecological risk assessment was completed to evaluate the potential for adverse effects to individual animal health associated with exposure to chemicals from the Project. Emission sources considered in the assessment included those outlined above (i.e., fugitive dust, air emissions, surface water runoff and seepage, leaching of PAG rock, and exposed sediments), and potential exposure pathways included changes in air, water, soil, and vegetation quality. The result of the assessment was that no impacts were predicted for carnivore health. Consequently, the pathways described above were determined to have no linkage to effects on the persistence of carnivore populations, and continued opportunity for traditional and non-traditional use of carnivores.

- Chemical spills (including de-icing fluid runoff) within the Project footprint, the airstrip or along the Winter Access Road or Tibbitt-to-Contwoyto Winter Road may cause negative changes to health or mortality of individual animals.

Chemical spills have not been reported as the cause of wildlife mortality at the Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Project, or Snap Lake Mine (BHPB 2010; Tahera 2008; DDMI 2010; De Beers 2010). Chemical spills are usually localized, and are quickly reported and managed. Mitigation practices identified in the Emergency Response and Contingency Plan (Section 3, Appendix 3.I, Attachment 3.I.1), and environmental design features will be in place to limit the frequency and extent of chemical spills at the Project, and along the winter roads (Table 11.10-5). The following are examples of environmental design features and mitigation practices that will be used to reduce the risk to wildlife from chemical spills.

  – Hazardous, non-combustible waste, and contaminated materials will be temporarily stored in the waste storage transfer area in sealed steel or plastic, wildlife-resistent drums, and shipped off-site for disposal or recycling.

- Chemicals such as de-icing fluid, acids, solvents, battery acids, and laboratory agents will be collected in lined trays and drums and stored in suitable sealed containers in the waste transfer area.
- The waste transfer storage are will include a lined and enclosed pad for the collection and subsequent return of hazardous waste to suppliers or to a hazardous waste disposal facility.
- Spill containment supplies will be available in designated areas where fuel and chemicals are stored.
- All fuel storage tanks will be designed and constructed according to the American Petroleum Institute 650 standard.
- The design of the containment area for tanks will be based on the requirements of the Canadian Council of Ministers of the Environment (CCME) *Environmental Code of Practice for Above-Ground Storage Tanks Systems Containing Petroleum Products* (2003, internet site), the National Fire Code of Canada, and any other standards that are required.
- Aviation fuel for helicopters will be stored in sealed drums inside a lined berm area at the helipad.
- Aircraft will be sprayed with de-icing fluids in a specific area at the airstrip that will be equipped with swales to collect excess fluids if necessary.
- Puddles of de-icing fluids in the swales will be removed by a vacuum truck and deposited into waste de-icing fluid drums for shipment off-site and recycling if necessary.
- Prior to demolition, buildings and equipment will be inspected so that potentially hazardous materials are correctly identified and flagged for appropriate removal and disposal.
- Soils will be sampled during closure and analyzed for contaminants. Any contaminated soil will be excavated and either permanently encapsulated in a secure area, treated on-site to an acceptable standard, or stored in appropriate sealed containers for off-site shippment and disposal.
- Any spills will be isolated and immediately cleaned up by a trained spill response team consisting of on-site personnel who will be available at all times.

The implementation of the Emergency Response and Contingency Plan, environmental design features, mitigation and monitoring programs is expected to result in no detectable change to health or mortality of carnivores. Consequently, this pathway was determined to have no linkage to effects on the persistence of carnivore populations, and continued opportunity for traditional and non-traditional use of carnivores.

- Changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering of Kennady Lake may cause injury/mortality to individual animals.

Carnivore mortality from stream flooding is not anticipated to increase beyond the number of animals drowning that occur naturally. Dewatering and operation discharges will be limited so that pumping will not increase discharges above the baseline 2-year flood levels in downstream lakes and channels (Table 11.10-5). Consequently, carnivore mortality from dewatering of Kennady Lake is determined to have no linkage to effects on the persistence of carnivore populations.

- Changes in the timing of freeze and break-up downstream may alter carnivore movement and behaviour, and could cause injury/mortality to individual animals.

Dewatering and operation discharges will be limited so that pumping will not increase discharges above the baseline 2-year flood levels in downstream lakes and channels (Table 11.10-5). It is anticipated that pumping will begin in June immediately after ice-out and will continue until ice-begins to form on the shorelines. Dewatering and pumped discharge over the life of the Project may result in a thaw period extending into November for Lake N11 and the interlake system. However, the extended thaw period is not anticipated to affect the movement and behaviour of carnivores. It is expected that the dewatering of Kennady Lake will have no measurable influence on the freeze and break-up cycle downstream. Consequently, this pathway was determined to have no linkage to effects on the persistence of carnivore populations.

11.10.3.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on carnivores relative to baseline or guideline values (e.g., a slight increase in a soil quality parameter above CCME guidelines, that would not affect wildlife health). The following pathways are anticipated to be secondary, and will not be carried through the effects assessment.

Changes to Habitat Quantity and Fragmentation

The pathways described in the following bullets are expected to result in minor changes to habitat quantity and fragmentation.

- Dust deposition may cover vegetation and decrease abundance of forage for prey species and carnivores (i.e., habitat quantity).

Accumulation of dust (i.e., total suspended particulate [TSP] deposition) produced from the Project may result in a local direct change to the quantity of habitat available within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition from the Project. Air quality modeling was completed for the baseline case, construction case, and application case. The baseline case also includes emissions from the Snap Lake Mine (Section 11.4).

As per the Terms of Reference, a construction case was modeled for the Project. Typically, the construction phase will have lower emissions than the operations phase of a project. As expected, the construction case emissions are much lower than the application case emissions, and therefore result in lower predictions than those for the application case (Section 11.4). The assessment of the application case (i.e., operations) is anticipated to capture the maximum effects resulting from the Project.

Sources of dust deposition modelled in the application case include blasting activities, haul roads, the processing plant, activities at the mine pits and other ancillary facilities (e.g., mine rock piles, Coarse PK Pile, and Fine PKC Facility), and vehicle traffic along the Winter Access Road (Section 11.4). Environmental design features and mitigation have been incorporated into the Project to reduce potential effects from dust deposition (Table 11.10-5). For example, the watering of roads, airstrip, and laydown areas will facilitate dust suppression (Table 11.10-5). Although these environmental design features and mitigation will be implemented to reduce dust deposition, assumptions incorporated into the model are expected to contribute to conservative estimates of deposition rates (Section 11.4).

The results of the air quality modelling predicted that the maximum annual dust deposition resulting from the Project is 6,292 kilograms per hectare per year (kg/ha/y) within the Project development area boundary and 5,520 kg/ha/y outside of the Project development area boundary (Table 11.10-6). The maximum deposition that occurs is mostly associated with the mine pits and haul roads. The maximum deposition rate for dust is predicted to occur within 100 m of the Project footprint. The strongest effects from dust are generally confined to the immediate area adjacent to the dust source, such as roads (Walker and Everett 1987).

Table 11.10-6 Summary of Key Predicted Annual Deposition Rates from the Project

Substance	Criteria	Maximum Predicted Deposition Rate		
		Local Study Area Baseline	Application	
			Outside Project Development area boundary	Distance to Maximum from the Project Development area boundary (m)
TSP Annual (kg/ha/y)	none	0.00	5,520	0
PAI Annual (keq/ha/y)	0.25[a]	0.06	0.96	0.2

[a] Criteria is based on the Clean Air Strategic Alliance (CASA 1999).

km = kilometres; kg/ha/y = kilograms per hectare per year; keq/ha/y = kiloequivalent per hectare per year; PAI = potential acid input

Increased dust deposition has been documented to have varying effects on plants (Forbes 1995; Walker and Werbe 1980; Spatt and Miller 1981; Walker and Everett 1987). However, Auerbach et al. (1997) states that although the species composition may change and the aboveground biomass is lowered due to dust deposition, the ground cover is still maintained. Some species such as cloudberry, willow, and cottongrass were observed to be more abundant as a result of dust deposition (Forbes 1995).

Overall, direct effects from dust deposition are predicted to be largely confined to the Project development area boundary (i.e., Project footprint) and are anticipated to result in a minor change to habitat quantity and prey species relative to baseline conditions (secondary pathway; Table 11.10-5). Subsequently, residual effects to the persistence of carnivore populations, and the continued opportunity for traditional and non-traditional use of carnivores are predicted to be negligible.

- Changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from dewatering of Kennady Lake may affect the quantity of riparian habitat, which could alter carnivore movement and behaviour.
- Changes in downstream flows (e.g., isolation and diversion, altered drainage patterns) and water levels from refilling of Kennady Lake may affect the quantity of riparian habitat, which could alter carnivore movement and behaviour.

Changes to downstream habitat quantity (i.e., riparian vegetation) from the discharge of water to Lake N11 (i.e., throughout construction and operations) are anticipated to be minor. Environmental design features and mitigation have been included to limit erosion, and subsequently, reduce the potential for loss of riparian habitat (Table 11.10-5). For example, discharges will be limited so that pumping will not increase discharges above the baseline 2-year flood levels in downstream lakes and channels. These levels were selected to reduce potential bank erosion and limit the changes to habitat quantity (Section 9).

Construction of dykes will cause changes to drainage flow patterns and surface water elevations in some lakes. For example, the construction of Dykes E and D will divert drainage flows from Lake B1 to N6 (Section 3). Construction of Dykes F and G will divert water from Lakes D3, D2, E1, and N14 through Lake N17. The construction of Dyke C will divert water from Lake A3 through Lake N9. In addition to diversion of drainage flows, the construction of these dykes will also raise baseline surface water elevations in Lakes D2, D3, E1, and A3. For example, it is anticipated that surface water elevations in Lakes D2 and D3 will increase from approximately 424.2 m and 425.4 m at baseline, respectively, to 427.0 m throughout the construction and operational phases (Section 3). Surface water elevation in Lake E1 is anticipated to increase from 425.2 m to 426.0 m. The greatest increase in lake levels is predicted to be in Lake A3 where surface water elevations will increase from 423.0 m to 426.5 m after the construction of Dyke C. Because of the anticipated changes in lake levels, riparian vegetation surrounding Lakes D2, D3, E1, and A3 will be removed during the construction of the diversion dykes, prior to flooding (Section 3).

Vegetation ecosystems and plants downstream of Kennady Lake that could be affected by the dewatering process include sedge-dominated wetlands and riparian areas, and upland tundra comprised primarily of dwarf woody vegetation (Section 11.7). Wetlands and riparian plant species are better adapted to fluctuating water levels and should be able to withstand and recover from high water level conditions more successfully than their upland counterparts. Upland ecosystem types with more freely drained soils and dwarf vegetation will likely be less resilient to prolonged flooding, and are expected to display a more adverse response to these conditions (Section 11.7). In addition, the margins of Kennady Lake are composed primarily of boulder and cobble substrates (Section 8). Portions of the lake margin that are vegetated may die back if they are sensitive to water table declines resulting from dewatering. However, as the margins become drier, the species composition may shift to plants more commonly found in upland areas.

The progressive reclamation strategy will be extended to the water management of Kennady Lake, where portions of the lake will be isolated and brought back to original water levels and compliant water quality as quickly as possible. The closure water management plan requires annually pumping water from Lake N11 to Area 3 to reduce the overall time for the closure phase. The pumping rates are anticipated to be managed such that the total outflow from Lake N11 does not drop below the 1 in 5-year dry conditions (Table 11.10-5). At closure, dykes will be breached to return drainage flows and water levels to baseline conditions.

While most changes are predicted to revert back to natural conditions, it is anticipated that the drainage flow from Lake A3 to Lake N9 will be permanent and the surface water elevation in Lake A3 will remain above baseline conditions (Section 3).

Overall, the increase in drainage flows and surface water elevations associated with the dewatering and refilling of Kennady Lake is localized and is expected to have a minor influence on habitat quantity for carnivores relative to baseline conditions. Therefore, the residual effects to the persistence of carnivore populations, and continued traditional and non-traditional land use of carnivores from the dewatering and refilling of Kennady Lake are predicted to be negligible.

- Dewatering may result in newly established vegetation on the exposed lakebed sediments and increase habitat quantity.

The development of the Project will require the dewatering of Kennady Lake, resulting in the exposure of a portion of the lake-bed. Although it is anticipated that the sediment would solidify and form a hardpan crust, there is potential for vegetation to establish on the exposed lake-bed sediments. The exposure of bare, nutrient-rich lakebed sediments can provide a substrate that may favour the establishment of rapid colonizing plants, some of which could be weedy, invasive species (Shafroth et al. 2002). If the substrate remains moist during the initial stages of plant colonization, then riparian plant species may become established on the exposed lakebed. Over time as the substrate becomes drier, the species composition may shift to plants more commonly found in upland areas (Section 11.7).

The lack of fine sediment around the periphery of Kennady Lake, and the consistent presence of boulder and cobble through the shallow areas of the lake, should limit colonization of the lakebed by terrestrial vegetation through vegetative propagation (i.e., root growth). Vegetation is more likely to be established through seed dispersal and subsequent germination, with the seeds being dispersed across the nearshore rocky habitat to colonize the fine sediments that are currently located in the deeper sections of the lake (Section 8). Vegetation is expected to establish slowly and coverage would be patchy. Initial colonizers are thought to be graminoids (grasses and sedges).

The anticipated effects on riparian vegetation will be localized, and it is expected that dewatering will result in a minor change to the quantity of habitat available for carnivores relative to baseline conditions (secondary pathway; Table 11.10-5). Therefore, the residual effects to the persistence of carnivore populations resulting from the dewatering of Kennady Lake are predicted to be negligible.

Changes to Habitat Quality, Movement, and Behaviour

The pathways described in the following bullets are expected to result in minor changes to habitat quality, movement, and behaviour of carnivores.

- Dust deposition and air emissions may change the amount of different quality habitats for prey species (through chemical changes in soil and vegetation), and alter carnivore movement and behaviour.

Accumulation of dust (i.e., TSP deposition) and concentrations of air emissions produced from the Project may result in a local indirect change on the quality of habitat available within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project. Air quality modeling was completed for the baseline case, the construction case, and the application case (Section 11.4). The baseline case includes background concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and PM, as well as background PAI depositions from the regional modelling network. The baseline case also includes air emissions from the Snap Lake Mine (Section 11.4).

Sources of dust deposition and air emissions modelled in the application case (maximum effects case) include blasting activities, haul roads, the processing plant, activities at the mine pits and other ancillary facilities (e.g., mine rock piles, Coarse PK Pile and Fine PKC Facility), and vehicle traffic along the Winter Access Road (Section 11.4). Environmental design features and mitigation have been incorporated into the Project to reduce potential effects from dust deposition (Table 11.10-5). For example, the watering of roads, airstrip, and laydown areas will facilitate dust suppression (Table 11.10-5). In addition, programs will be instituted to review power and heat use to reduce energy use. Although these environmental design features and mitigation will be implemented to reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates (Section 11.4).

Haul trucks travelling on the Winter Access Road have the potential to transfer dust from vehicles and loads during the winter months (e.g., dust deposited on wheels and undercarriage while at mine sites and in Yellowknife). However, the relative contribution of these loads to the overall dust accumulation in the area along the roads is considered to be negligible (Section 11.4). During the winter, dust that accumulates on snow may settle on vegetation during the spring melt. Although snow melting does not result in “washing away” of dust, the dust that has accumulated on snow during the winter may be diluted during snow melt and spring freshet, and eventually removed by rain (Section 11.7). The air emissions from the Winter Access Road were included in the application case and assumed that the road was in operation for 63 days (Section 11.4). In general, emissions from the Winter Access Road are small, and if extended over whole year, a negligible effect on annual depositions was predicted (Section 11.4). Annual emissions from the Winter Access Road are anticipated to result in no detectable changes to vegetation (Section 11.7).

The results of the air quality modelling predicted the maximum annual dust deposition resulting from the Project is 6,292 kg/ha/y within the Project development area boundary (i.e., Project footprint) and 5,520 kg/ha/y outside of the Project development area boundary (Table 11.10-6). The maximum deposition that occurs is mostly associated with the mine pits and haul roads. The maximum predicted dust deposition rate outside the Project development area boundary is predicted to occur within 100 m of the Project footprint (Table 11.10-6). The strongest effects from dust are generally confined to the immediate area adjacent to the dust source, such as roads (Walker and Everett 1987). Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50-m buffer on either side of a road. Moreover, Meininger and Spatt (1988) found that most of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road.

The potential acid input (PAI) modelling results indicates maximum deposition rates of 0.06 kiloequivalent per hectare per year (keq/ha/y) and 0.96 keq/ha/y 0.2 m beyond the Project development area boundary for the baseline and application case, respectively (Table 11.10-6). The maximum deposition occurs near the three mine pits and around of the plant site, where haul road emissions are coupled with those from the power generation plant. Interpretation of PAI predictions is based on the Clean Air Strategic Alliance (CASA 1999) deposition loading benchmarks, including the critical threshold of 0.25 keq/ha/y for the most sensitive ecosystems. The area outside the Project development area boundary that is predicted to have above the critical load of 0.25 keq/ha/y is estimated at 169 hectares (ha), extending up to 500 m from the Project development area boundary.

The air emissions modelling results show that predicted peak concentrations for SO_2 are below the Ambient Air Quality Standards for NWT for the application case (Table 11.10-7). Annual peak concentrations for NO_2 are predicted to slightly exceed guidelines at 64.3 micrograms per cubic metre (µg/m^3). The area of exceedances is predicted to occur near the South Mine Rock Pile and the haul roads along the south side of the development area (Table 11.10-7). The Annual maximum TSP concentration outside the Project development area boundary is predicted to be 604.8 µg/m^3, compared to the NWT standard of 60 µg/m^3. The area that is predicted to exceed the NWT standard extends no further than approximately 1 km from the Project development area boundary.

Table 11.10-7 Summary of Key Predicted Peak Annual Air Quality Concentrations in the Regional Study Area

Substance	Criteria ($\mu g/m^3$)	Maximum Predicted Concentration			
		Baseline		Application	
		Concentrations in the Regional Study Area ($\mu g/m^3$)	Distance to Peak Predictions (km)	Concentrations Outside Project Development area boundary ($\mu g/m^3$)	Distance to Peak Predictions (km)
NO_2 Annual	60	11.9	86.1	**64.3**	1.6
SO_2 Annual	30	3.0	86.1	4.8	2.9
TSP Annual	60	7.1	8.5	**604.8**	1.6
$PM_{2.5}$ Annual	none	2.2	86.1	24.1	1.6

Note: A predicted value that exceeds a criterion is accentuated in **bold**.

$\mu g/m^3$ = micrograms per cubic metre; NO_X = nitrogen oxides; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; $PM_{2.5}$ = particulate matter; TSP = total suspended particulate.

Although concentrations are predicted to be above baseline conditions, the anticipated changes to habitat quality are localized and considered minor. The maximum predicted annual TSP deposition rate is expected to occur within 100 m of the Project footprint. When comparing changes to the elemental concentrations in soil from TSP deposition, predictions are be below CCME (2007) soil quality guidelines. Therefore, changes to the chemical content of soil should not affect the soils ability to support vegetation (habitat quality). In addition, the deposition predictions are considered to be conservative and therefore, the presented deposition rates are likely overestimated. Overall, changes in habitat quality for prey species (and associated changes to carnivore movement and behaviour) due to dust deposition and air emissions are anticipated to be minor relative to baseline conditions (secondary pathway; Table 11.10-5). Consequently, residual effects to the persistence of carnivore populations from dust deposition and air emissions are predicted to be negligible.

- Road footprint may cause changes to the amount of different quality habitats (e.g., degradation to vegetation), and alter carnivore movement and behaviour.

Construction and operation of the Winter Access Road connecting the Project with the Tibbitt-to-Contwoyto Winter Road will follow best practices (e.g., use of snow or ice pads of sufficient thickness to limit damage to overland portages between lakes, and discontinued use of the road when the ground surface becomes too soft). These practices are implemented in the design, construction, and operation of the Tibbitt-to-Contwoyto Winter Road and have proven to be successful in limiting the effects to vegetation (EBA 2001) (Section 11.7). As such, only minor compression of vegetation comprising the portages is anticipated. Some degradation to vegetation along the boundary between lakes and shorelines may also occur.

Overall, the Winter Access Road is anticipated to have a minor influence on habitat quality relative to baseline conditions (Table 11.10-5). Therefore, the residual effects to the persistence of carnivore populations are predicted to be negligible.

Changes to Survival and Reproduction

The pathways described in the following bullets are expected to result in a minor change to the survival and reproduction of carnivores.

- Physical hazards from the Project may increase the risk of injury/mortality to individual animals, which can affect carnivore population sizes.
- Injury or mortality to animals getting trapped in exposed sediments.

The presence of physical hazards (e.g., open pits, ditches, blasting, and exposed sediments) on-site may result in an increased frequency of injury or mortality to carnivores. However, the implementation of environmental design features (Table 11.10-5) and the Wildlife Effects Mitigation and Management Plan (Appendix 7.I), are expected to decrease the risk to animals from physical hazards on-site.

- Blasting in pits will be carefully planned and controlled to reduce the throw of ore bearing materials.
- At closure, the entire site area will be re-contoured to reduce hazards to wildlife.
- Non-salvageable and non-hazardous components from demolition of the site buildings, structures, and equipment will be dismanteled and deposited in the inert materials landfill within the mine rock pile, and will then be covered with a layer on NAG mine rock.
- Ramps to facilitate the access and egress of wildlife form the mine rock pile will be constructed during closure.

Wildlife deterrent actions will be also implemented by knowledgeable and trained personnel. The goal of these deterrents is to respond to wildlife situations using humane management methods in ways that will keep both humans and animals safe. Lakebed sediments are expected to dry quickly and form a hard pan crust and are not predicted to cause injury or death to animals.

The frequency of accidental mine-related carnivore mortalities is extremely low at existing mine sites from 1998 through 2009. For example, all six occasions where carnivores were accidentally destroyed at a project, and where the cause of death was clearly attributable to the mine, were a result of vehicle collisions (Section 11.10.2.4). No reported injuries or mortalities have been related to open pits, fly rock, and mine rock piles.

Although there is a potential for mortality or injury to occur, the implementation of the Wildlife Effects Mitigation and Management Plan (Appendix 7.I) is anticipated to reduce the risk to carnivore mortality from physical hazards on-site. Changes in mortality are predicted to be minor relative to baseline conditions (secondary pathway; Table 11.10-5). As such, carnivore mortality from physical hazards on-site is expected to have a negligible residual effect on the persistence of carnivore populations.

- Aircraft/vehicle collisions may cause injury or mortality to individual animals.

There is potential for an increase in the risk of injury or death to carnivores through collisions with aircraft and on-site vehicles. For example, four vehicle-related wildlife mortalities were reported from 1998 to 2009 at the Ekati Diamond Mine (BHPB 2010). Aircraft collisions have not been the cause of any recorded wildlife injuries or mortalities at the Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Mine, or the Snap Lake Mine (BHPB 2010; Tahera 2007; DDMI 2010; De Beers 2010).

Similar to other mining operations in the region, access to the Project will be via a 120 km winter spur road, connecting with the Tibbitt-to-Contwoyto Winter Road at kilometre 271, just north of Lake of the Enemy. The Winter Access Road will typically be in operation for about 8 to 12 weeks per year. From 1998 to 2007, traffic volume on the Tibbitt-to-Contwoyto Winter Road increased from 2,543 loaded trucks in 2000 to 10,922 in 2007 (GNWT 2006, internet site; Tibbitt-to-Contwoyto Winter Road Joint Venture 2007, internet site). Traffic volume on the Tibbitt-to-Contwoyto Winter Road decreased during 2008 through 2010 (3,506 northbound loads in 2010; Section 11.8.2.5).

The predominant factors that contribute to road-related wildlife deaths are traffic volume and vehicle speed (EBA 2001). These factors directly affect the success of an animal reaching the opposite side of the road. An increase in either factor reduces the probability of an animal crossing safely (Underhill and Angold 2000). However, implementation of the Winter Road Policy, Rules and Procedures for the Tibbitt-to-Contwoyto Winter Road is anticipated to reduce the potential for injury/mortality of wildlife from vehicle collisions (Tibbitt-to-Contwoyto Winter

Road Joint Venture 2000). For example, from 1996 to 2009, there have been three reported road-related wildlife mortalities along the Tibbitt-to-Contwoyto Winter Road. In 1996, a wolverine was killed by a pick-up truck (Banci, pers. comm. in EBA 2001). In March 1999, five caribou were killed by a grocery (meat) truck on a portage near Gordon Lake (EBA 2001). In 2009, a red fox was killed on the Tibbitt-to-Contwoyto Winter Road (Madsen 2010, pers. comm.)

Mitigation strategies have been established to reduce the potential for vehicle and aircraft collisions at the Project and along the Winter Access Road (Table 11.10-5). These strategies are outlined in the Wildlife Effects Mitigation and Management Plan (Appendix 7.I), and are similar to management practices and policies implemented at other diamond mines in the NWT and Nunavut. The following environmental design features and mitigation are expected to limit the risk from vehicle and aircraft collisions with carnivores:

- personnel arriving at or leaving the site will be transported by bus, which will reduce the amount of traffic between the airstrip and the accommodation complex;
- levels of private traffic using the Winter Access Road will be monitored;
- all wildlife have the “right-of-way”;
- the site will be designed to limit blind spots where possible to reduce the risk of accidental wildlife-human encounters;
- speed limits will be established and enforced; and
- drivers will be warned when wildlife are moving through an area using signage and radio.

The implementation of the Winter Road Policy, Rules and Procedures, and the Wildlife Effects Mitigation and Management Plan (Appendix 7.I) is anticipated to limit carnivore mortality from vehicle collisions along the Winter Access Road. Based on the success of mitigation and management practices used at operating mines in the NWT, the environmental design features and mitigation implemented for the Project are anticipated to reduce carnivore mortality from vehicle and aircraft collisions. As such, carnivore mortality from vehicle and aircraft collisions is expected to have a negligible residual effect on the persistence of carnivore populations, and the continued opportunity for traditional and non-traditional use of carnivores.

- Attractants to site (e.g., food waste, oil products) may increase the risk of mortality to individual animals and affect carnivore population sizes.

Carnivores have a keen sense of smell and can be attracted from long distances to a Project if food items are frequently present. Carnivores are also attracted to aromatic waste material such as oil and aerosols, in addition to infrastructure that can serve as a temporary refuge to escape extreme heat or cold. For example, wildlife effects monitoring programs completed at the Ekati Diamond Mine (2000 through 2009), the Diavik Diamond Mine (2002 through 2009), the Jericho Diamond Mine (2000, 2005 through 2007), and the Snap Lake Mine (2001 through 2009) have reported attractants (e.g., non-burned food items, oil products, and food packaging) in the landfill. However, most of the animals and sign observed during these landfill surveys were associated with foxes. Grizzly bears, wolverine, and wolf tracks were occasionally observed (Section 11.9).

At the Diavik Diamond Mine, only one wolverine and one grizzly bear have been intentionally destroyed from 1996 through 2009 (Section 11.10.2.4). At the Ekati Diamond Mine, five wolverine, three grizzly bears, 16 foxes, and one wolf have been intentionally destroyed from 1998 through 2009 (Section 11.10.2.4). One wolf and three foxes have been unintentionally destroyed on the Ekati mine site from 1998 to 2009 (Section 11.10.2.4). The Snap Lake Mine has had only one Project-related wolverine mortality during the ten-year period from advanced exploration through construction (Section 11.10.2.4).

Environmental design features and mitigation strategies have been established to reduce the numbers of carnivores attracted to the Project (Table 11.10-5). These strategies are outlined in the Wildlife Effects Mitigation and Management Plan (Appendix 7.I), and are similar to management practices and policies implemented at other diamond mines in the NWT and Nunavut. The following wildlife-specific environmental design features are included in the Waste Management Plan (Section 11.9) and the Wildlife Effects Mitigation and Management Plan, and should reduce the numbers of carnivores attracted to the Project.

- Education and reinforcement of proper waste management practices to all workers and visitors to the site will be provided.
- Separate bins will be located throughout the accommodations complex, processing plant, shops, and other facilities on-site for immediate soring of domestic waste.
- Food waste will immediately be planced and sealed in plastic bags. The plastic bags will be stored in sealed, wildlife-resistant containmers before transport directly to the incinerator storage area for incineration.
- Incinerator ash from combustion of kitchen and office waste will be stored in wildlife-resistant containers and transported to the landfill.

- The landfill will be covered regularly with crushed or mine rock.
- A fenced area will be established for the handling and temporary storage of wastes. Fencing will be 2 m high, slatted-type, and partially buried to prevent animals from burrowing underneath.
- People will be educated on the risks associated with feeding wildlife and careless disposal of food garbage.
- Ongoing review of the efficiency of the waste management program and improvement through adaptive management.

At the Snap Lake Mine, there were no reported waste or attractant-related incidents or mortalities to carnivores from 1999 to 2009 (Golder 2008b; De Beers 2010), which indicates a low frequency of attractants at site. The implementation of the Waste Management Plan and the Wildlife Effects Mitigation and Management Plan are expected to limit the numbers of carnivores attracted to the site, particularly wolves. Therefore, wolf mortality from being attracted to the Project is expected to have a negligible residual effect on the persistence of the populations (secondary pathway). Alternately, residual effects to grizzly bear and wolverine populations from direct mine-related mortality are further assessed in the effects analysis (primary pathway; Table 11.10-5).

- Increased access for traditional and non-traditional harvesting may alter carnivore movement and behaviour, which can affect survival and reproduction.

Because the Winter Access Road leading to the Project connects with the Tibbitt-to-Contwoyto Winter Road, the improved access may lead to an increase in harvest rates on carnivores. The exception is grizzly bears, which are typically hibernating during the winter road season (January to March). Non-Aboriginal harvest of carnivores is regulated by the ENR. Non-resident hunters are allowed to hunt wolves and wolverines when the winter roads are in operation (approximately 8 to 12 weeks each year). The non-resident hunting season for wolves is from August 15 to May 31, and for wolverines is from December 1 to March 15 (ENR 2010a, internet site).

Resident hunters are also allowed to hunt wolves and wolverines when the winter roads are in operation. The harvest period for resident hunters for wolves is from August 15 to May 31, and for wolverines is from July 25 to April 30 (ENR 2010a, internet site). Aboriginal hunters also may benefit from increased access to carnivores from the Winter Access Road. Although no harvest data exists for the Tibbitt-to-Contwoyto Winter Road, Ziemann (2007, internet site) has tracked the level of hunting activity for 2004 through 2006. The number of vehicles travelling for hunting on the Tibbitt-to-Contwoyto Winter Road showed a decline from 573 vehicles in 2004 to 284 vehicles in 2006 (Ziemann 2007, internet site). Decreases in hunting traffic may have been due to previous high volumes of mine-related vehicles on the road [e.g., 2,543 loaded trucks in 1998 versus 11,740 in 2007 (Section 11.8.2.5)].

Increased access from the Winter Access Road may increase the number of individuals harvested from the RSA by residents, non-residents, and Aboriginals. However, the increase in access to the region associated with the winter roads is limited to an 8 to 12 week period each year, and should result in minor changes to the annual harvest rate of carnivores relative to baseline conditions. The number of animals harvested by residents and non-residents is regulated. Policies implemented by De Beers Canada Inc. (De Beers) will prevent people at the Project site from using the Winter Access Road for hunting carnivores (while they are at site). Therefore, increased access for harvesting along the winter roads is expected to have a negligible residual effect on the persistence of carnivore populations, and the continued opportunity for traditional and non-traditional use of carnivores.

11.10.3.2.3 Primary Pathways

The following primary pathways are analyzed and classified in the effects assessment.

Changes to Habitat Quantity and Fragmentation

- Direct loss and fragmentation of wildlife habitat from the physical footprint of the Project may alter carnivore movement and behaviour.
- Winter road footprint decreases habitat quantity and may cause fragmentation, which can alter carnivore movement and behaviour.

Changes to Habitat Quality, Movement, and Behaviour

- Dust deposition may cover vegetation and change the amount of different quality habitat for prey species, and alter carnivore movement and behaviour.
- Sensory disturbance (e.g., presence of buildings, people, lights, smells, and noise) change the amount of different quality habitats, and alter movement and behaviour, which can influence survival and reproduction.

Changes to Survival and Reproduction

- Attractants to site (e.g., food waste, oil products) may increase the risk of mortality to individual animals and affect grizzly bear and wolverine population sizes.

11.10.4 Effects on Population Size and Distribution of Grizzly Bear and Wolverine

11.10.4.1 General Approach

The effects analysis considers all primary pathways that result in expected changes to grizzly bear and wolverine, after implementing environmental design features and mitigation. Thus, the analysis is based on the residual effects from the Project. Residual effects to grizzly bear and wolverine are analyzed using measurement endpoints (e.g., habitat quantity and quality, survival and reproduction) and are expressed as effects statements, including:

- direct effects from changes in habitat quantity and fragmentation from the physical footprint and winter roads;
- indirect effects from changes in habitat quality, movement, and behaviour, and
- effects from changes in survival and reproduction from negative interactions with projects due to site attractants (food waste, shelter).

The magnitude, spatial extent, and duration of changes in measurement endpoints (e.g., habitat quantity and quality) from the Project and other developments are expected to be similar to or greater than the actual effects to the abundance and distribution of populations. Effects statements may have more than one primary pathway that link a Project activity with a change in grizzly bear and wolverine (and wolf). For example, the pathways for effects on carnivore habitat quality, movement, and behaviour include changes due to noise, dust deposition, and the presence of vehicles and mine 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 change the behaviour and occurrence of grizzly bear and wolverine (and wolf). 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). All of these changes can ultimately affect carnivore population size and distribution.

The spatial scale of the analysis considers natural and human-related effects that occur within the population ranges of carnivores (i.e., study areas). The temporal scale looks at natural and development-related changes from reference conditions through application of the Project (most effects from reasonably foreseeable projects are discussed in Section 11.10.9). Baseline conditions represent a range of temporal values on the landscape from reference (little to no development) through existing conditions (year 2010). Environmental conditions on the landscape before industrial development (i.e., reference 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 (Section 6.6). Analyzing a range of temporal conditions on the landscape is fundamental to understanding the cumulative effects of increases in development on carnivore populations.

The effects analyses determine both the incremental and cumulative changes from the Project on the landscape, carnivores, and the use of carnivores by people. Incremental effects represent the Project-specific changes relative to baseline values in 2010 (current or existing conditions). Project-specific effects typically occur at the local scale (e.g., habitat loss due to the Project footprint, mortality of individuals) and regional scale (e.g., combined habitat loss, dust, noise, and sensory disturbance from Project activities [i.e., zone of influence]).

Cumulative effects are the sum of all changes from reference values through application of the Project (Section 6.6). 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 carnivores travel large distances during their seasonal and annual movements and can be affected by the Project, and several other developments. In other words, the combined local and regional effects from the Project and other developments overlap with the distribution of the populations.

Cumulative effects do not just include the combined effects from human development on carnivore populations. Cumulative effects represent the sum of all natural and human-induced influences on the landscape and carnivore 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 prey cycles, and periodic harsh and mild winters. The objective of the cumulative effects analysis is to estimate the relative contribution of natural and human-related influences on the observed and expected changes to carnivore population size and distribution.

Detailed descriptions of the spatial and temporal boundaries, and methods used to analyze residual effects from the Project on grizzly bear and wolverine 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. Traditional knowledge and community information were incorporated where available. Due to the amount and type of data available, some analyses were qualitative and included professional judgement or experienced opinion.

11.10.4.2 Habitat Quantity and Fragmentation

11.10.4.2.1 Methods

The incremental and cumulative direct habitat effects to grizzly bear and wolverine from the Project footprint and other previous, existing, and future developments in the study area (i.e., population range) were analyzed through changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics). Landscape metrics for each habitat included total area, number of patches, and mean distance to the nearest similar patch. Changes in landscape metrics are reported for all habitat types, but emphasize esker habitat for the grizzly bear assessment (McLoughlin et al. 2002). Decreases in habitat area and number of similar quality habitat patches can directly influence population size by reducing the carrying capacity of the landscape. Changes in the number of patches and distance between similar habitat patches can influence the distribution (and abundance) of carnivores by affecting the ability of animals to travel across the land.

The quantity of grizzly bear and wolverine habitat was classified using a remote sensing Land Cover of Canada (1985 to 2000) provided by the Government of Canada in a Geographic Information System (GIS) platform (Johnson et al. 2004, 2005). The latter 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 SGP dataset used in Johnson et al. (2004, 2005).

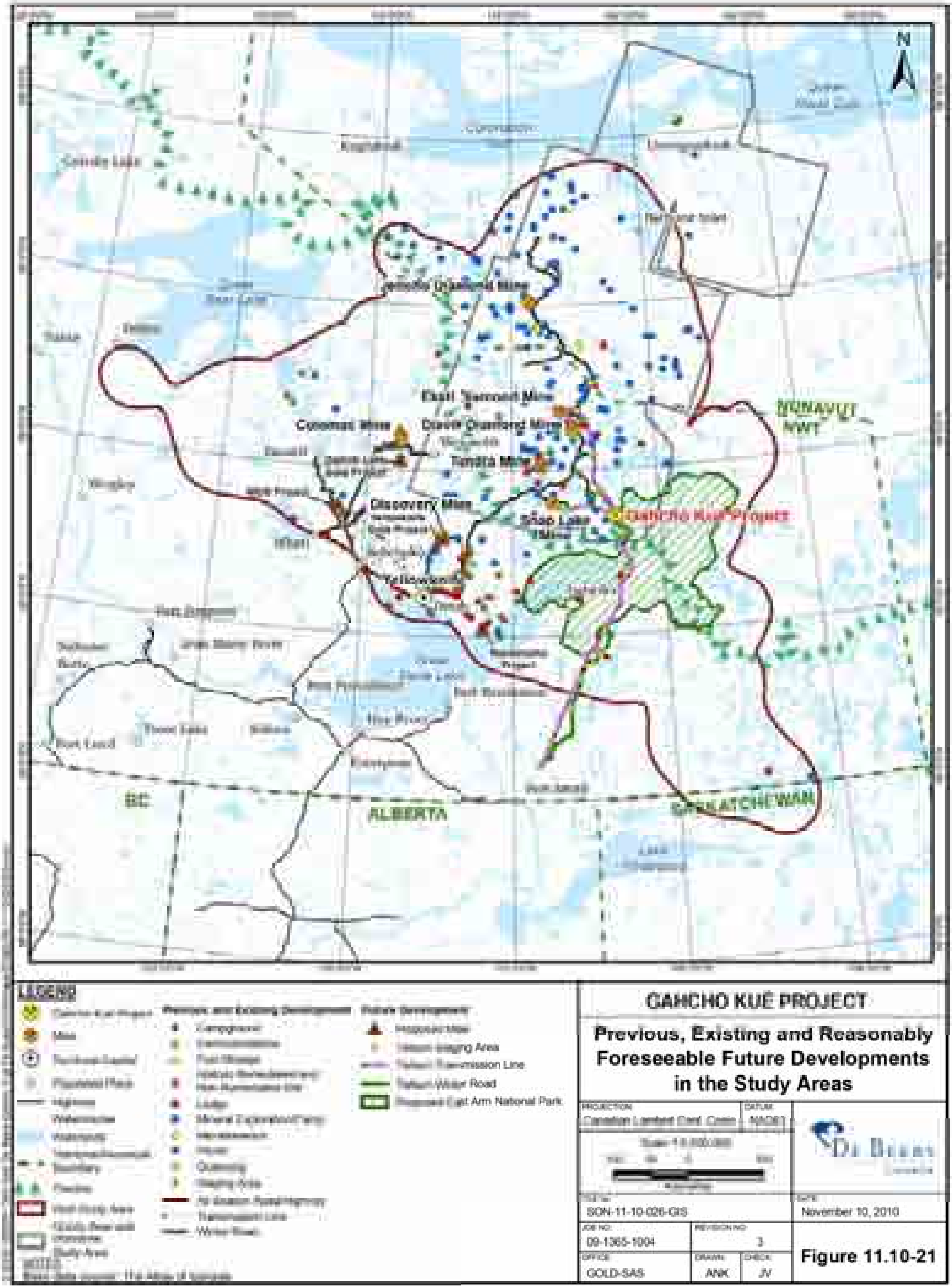
However, upon joining layers, the dataset was re-sampled to 200-m cell sizes using a nearest neighbour algorithm (versus 100 m in Johnson et al. [2004, 2005]) because of computational constraints with generating habitat rasters over the large study area. Tests for accuracy suggested there were marginal differences in the overall areas per cover type between a 100-m resampled dataset, versus a 200-m resampled dataset (i.e., less than 0.1%). Finally, the Land Cover of Canada dataset was reclassified into 12 classes similar to Johnson et al. (2004, 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.

Landscape metrics were determined using the program FRAGSTATS (Version 3.0) (McGarigal et al. 2002, internet site) within a GIS platform. The analysis determined the extent of landscape fragmentation by calculating statistical outputs based on the values of each raster cell. Raster cells for habitats with extensive coverage (including disturbed areas) were increased to 200 by 200 m in size. For example, road widths are about 20 m. However, in order to include roads in the 200 m ecological land cover layer, roads must have a width of 200 m. Therefore, results determined from the fragmentation analysis are conservative and result in an overestimation of disturbed area within the study area (population range).

Previous, existing, and reasonably foreseeable developments in the grizzly bear and wolverine (and wolf) study area are listed in Table 11.10-8 and illustrated in Figure 11.10-21. 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;
- INAC: contaminated sites database;
- Natural Resources Canada (NRCAN): obtained a geographical information system (GIS) file of community locations from NRCAN's GeoGratis website;
- GNWT: Location of parks within the NWT;
- company websites; and
- knowledge of the area and project status.

Initially, data indicating permitted and licensed activities were obtained in spreadsheet format. 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 pieces of location information for the same activity were present, the extra information was deleted from the file so that it contained only one point per development. Data associated with the location attributes (e.g., permit status, feature name) also were edited in some instances to update the information or make it more standardized for running modelling scenarios efficiently. The information was used to generate a development layer within a GIS platform.



N
Coppermine
Kugluktuk
Umingmaktok
Jericho Diamond Mine
Ekati
Diavik Diamond Mine
Colomac Mine
Tundra Mine
Discovery Mine
Snap Lake Mine
Gahcho Kué Project
Yellowknife
NUNAVUT
NWT
BC
ALBERTA
SASKATCHEWAN
LEGEND
Gahcho Kué Project
Mine
Previous and Existing Development
Future Development
Tibbitt Transmission Line
Tibbitt Winter Road
Proposed East Arm National Park
All Season Road/Highway
Transmission Line
Winter Road
GAHCHO KUÉ PROJECT
Previous, Existing and Reasonably Foreseeable Future Developments in the Study Areas
PROJECTION
DATUM
NAD83
SON-11-10-026-GIS
November 10, 2010
JOB NO.
09-1365-1004
REVISION NO.
3
OFFICE
GOLD-SAS
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Figure 11.10-21

Table 11.10-8 Previous and Existing Developments in the Study Area That Have the Potential to Affect Wolverine and Grizzly Bear

Type of Development	Footprint Area (ha)	Number of Developments	Linear Feature Length (km)
Communications (e.g., microwave towers)	25.1	2	n/a
Community	980.8	3	n/a
Fuel storage	12.6	1	n/a
Historic remediated and non-remediated site[a]	25.1	2	n/a
Lodge (outfitters, tourism)	163.3	13	n/a
Mine	4,811.7	5	n/a
Mineral exploration	11,295.6	128	n/a
Miscellaneous (e.g., bridge / culvert installation)	75.4	6	n/a
Quarrying	12.6	1	n/a
Staging area	12.6	1	n/a
Winter road segments	19,938.9	44	1,002.1
Total disturbance	**37,353.6**	**206**	**1,002.1**

(a) Includes moderate and high risk contaminated sites.

n/a=not applicable; ha = hectare; km = kilometres.

The database contains no information on the size of the physical footprint of the development. 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 other developments, the physical area of the footprint was estimated using a number of assumptions. For example, footprints for linear developments (all roads) were based on a 200-m corridor, which was related to the raster cell size of 200 x 200 m for the land cover data.

The area of the footprint for most other developments (except exploration sites) was assumed to be a 200-m radius (12.6 ha) (Table 11.10-9). A 500-m radius was used to estimate the area of the footprint for exploration sites (78.5 ha), which 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 x 5 m area) at one location at a time. 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. Footprints with overlapping areas on the landscape were not counted twice.

Table 11.10-9 Hypothetical Footprints for Previous, Existing and Future Developments in the Study Area for Grizzly Bear and Wolverine

Type	Feature Type[a]	Footprint Extent (m)
Communications	point	200
Community	polygon	actual
Fuel storage	point	200
Historic remediated and non-remediated site	point	200
Lodge (outfitters, tourism)	point	200
Mine	polygon	actual
Mineral exploration	point	500
Miscellaneous (e.g., bridge)	point	200
Quarry	point	200
Staging area	point	200
Winter roads	line	200
Transmission line	line	200

[a] Footprint estimated with the exception of mine operations and communities, which were delineated and digitized from remote sensing imagery.

m = metre.

The Project footprint was derived from the Project Description, and includes both the terrestrial and aquatic areas of disturbance. The development layer was then applied to the landscape classification of the study area for the baseline, application, and future cases (Table 11.10-10).

Table 11.10-10 Contents of Each Assessment Case

Baseline Case	Application Case	Future Case
Range of conditions from little or no development to all previous and existing projects[a] prior to the Gahcho Kué Project	Baseline case plus the Gahcho Kué Project	Application case plus reasonably foreseeable projects

[a] Includes approved projects.

The baseline case includes the temporal changes in the number of previous and existing projects known to occur within the study area, which can include little or no previous development (Section 6.6.2). Environmental conditions on the landscape before human development (i.e., reference conditions) were also included in the analysis. Analyzing a range of temporal conditions on the landscape is fundamental to understanding the cumulative effects of increasing development on wildlife populations. The application case occurs the anticipated year of construction of the Project, through the duration of predicted effects (i.e., until the effects are reversed or are deemed irreversible).

The future case includes the baseline case, application case, and reasonably foreseeable developments (Section 6.6.2). Currently, there are two known, reasonably foreseeable developments that may generate incremental changes on vegetation ecosystems (habitat) in the study areas for grizzly bear, wolverine, and wolf:

- Taltson Hydroelectric Expansion Project; and
- proposed East Arm National Park.

For wolf, there are four additional reasonably foreseeable developments that could affect population size and distribution:

- Yellowknife Gold Project;
- Nechalacho Project;
- Damoti Lake Gold Project; and
- NICO Project.

The temporal boundary for cumulative effects from future developments is a function of the duration of effects from the Project on carnivore populations. At a minimum, the time period for effects from the Project, and reasonably foreseeable developments would occur over 22 years (construction through closure). Except for the Taltson Hydroelectric Expansion Project (for which the anticipated footprint is known), effects analyses for the future case are mostly qualitative due to the large degree and number of uncertainties. There are uncertainties associated with the rate, type, and location of developments in the study area. There are also uncertainties in the direction, magnitude, and spatial extent of future fluctuations in vegetation (i.e., habitat), independent of Project effects. Consequently, potential cumulative effects from reasonably foreseeable developments (future case) other than the Taltson Hydroelectric Expansion Project are discussed in the section on uncertainty (Section 11.10.9).

Landscape metrics were determined for the reference, 2010 baseline, application, and future case in the study area, and for the spring through autumn period and winter period. Fragmentation analysis included the Tibbitt-to-Contwoyto Winter Road, other winter roads, and the Project Winter Access Road footprint for the winter period only. As mentioned above, reference conditions represent the initial period of baseline conditions (as far back as data are available). Here, the 2010 baseline case includes all previous, existing, and approved developments up to 2010, and includes the Winter Access Road for the Project (which was constructed in 2001, 2002, and 2006).

The incremental and cumulative changes from the Project and other developments on the loss and fragmentation of habitat were estimated by calculating the relative difference between the 2010 baseline and reference case, between the application and 2010 baseline case, and between the future and application case. The following equations were used:

- (2010 baseline value – reference value) / reference value
- (application value – 2010 baseline value) / 2010 baseline value
- (future case – application value) / application value

The resulting value was then multiplied by 100 to give the percent change in a landscape metric for each comparison. The result provides both the direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of that habitat type. Alternately, a negative value for mean distance to nearest neighbour indicates an increase in patch connectivity. Appendix 11.10.I (Tables 11.10.I-1 and 11.10.I-2) contains absolute values per habitat type and assessment case (i.e., reference, baseline, application, and future).

11.10.4.2.2 Results

For grizzly bear and wolverine, the assessment of effects was based on the predicted cumulative changes from reference conditions through application of the Project and other reasonably foreseeable developments. The spatial boundary of the assessment is at the scale of the range of the populations. Cumulative effects from the Project and other developments influence the entire population range (i.e., beyond local and regional scale effects). In contrast, the geographic extent of incremental changes to habitat quantity from the Project has a local to regional influence on the population range of carnivores.

The total area of the Project footprint is estimated to be 1,235 ha. This includes 853.3 ha of mine and infrastructure that will directly affect terrestrial and aquatic resources (Section 11.7). An additional 382.1 ha of water (shallow and deep water) is not expected to be directly altered by the Project during construction and operation. Approximately 68% of the Project footprint is aquatic habitat and 32% is terrestrial habitat.

At the local scale, the Project footprint will alter 4.4% of the baseline LSA. Most of the winter road within the LSA will be over frozen lake areas and not affect terrestrial habitat types (Figure 11.7-3). Terrestrial habitat types that will be disturbed most include tussock-hummock, sedge wetland, and peat bog (all decreased by 0.4%). These habitats are some of the most abundant vegetation communities within the LSA (and RSA). Other terrestrial habitats altered by the Project footprint include heath tundra, heath tundra with bedrock or boulders, birch seep, and riparian tall shrub (all decreased by less than 0.4% relative abundance in the LSA). No esker is expected to be altered. During construction and operation, the Project footprint will decrease the lake surface area within the LSA by 2.2%.

Although progressive reclamation will be integrated into mine planning as part of De Beers' design for closure policy, arctic ecosystems are slow to recover from disturbance. In addition, not all of the areas will be reclaimed. For example, as a result of locally expressed concerns, the Fine PKC Facility will not be vegetated to prevent the facility from becoming attractive to wildlife (Section 11.7). The mine rock piles, Coarse PK Pile and Fine PKC Facility will be permanent features on the landscape, covering approximately 302.7 ha of terrestrial habitat.

At the scale of the population range and under reference conditions, waterbodies (non-vegetated) constituted about 34% of the study area (i.e., SGP) for grizzly bear and wolverine. Heath tundra and heath rock made up 22% and 17% of the landscape, respectively. The study area was comprised of 7% boulder fields, 3% lichen veneer, and 2% of forest and low shrub. Eskers and riparian shrub each represented less than 1% of the landscape during reference conditions.

For spring through autumn, total area per habitat was reduced by less than 1% from reference to 2010 baseline conditions. Previous and existing developments have physically altered about 1.6% of the landscape in the study area (Table 11.10-11). With the addition of the Project, incremental decreases in the area of each habitat were less than 0.01% per habitat type. Overall, the Project is expected to disturb less than 0.1% of the landscape in the study area. Development of reasonably foreseeable projects (i.e., Taltson Hydroelectric Expansion Project) would be expected to further reduce the quantity of each habitat by less than 0.1% (Table 11.10-11). The cumulative direct disturbance to the landscape from the Project and other previous, existing and future developments is predicted to be about 2% relative to reference conditions.

Esker habitat is of particular importance for grizzly bears. The area of esker habitat has declined by 0.9% within the population range since reference conditions (Table 11.10-11). The Project is predicted to not disturb esker habitat. Footprints from the Project and previous, existing, and future developments are expected to reduce the area of esker habitat by approximately 1%. Similar trends were noted for the number of patches of esker habitat, and distance between patches. Previous and existing developments have reduced the number of esker patches and increased the distance between patches by about

0.3% (Table 11.10-11). The addition of potential future developments resulted in a less than 0.1% change in the number and distance between esker patches.

Increasing development on the landscape has also resulted in marginal changes to the number and distance between similar habitat patches (other than eskers) in the population range of grizzly bears and wolverine during the spring to autumn period. The change in number of patches and distance between similar habitat patches for any habitat from reference to 2010 baseline conditions was calculated to be less than 0.1% for both metrics (Table 11.10-11). Habitat-specific incremental changes from the Project or future projects are estimated to be less than 0.1%.

During the winter period, previous and existing developments (which include footprints from the Winter Access Road to the Project and other winter roads) have physically altered about 2.3% of the landscape relative to reference conditions. This represents a marginal increase in landscape disturbance of 0.7% (from 1.6 to 2.3%) relative to the non-winter period (compare Table 11.10-11 and Table 11.10-12). Most of the change is associated with the temporary disturbance of frozen lakes from winter roads; however, there was an additional disturbance of 0.1% to esker habitat. Similar results were produced for relative changes between the non-winter and winter periods for the number and distance between similar habitat patches (Table 11.10-11 and Table 11.10-12).

Application of the Project resulted in less than a 0.1% decrease in habitat on the landscape during winter. Addition of the proposed Taltson Hydroelectric Expansion Project (and associated winter roads during construction) reduced the amount of habitat in the study area by approximately 0.5%. Habitat-specific changes in the number and distance between similar habitat patches were less than 0.1% for both the application and future cases (Table 11.10-12).

Table 11.10-11 Change (%) in Area and Configuration of Habitat Types from Development within the Study Area for Grizzly Bear and Wolverine during Baseline, Application, and Future Conditions in the Spring to Autumn

Habitat	Area (ha)	% Change to			Number of Patches	% Change to			Mean Nearest Neighbour Distance (m)	% Change to		
	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future
Esker	88,220	-0.94	0.00	-0.05	9,707	-0.27	0.00	-0.03	1,080	0.29	0.00	0.03
Non-vegetated	6,667,012	-0.08	-0.01	-0.02	90,108	0.01	0.02	0.03	486	0.01	0.00	0.01
Forest	402,820	-0.02	0.00	-0.03	10,770	-0.06	-0.01	-0.02	726	0.03	-0.07	-0.02
Peat bog	62,420	-0.06	0.00	-0.05	8,630	-0.06	0.00	-0.03	695	0.01	0.00	0.01
Heath rock	3,208,956	-0.06	0.00	-0.05	93,409	-0.06	0.00	-0.03	509	0.01	0.00	0.01
Heath tundra	4,328,192	-0.10	0.00	-0.05	82,406	-0.02	0.00	0.03	513	0.02	0.00	0.00
Lichen veneer	607,216	-0.08	-0.01	-0.05	33,085	-0.01	0.01	0.08	704	0.01	0.00	-0.01
Rock assoc.	1,440,404	-0.05	-0.01	-0.04	45,304	-0.05	-0.02	-0.01	678	0.01	0.01	0.01
Sedge assoc.	2,071,948	-0.07	0.00	-0.01	94,458	-0.07	0.00	-0.02	555	0.04	0.00	0.01
Low shrub	323,088	-0.09	0.00	-0.04	20,017	-0.05	0.00	0.02	826	0.02	0.00	-0.01
Riparian shrub	101,664	-0.03	0.00	-0.02	13,747	-0.07	0.00	-0.01	917	0.05	0.00	-0.04
Old burn	46,208	0.00	0.00	0.00	2,942	0.00	0.00	0.00	785	0.00	0.00	0.00
Young burn	25,392	0.00	0.00	0.00	156	0.00	0.00	0.00	4,031	0.00	0.00	0.00

Notes: % Change was measured as the relative incremental change from one time period to the next (e.g., reference (no to little development) to 2010 baseline, 2010 baseline to application, and application to future).

Values of 0.00 represent values greater than or equal to zero, but less than 0.005.

ha = hectares; m = metres

Table 11.10-12 Change (%) in Area and Configuration of Habitat Types from Development within the Study Area for Wolverine during Baseline, Application, and Future Conditions in the Winter

Habitat	Area (ha)	% Change to			Number of Patches	% Change to			Mean Nearest Neighbour Distance (m)	% Change to		
	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future
Esker	88,220	-1.04	0.00	-0.05	9,707	-0.28	0.00	-0.04	1,080	0.20	0.00	0.04
Non-vegetated	6,667,012	-0.30	-0.01	-0.04	90,108	0.11	0.02	0.06	486	0.01	0.00	0.00
Forest	402,820	-0.08	0.00	-0.05	10,770	-0.03	-0.01	-0.06	726	0.06	-0.07	0.02
Peat bog	62,420	-0.10	0.00	-0.09	8,630	-0.08	0.00	-0.02	695	0.02	0.00	0.02
Heath rock	3,208,956	-0.10	0.00	-0.09	93,409	-0.08	0.00	-0.02	509	0.02	0.00	0.02
Heath tundra	4,328,192	-0.13	0.00	-0.06	82,406	-0.01	0.00	0.03	513	0.02	0.00	0.00
Lichen veneer	607,216	-0.13	-0.01	-0.05	33,085	0.04	0.00	0.07	704	0.00	0.00	-0.02
Rock assoc.	1,440,404	-0.07	-0.01	-0.04	45,304	-0.07	-0.02	-0.01	678	0.01	0.01	0.01
Sedge assoc.	2,071,948	-0.08	0.00	-0.01	94,458	-0.07	0.00	-0.03	555	0.03	0.00	0.01
Low shrub	323,088	-0.13	0.00	-0.05	20,017	-0.04	0.00	0.03	826	0.03	0.00	-0.01
Riparian shrub	101,664	-0.05	0.00	-0.02	13,747	-0.10	0.00	-0.03	917	0.10	0.00	-0.03
Old burn	46,208	-0.04	0.00	0.00	2,942	-0.14	0.00	0.00	785	0.07	0.00	0.00
Young burn	25,392	0.00	0.00	0.00	156	0.00	0.00	0.00	4,031	0.00	0.00	0.00

Notes: % Change was measured as the relative incremental change from one time period to the next (e.g., reference (no to little development) to 2010 baseline, 2010 baseline to application, and application to future).

Values of 0.00 represent values greater than or equal to zero, but less than 0.005.

ha = hectares; m = metres; % = percent

11.10.4.3 Habitat Quality, Behaviour, and Movement

11.10.4.3.1 Local and Regional-scale Effects from the Project

Dust Deposition and Sensory Disturbances

Methods

Although the indirect effects from dust deposition and sensory disturbance are included in the habitat suitability modelling, the potential effects on grizzly bear and wolverine from each stressor are also assessed separately. Accumulation of dust (i.e., TSP deposition) produced from the Project may result in a local indirect change on the quality of habitat available within the LSA. Air quality modelling was completed to predict the spatial extent of dust deposition from the Project. Air quality modeling was completed for the baseline case, the construction case, and the application case. The assessment of the application case is anticipated to capture the maximum effects resulting from the Project.

Sources of dust deposition modelled in the application case include blasting activities, haul roads, the processing plant, activities at the mine pits and other ancillary facilities (e.g., mine rock piles, Coarse PK Pile and Fine PKC Facility), and vehicle traffic along the Winter Access Road. Assumptions incorporated into the model are expected to contribute to conservative estimates of deposition near the Project emission sources (Section 11.4).

Mining activities and associated infrastructure generate noise which may influence the habitat quality, movement, and behaviour of carnivores. Therefore, a noise assessment was completed to identify the sound emissions associated with the Project activities and the potential effects on grizzly bears and wolverine.

The focus of the noise assessment was on determining changes to the existing ambient noise levels due to Project operation, and comparing the results with noise regulations and guidelines from North American jurisdictions. Because there are no noise level guidelines for wildlife, human noise level guidelines were applied to predicting effects on carnivores. The evaluation of the noise effects focused on evaluating the noise levels associated with the fully developed operation. Model scenarios were established to calculate normal Project operations that could potentially affect noise levels (e.g., blasting, crusher, mill, workshop, power plant, auxiliary equipment, and “building hum”), resulting in predictions for continuous noise, and airstrip noise events.

The Project will be accessed annually during the winter months for delivery of major materials along the Winter Access Road, which will typically be in operation from late January or early February through March, and under favourable conditions, into early April. This may result in noticeable noise at key receivers near the Project during the winter season. However, grizzly bears will not be affected by sensory disturbance from the Winter Access Road because individuals are typically hibernating at this time.

Results

The results from the air quality modelling predicted that the maximum annual dust deposition from the Project is 6,292 kg/ha/y within the Project development area boundary (i.e., Project footprint) and 5,520 kg/ha/y outside of the Project development area boundary. The maximum deposition that occurs is mostly associated with the mine pits and haul roads. The maximum predicted dust deposition rate is expected within 100 m of the Project footprint. The most deleterious effects of dust are generally confined to the immediate area adjacent to the dust source (e.g., a haul road) (Everett 1980; Walker and Everett 1987). Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50-m buffer on either side of a road. Meininger and Spatt (1988) found that the majority of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 and 500 m from the road.

Noise will be generated from mobile and stationary mining equipment, blasting, and aircraft at the Project. The recommended maximum value for the nighttime noise level for undeveloped areas is 40 (dBA). This is the average nighttime (23:00 – 07:00) sound level L_{eq} in dBA, that includes both project related noises and the ambient sound level (existing sound levels without project related noises). The typical nighttime ambient sound level in rural Alberta is 35 dBA Leq[1] with higher winds, precipitation, and thunder being the principal sources of increase above this value (Section 7; Appendix 7.II). During daytime hours these levels can be higher, due to higher levels of human activity and associated tolerance for noise levels. The projected noise levels from the various Project activities are compared with benchmarks in Table 11.10-13. The results show that while noise will be generated by the Project, the projected levels at identified noise receptors are below the benchmarks (with the exception of the 40 dBA limit at 1.5 km from the Project due to mine operations).

[1] ERCB 2007, Directive 038, Noise Control

Table 11.10-13 Summary of Noise Effects from the Project

Receptor	Mine Operations[c] L_{eq} (dBA)		Winter Road L_{eq} (dBA)		Airstrip L_{max} (dBA)	
	Prediction	Benchmarks	Prediction	Benchmarks	Prediction	Noise Event Benchmarks
Accommodations Complex (west side)	69	55[a]	35	55[a]	68	70[a]
Accommodations Complex (east side)	58	55[a]	35	55[a]	69	70[a]
East Arm National Park Boundary Location[d]	38	40[b]	35	40[b]	90	-
1.5 km Boundary Location[d]	44	40[b]	35	40[b]	92	-

[a] World Health Organization 1999

[b] ERCB 2007.

[c] Highest cumulative noise levels calculated at each receptor.

[d] Location with highest projected noise level along the length of the boundary.

L_{eq} = equivalent continuous sound and noise level; dBA = A-weighted decibel; L_{max} = maximum sound and noise level;

km = kilometre; ≥ = greater than or equal to; - = not applicable.

The analysis of blasting activity indicates that the maximum distances at which the criteria for peak ground (12.5 millimetres per second [mm/s]) and airborne vibration levels (120 linear decibels [dBL]) would be met are 596 and 730 m, respectively. A summary of the maximum distances for Project noise to attenuate to background levels are shown in Table 11.10-14. The distances indicate the area within which Project-related noises may be found to be distinguishable from the natural environment by people. When Project noise predictions diminish to levels below background, they are not expected to be distinguishable from natural noises.

Table 11.10-14 Distance for Noise Attenuation to Background Sound Levels for the Project

Background Noise Level	Mine Operations (km)	Winter Access Road (km)	Airstrip (km)
Continuous (35 dBA)	3.5 [a]	–	–
Noise Event	–	3.0 [b]	5.5

[a] Based on the distance to the nearest noise sources

[b] Based on maximum pass-by level.

n/a = not applicable; dBA = decibels; km = kilometres.

The distance for noise attenuation to background for mining operations (including blasting) is 3.5 km. Aircraft will be used for the movement of personnel and supplies to the Project site year-round. Aircraft noise will be limited to a few minutes during takeoff and landings, and a maximum of two round-trip flights per day are expected during Project construction and operations. The distance for noise attenuation to reach background levels from the airstrip is 5.5 km

(Table 11.10-14). However, disturbance from large aircraft is expected to be infrequent and short-term (less than 5 minutes in duration).

Wildlife are generally considered to avoid noise, but will habituate to high noise levels if there are advantages. For example, studies of birds at airfields have shown that birds will habituate to noise levels of over 120 dBA, likely because of an absence of humans and an abundance of vegetation and/ or food (Busnel and Briot 1980). Discriminating wildlife perception of noise in isolation of other senses (such as odours and sight) is also problematic. No information specific to the effects of noise on grizzly bear or wolverine was identified; however black bear spatial distribution was not found to be affected by noise in a military training area (Telesco and Van Manen 2006).

In contrast, results of a telemetry study showed that wolves were found to be attracted to weapons-firing noise (Merrill and Erickson 2003). Two of three wolves studied showed movements towards firing points more often than expected, particularly if wolves were less than 5 km from the firing point when firing began. The authors noted that this was the first study to document wildlife movement towards loud anthropogenic (man-made) noise, and cited several confounding factors such as sample size, wolf relatedness, and territorial behaviour (Merrill and Erickson 2003). Reproductive rates and pup survival in farmed blue fox were not found to be affected by aviation noise (Pyykoenen et al. 2007). Noise varied from 85 to 120 dBA from aircraft overflights at a fox farm, which was compared to a control farm without aircraft overflights (Pyykoenen et al. 2007).

Effects from Winter Roads

During the two-year construction period, up to 25 trucks are anticipated to be on the Winter Access Road in a 24-hour period (1,500 to 2,000 trucks per year per 12 week period). Traffic is anticipated to decrease to 14 trucks and 3 trucks per 24 hour period on the Winter Access Road during operations and initial closure (two year period), respectively. The predicted noise levels from the winter road are compared with relevant criteria in Table 11.10-13. The results show that while noise will be generated by the Winter Access Road, the expected levels are within relevant criteria established for remote areas. This change in habitat suitability is periodic as winter roads are in operation for an average of 8 to 12 weeks each year.

Noise from the Winter Access Road is predicted to diminish to background levels within 3 km (Table 11.10-14), based on traffic volume during the construction period, and within 500 m during the operation phase. Although there is potential for trucks passing by a location along the Winter Access Road to alter wolverine movement and behaviour, the potential effects will be limited to the seasonal use of the Winter Access Road. Grizzly bear movements and behaviour should not be affected by winter roads because the roads will only be in use during the winter months, when bears are in hibernation.

11.10.4.3.2 Effects Beyond the Regional Scale of the Project

Methods

At the scale of the population range, the quality of grizzly bear and wolverine habitat was classified using resource selection function methods with both a human development database (described in Section 11.10.4.2.1) and a remote sensing Land Cover of Canada (1985 to 2000) provided by the Government of Canada in a GIS platform (Johnson et al. 2004, 2005). The latter land cover dataset was modified from 1,000-m cell sizes to a 25-m resolution, and then joined with an esker layer (1:50,000 scale) from the national topographic database (NTDB). The merged database was similar to SGP dataset used in Johnson et al. (2004, 2005). However, upon joining layers, the dataset was re-sampled to 200-m cell sizes using a nearest neighbour algorithm (versus 100 m in Johnson et al. [2004, 2005]) because of later computational constraints with generating habitat rasters for the study area. Tests for accuracy suggested there were marginal differences in the overall areas per cover type between a 100-m resampled dataset, versus a 200-m resampled dataset (i.e., less than 0.1%). Finally, the Land Cover of Canada dataset was reclassified into 12 classes according to Johnson et al. (2004, 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.

Using the output from the reclassified dataset, patches of habitat per land cover type were identified such that each patch was as 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 resource selection function (RSF) coefficients and formulas in Johnson et al. (2004, 2005) (Table 11.10-15; Table 11.10-16), resource selection values were generated per cell. Waterbodies were designated as nil (zero) during the habitat mapping process.

Table 11.10-15 Coefficients and 95% Confidence Intervals (CI) from Resource Selection Models for Grizzly Bear of the Canadian Central Arctic

Covariate	Spring Coefficient	Lower 95% CI	Upper 95% CI	Early Summer Coefficient	Lower 95% CI	Upper 95% CI
Sedge patch	0.585	0.142	1.029	1.381	0.994	1.768
Riparian shrub patch	1.527	0.458	2.595	2.085	1.003	3.167
Low shrub patch	1.388	0.849	1.928	1.994	1.484	2.504
Peat bog patch	n/a	n/a	n/a	n/a	n/a	n/a
Heath tundra	0.465	0.169	0.760	0.917	0.644	1.191
Heath rock	0.626	0.290	0.962	-0.001	-0.354	0.352
Rock patch	0.594	0.133	1.055	0.477	0.016	0.937
Forest patch	0.440	-1.811	2.692	n/a	n/a	n/a
Lichen patch	0.891	0.128	1.654	-0.542	-1.528	0.445
Esker patch	1.684	0.361	3.008	1.745	0.480	3.011
Unvegetated patch	2.053	1.447	2.660	0.081	-0.690	0.851
	Late Summer Coefficient	**Lower 95% CI**	**Upper 95% CI**	**Autumn Coefficient**	**Lower 95% CI**	**Upper 95% CI**
Sedge patch	1.269	0.852	1.686	0.631	0.087	1.176
Riparian shrub patch	2.164	1.175	3.154	1.364	0.125	2.604
Low shrub patch	1.963	1.389	2.537	2.030	1.275	2.785
Peat bog patch	1.366	-0.840	3.571	-0.866	-3.533	1.801
Heath tundra	0.630	0.330	0.930	1.137	0.795	1.479
Heath rock	0.214	-0.159	0.586	0.126	-0.321	0.572
Rock patch	0.158	-0.369	0.686	-0.072	-0.773	0.629
Forest patch	-0.131	-2.061	1.799	-0.486	-1.900	0.929
Lichen patch	-0.694	-1.718	0.330	-0.223	-1.316	0.870
Esker patch	4.876	3.812	5.940	1.864	-0.071	3.800
Unvegetated patch	0.999	0.246	1.752	0.594	-0.366	1.554

Source: Johnson et al. (2004, 2005).

n/a = not available; CI = confidence interval; % = percent.

Table 11.10-16 Coefficients and 95% Confidence Intervals from Resource Selection Models for Wolverine of the Canadian Central Arctic

Covariate	Winter Coefficient	Lower 95% CI	Upper 95% CI	Summer Coefficient	Lower 95% CI	Upper 95% CI
Sedge patch	1.802	1.146	2.458	1.739	0.975	2.504
Riparian shrub patch	1.509	-1.173	4.192	-0.687	-4.341	2.966
Peat bog patch	n/a	n/a	n/a	-4.949	-13.307	3.408
Heath tundra patch	0.445	-0.121	1.011	0.615	-0.001	1.230
Heath rock patch	0.749	0.230	1.268	0.181	-0.485	0.847
Rock patch	2.735	1.520	3.950	-0.791	-2.557	0.975
Lichen patch	-0.355	-1.715	1.005	-1.484	-3.629	0.660
Esker patch	-1.541	-4.671	1.590	0.579	-2.600	3.758

Source: Johnson et al. (2004, 2005).

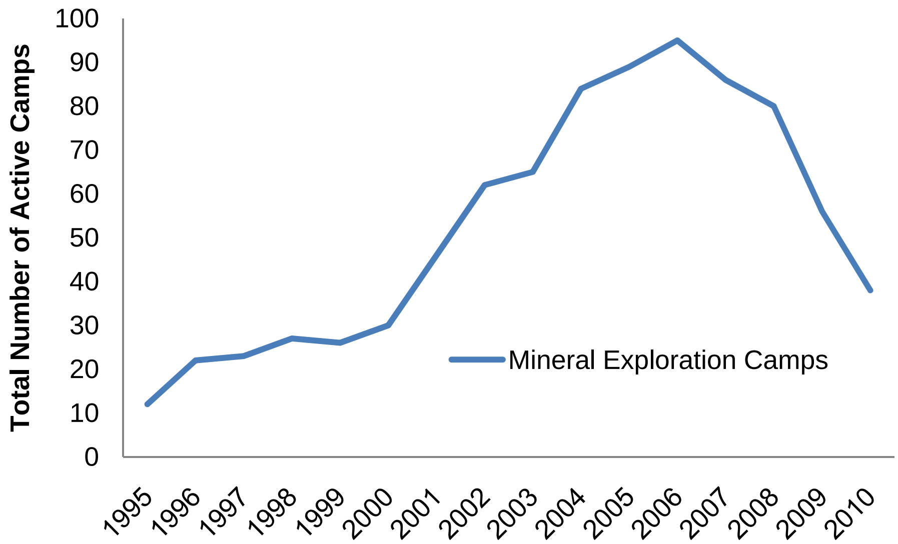
n/a = not available; CI = confidence interval; % = percent.

Effects of assumed disturbance, which were based on hypothetical (not modelled), disturbance coefficients and zones of influence, 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). Disturbance coefficients (DC) reduce habitat quality within each defined zone of influence (ZOI). For example, a DC of 0.05 implies that habitat quality was reduced by 95% of the original value.

Several assumptions were made concerning the temporal and spatial extent of effects from the different types of development, particularly with respect to estimating the cumulative effects on carnivores. The development layer database does not contain information on the duration of activities associated with land use permits. For example, although the land use permit for mineral exploration may be active for five years, there are no data on the actual frequency and length of time that exploration activities occurred during that period. Subsequently, to estimate the temporal extent of the zone of influence from exploration sites, the analysis assumed that approved land use permits were active for five years. The assumption likely overestimates the effect from exploration activities, as exploration typically does not occur throughout the year.

Effects of assumed disturbance were used to quantify changes in the relative availability of different quality habitats during different periods of increasing and decreasing development during baseline conditions (i.e., reference, 2000, 2006, and 2010), application of the Project, and future conditions (Figure 11.10-22). The number of human developments in the study area has changed over time and a key driver of this change has been the number of mineral exploration camps.

Figure 11.10-22 Temporal Changes in the Number of Active Mineral Exploration Camps in the Effects Study Area



Values of disturbance coefficients and zones of influence were guided by the published literature (Johnson et al. 2004, 2005; Table 11.10-17). Correlation among disturbance effects could not be statistically controlled, and therefore, the effects of multiple coefficients at the same location were not multiplied. The coefficient with the strongest effect was applied where zones of influence overlapped, which increased certainty that the predicted effect would not be under estimated. For all closed projects 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 the zone of influence was similar for all permitted mines (i.e., 15 km) regardless of the level of activity or size of the Project footprint.

After habitat maps and modelling for each seasonal home range were completed, raster cells (ranging 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 (i.e., no developments) were used as a reference condition within the baseline case.

Table 11.10-17 Disturbance Coefficients and Associated Zones of Influence for Development Activities in the Study Area for Grizzly Bear and Wolverine

Type	Feature Type	Footprint Extent (m)	Footprint DC	ZOI Range 1[c]	DC	ZOI Range 2	DC	ZOI Range 3	DC
Communications (e.g., microwave towers)	point	200	0.00	0 - 1 km	0.90	n/a	n/a	n/a	n/a
Community	polygon	actual[b]	0.00	0 - 1 km	0.05	1 - 5 km	0.50	5 - 15 km	0.75
Fuel storage	point	200	0.00	n/a	n/a	n/a	n/a	n/a	n/a
Historic remediated and non-remediated sites[a]	point	200	0.00	n/a	n/a	n/a	n/a	n/a	n/a
Lodge (outfitters, tourism)	point	200	0.00	0 - 5 km	0.10	n/a	n/a	n/a	n/a
Mine	polygon	actual[b]	0.00	0 - 1 km	0.05	1 - 5 km	0.50	5 - 15 km	0.75
Mineral exploration	point	500	0.00	0 - 1 km	0.50	1 – 5 km	0.75	n/a	n/a
Miscellaneous (e.g., bridge)	point	200	0.00	0 - 1 km	0.90	n/a	n/a	n/a	n/a
Quarry	point	200	0.00	0 - 5 km	0.75	n/a	n/a	n/a	n/a
Staging area / barge landings	point	200	0.00	0 - 5 km	0.75	n/a	n/a	n/a	n/a
Winter roads	line	200	0.00	0 - 1 km	0.05	1 - 5 km	0.75	n/a	n/a
Transmission line	line	200	0.25	0 – 1 km	0.50	1 -5 km	0.75	n/a	n/a

Note: Values were guided by published literature (Vistnes and Nelleman 2001; Mahoney and Schaefer 2002; Nelleman et al. 2003; Johnson et al. 2005).

(a) From INAC contaminated sites database (classified as medium and high risk sites).

(b) Activities estimated with the exception of mine operations and communities, which were delineated and digitized from remote sensing imagery.

(c) From edge of measured or hypothetical footprint.

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

The following equations were used to calculate the relative change in the amount of different quality habitats for each seasonal-range for different conditions on the landscape:

- (2000 baseline area – reference area) / reference area x 100
- (2006 baseline area – 2000 baseline area) / 2000 baseline area x 100
- (2010 baseline area – 2006 baseline area) / 2006 baseline area x 100
- (application case area – 2010 baseline area) / 2010 baseline area x 100
- (future case area – application case area) / application case area x 100

Results

Changes to preferred habitats (i.e., good and high quality habitats) were evaluated through the use of RSF maps of the population range (i.e., study area) per season for grizzly bear and wolverine. The relative changes in the area of good- and high quality habitats between landscape conditions were described to assess incremental and cumulative effects from the Project and other developments in the study area on grizzly bear and wolverine populations (see figures in Appendix 11.10.II).

The amount of high and good quality habitats for grizzly bear and wolverine in the study area decreased from reference to 2010 baseline conditions (Table 11.10-18; Table 11.10-19). Most of the decline in habitat quality occurred from 2000 to 2006 and was associated with the increasing number of exploration sites on the landscape (Figure 11.10-22). Relative to 2006, the availability of quality habitats in the study area was higher in 2010 (Tables 11.10-18 and 11.10-19), which was due to the decrease in the number of active developments.

There was also a noticeable increase in the quantity of poor habitat in the study area from reference to future conditions, particularly the late summer season for both grizzly bear (130%) and wolverine (179%) (Table 11.10-18; Table 11.10-19). This increase is partially due to the smaller amount of poor habitat relative to low and preferred habitats on the landscape (i.e., a small absolute increase represents a large proportional change). Except for development footprints, most poor habitat in the study area is a result of indirect changes to habitat quality and does not represent inhospitable or potential hazardous areas for grizzly bear and wolverine. Unlike the matrix of more rural and urban landscapes that can restrict movement between habitat patches or dispersal across the area (Fahrig 1997; Swift and Hannon 2010), the increase in poor habitat in the study area is predicted to have a negligible effect on the movement and survival of individual grizzly bears and wolverines.

For the spring season, preferred grizzly bear habitat decreased by 9.8% from reference to 2010 baseline conditions (Table 11.10-18). Addition of the Project resulted in an incremental decrease of 0.1% of good quality habitat. Under future conditions, the Taltson Hydroelectric Expansion Project could produce a further decrease in preferred habitat of 2.5%. The predicted cumulative decrease in high and good quality habitat from reference to future conditions is 12.4%.

Table 11.10-18 Relative Changes in the Availability of Different Quality Habitats per Season for Grizzly Bear from Reference to Reasonably Foreseeable Projects

Season / Habitat Category	Reference (ha)	% Change Reference to 2000 Baseline	% Change 2000 to 2006 Baseline	% Change 2006 to 2010 Baseline[(a)]	% Change 2010 to Application	% Change Application to Future	Cumulative % Change Reference to Future
Spring							
High	1046452	-4.98	-2.84	1.85	0.00	-1.34	-7.31
Good	2364664	-2.70	-4.39	3.30	-0.11	-1.19	-5.09
Low	2211996	-3.58	-2.14	2.21	-0.78	-1.15	-5.45
Poor	9980676	1.96	1.72	-1.32	0.19	0.63	3.17
nil (water)	4252192						
Total	**19855980**						
Early Summer							
High	2204724	-2.08	-2.76	2.32	0.00	-1.02	-3.55
Good	2553100	-3.55	-2.44	1.90	-0.80	-1.04	-5.93
Low	4204980	-3.37	-2.54	1.86	-0.50	-1.10	-5.65
Poor	6636288	4.19	3.23	-2.36	0.57	1.30	6.94
nil(water)	4251236						
Late Summer							
High	2574400	-2.55	-4.66	3.27	-0.02	-1.21	-5.16
Good	3601020	-3.81	-2.16	1.83	-0.64	-1.19	-5.97
Low	8888700	-3.18	-2.58	1.83	-0.61	-1.15	-5.70
Poor	539668	90.02	40.36	-20.41	6.54	13.78	130.29
nil (water)	4252192						
Autumn							
High	2165200	-2.04	-5.46	3.29	-0.18	-1.80	-6.19
Good	2165888	-3.76	-1.78	1.59	-0.43	-1.12	-5.51
Low	10005828	-3.36	-2.56	1.88	-0.60	-1.12	-5.75
Poor	1266872	36.46	23.18	-12.96	3.77	8.68	59.13
nil (water)	4252192						

Notes: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous time period (analyses exclude nil habitat). Cumulative values may not exactly sum due to rounding.

Reference landscapes (no development) were compared to maps modified by hypothetical disturbance coefficients and zones of influence (i.e., assumed disturbance) for active developments.

2000, 2006, and 2010 Baseline = incremental changes from previous and existing developments.

Application case = Gahcho Kué Project plus 2010 baseline conditions; Future case = Taltson Hydroelectric Expansion Project plus application case.

(a) Increases in low to high quality habitats are due to expiration of exploration permits and absence of a zone of influence (i.e., no activity and only direct effects from physical footprint).

ha = hectares; % = percent.

Table 11.10-19 Relative Changes in the Availability of Different Quality Habitats per Season for Wolverine from Reference to Reasonably Foreseeable Projects

Season / Habitat Category	Reference (ha)	% Change Reference to 2000 Baseline	% Change 2000 to 2006 Baseline	% Change 2006 to 2010 Baseline[(a)]	% Change 2010 to Application	% Change Application to Future	Cumulative % Change Reference to Future
Summer							
High	3006804	-2.60	-4.44	3.33	-0.22	-1.44	-5.37
Good	2937620	-2.98	-2.45	1.76	-0.64	-0.93	-5.24
Low	9272880	-3.70	-2.47	1.80	-0.58	-1.17	-6.12
Poor	386484	131.74	46.91	-22.73	7.49	15.62	179.03
nil (water)	4252192						
Total	**19855980**						
Winter							
High	2175244	-5.95	-5.50	3.44	-0.38	-2.04	-10.42
Good	2149536	-6.09	-2.86	2.41	-1.08	-0.76	-8.39
Low	9694120	-6.46	-3.00	2.37	-1.04	-1.16	-9.30
Poor	1584888	55.97	17.88	-11.05	4.74	5.86	73.40
nil(water)	4252192						

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous time period (analyses exclude nil habitat). Cumulative values may not exactly sum due to rounding.

Reference landscapes (no development) were compared to maps modified by hypothetical disturbance coefficients and zones of influence (i.e., assumed disturbance) for active developments.

2000, 2006, and 2010 Baseline = incremental changes from previous and existing developments.

Application case = Gahcho Kué Project plus 2010 baseline conditions;

Future case = Taltson Hydroelectric Expansion Project plus application case.

(a) Increases in low to high quality habitats are due to expiration of exploration permits and absence of a zone of influence (i.e., no activity and only direct effects from physical footprint).

ha = hectares; % = percent.

For the early summer period, there was an estimated 6.6% decline in preferred habitats from reference to 2010 baseline landscapes, and an incremental decrease of 0.8% in good quality habitat with the addition of the Project. The Taltson Hydroelectric Expansion Project could result in a further 2.1% decrease in primary habitat. There is an estimated cumulative 9.5% decrease in preferred habitat from reference to future landscapes in the study area.

Previous and existing developments were calculated to have reduced preferred grizzly bear habitat by 8.1% in 2010 relative to reference conditions during the late summer season (Table 11.10-18). The Project is estimated to reduce both high and good quality habitat by less than 0.7%, and the Taltson Hydroelectric Expansion Project may decrease the availability of suitable habitat by an additional 2.4%. The predicted cumulative decrease in preferred grizzly bear late summer habitat from reference to future conditions is 11.1%.

There was an estimated 8.2% decline in high and good-quality habitats from reference to 2010 baseline conditions for the autumn season (Table 11.10-18). With the addition of the Project, there is a 0.6% incremental decline in preferred habitats. Under future conditions, the Taltson Hydroelectric Expansion Project may negatively affect a further 2.9% of high and good quality habitats. Thus, the cumulative change from the Project and other developments decreased preferred habitat by 11.7%.

The RSF and disturbance modelling approach was also used to describe relative changes in the availability of different quality habitats for wolverine during summer and winter periods. For the summer period, the 2010 baseline landscape had 7.4% less preferred habitat than the reference landscape (Table 11.10-19). The incremental change from the Project was a 0.9% reduction of preferred habitat, and the Taltson Hydroelectric Expansion Project could produce an additional 2.4% decrease. The predicted cumulative decrease in high and good quality habitat from reference to future conditions is 10.6%.

During the winter period, previous and existing developments decreased preferred habitat by 14.6% in 2010 relative to a landscape with no development (Table 11.10-19). Most of this decrease occurred prior to 2000 (12%) and is associated with seasonal ice roads such as the Tibbitt-to-Contwoyto Winter Road and access roads to mine sites (i.e., 86% of the area within zones of influence in the study area is due to winter roads). With the addition of the Project, there was an incremental decline in preferred habitat of 1.5%. Under future conditions, the Taltson Hydroelectric Expansion Project may negatively affect a further 2.8% of high and good quality habitats. Thus, the cumulative change from the Project and other developments decreased preferred habitat by 18.8% from reference to future conditions. However, most of this decrease (10%) is related to the temporary disturbance from winter roads on the landscape for 8 to 12 weeks during the winter period.

11.10.4.4 Effects on Population Viability

Another objective of this assessment was to evaluate the incremental effects of the Project, and cumulative effects of human land-use and natural factors on the viability of grizzly bear and wolverine populations using population viability analyses (PVA) in RAMAS 5.0® (Akçakaya 2005). The models were based on an existing software package (i.e., RAMAS) as it allows transparency and repeatability of methods.

Population viability analysis is an increasingly important modelling tool in the conservation and management of species (Akçakaya et al. 2004). In this assessment, previously published estimates of age-specific survival and reproduction rates, and considerations of internal population mechanisms were used to quantify the relative contribution of natural and human factors to modeled grizzly bear and wolverine population trajectories. It is emphasized that the models are not used to predict the number of grizzly bears or wolverines in 5 years, 10 years, or 30 years from now. Based on the lack of information for survival and reproductive rates associated with long-term temporal fluctuations in the abundance of grizzly bear and wolverine, the models should not be used to estimate future population sizes.

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 landscape scenarios or conditions. Local and regional effects from the Project and other developments on habitat quantity and quality, direct mine-related mortality, other human-conflict kills, and harvest rates were incorporated into model simulations. For example, results from the habitat quality analysis (Section 11.10.4.3.2), which includes direct and indirect habitat effects from development were linked to 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., severe weather-related events) and human activities (existing and future developments, and animal harvest) on the modeled population trajectories for grizzly bear and wolverine.

11.10.4.4.1 Methods

The models projected population sizes based on one population (i.e., there were not separate sub-populations). All simulations were run over a 30-year period (expected lifetime of the Project is 22 years) and replicated 1,000 times. At each time step, the number of animals per age group (or stage) 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 environmental variation associated with natural and human-related factors. In the simulations, sensitivity and effects analyses were completed by changing input parameters with different modifier variables (Table 11.10-20).

Table 11.10-20 Input Parameters and Associated Modifier Variables for Simulations in Population Viability Analysis Models

Input Parameters	Modifier Variables
Survival, fecundity	habitat harvest rate
Carrying capacity (K)	habitat
Initial population size	densities reported in literature
Catastrophe	frequency and intensity of severe weather-related events
Management actions	harvest rate

Structure of Current (2010) Baseline Model and Simulations

Grizzly Bear

A Leslie matrix was used to model an age-structured grizzly bear population (14 stages; 7 stages per sex): cubs, yearlings, subadults (including independent stages for age 2 to 5 years old) and adults (Table 11.10-21; Table 11.10-22). It was assumed that the minimum age of reproduction was 6 years (McLoughlin et al. 2003b). It was also assumed that male and female bears had identical age structures, mating was polygynous (each male can mate with more than one female at each time step) and that sex ratios at birth were equal (i.e., 1:1 ratio). A "birth-pulse" population was modelled, in which all breeding takes place in a short period of time. The Leslie matrix was based on a "post-breeding" census of bears, with the assumption that no mortality took place between breeding and the census.

The vital rates in the stage matrix for the PVA were based on rates used in McLoughlin et al. (2003b, c), which were calculated from 81 bears with satellite collars between May 1995 and June 1999 (Table 11.10-21, Table 11.10-22). Fecundity rates per sex were calculated by multiplying the annual fatality rate of 0.81 by a 0.5 sex ratio at birth, and then multiplied by the adult survival rate.

Table 11.10-21 Stage Matrix Comprised of Estimated Fecundity (first row of table) and Survival Rates (± 1 SD) of Stages for Female Grizzly Bear

	Cub	Yearling	Subadult (Age 2-5)[a]	Adult
Cub	0	0	0	0.396 (0.119)
Yearling	0.737 (0.118)	0	0	0
Subadult (age 2-5)[a]	0	0.683 (0.145)	0	0
Adult	0	0	0.831 (0.290)	0.979 (0.024)

(a) Implies independent 2, 3, 4, and 5 year stages for subadults.

Table 11.10-22 Stage Matrix Comprised of Estimated Fecundity (first row of table) and Survival Rates (± 1 SD) of Stages for Male Grizzly Bear

	Cub	Yearling	Subadult (Age 2-5)[a]	Adult
Cub	0	0	0	0.398 (0.119)
Yearling	0.737 (0.118)	0	0	0
Subadult (age 2-5)[a]	0	0.683 (0.145)	0	0
Adult	0	0	0.833 (0.294)	0.983 (0.033)

(a) Implies independent 2, 3, 4, and 5 year stages for subadults.

It is important to note that survival rates do not include mortality from hunting. To account for the influence of the annual regulated hunt in the baseline simulations, a harvest rate of five males and five females from the subadult and adult population was modelled (McLoughlin et al. 2003b), but only when the population was above 100 bears during a simulation. There is no current legal harvest of grizzly bear in the SGP (except in Nunavut). This cut-off likely overestimates effects from regulated hunting given that annual hunts would likely be banned well before the total population approached 100 individuals.

Another harvest scenario was simulated as part of the baseline model, which includes kills as part of non-regulated harvest, harvest for the protection of life and property, and subsistence hunting. This scenario is based on grizzly bear kills in the SGP summarized for the period of 1958 to 2000 in McLoughlin and Messier (2001). Specifically, it was assumed that 1.31% of male bears and 0.52% of female bears were removed each year from the population in the SGP. This is approximately five male bears and two female bears per year from a population of 800 bears.

Long-term data (1996 to 2009) collected at several mining operations were used to assess the effects of direct mine-related mortality from the Project and other developments (Table 11.10-4, Section 11.10.2.4). In total, there were four reported grizzly bear deaths over 54 mining years (construction and operation phases), all of which were assumed to be male bears greater than 1 year of age. In other words, the annual direct mine-related mortality is approximately 0.074 bears per mine per year. If there are four operating mines on the 2010 landscape, then the estimated total annual direct mine-related mortality is 0.30 bears per year. This is likely an overestimate considering that all mines would not concurrently contribute to the mortality of grizzly bear every year. Given that there are approximately 338 yearling, subadult, and adult males in a population of 800 bears (based on initial abundances in a stable age distribution), 0.089% (0.30 / 338) of the modeled male (greater than 1 year of age) bear population are removed each year because of direct mine-related mortality. The removal of individuals from the population by different mortality agents (i.e., regulated and non-regulated harvest, and mine-related loss) was modeled assuming that mortality was additive on survival rates.

Wolverine

A Leslie matrix was used to model an age-structured wolverine population (4 stages per sex [Table 11.10-23, Table 11.10-24] Persson et al. 2003; Persson 2003; Krebs et al. 2004). It was assumed that male and female wolverines had identical age structures. Mating was assumed to be polygynous (each male can mate with more than one female at each time step) and sex ratios at birth were assumed to be equal. A "birth-pulse" population was modelled, in which all breeding takes place in a short period of time. The Leslie matrix was based on a "post-breeding" census of wolverines, and the assumption that no mortality took place between breeding and the census.

The stage matrix for the PVA (Table 11.10-23, Table 11.10-24) incorporated fecundity rates and juvenile survival rates of Scandinavian wolverine (Persson 2003; Lofroth and Ott 2007), as well as survival rates synthesized for North America wolverines (Krebs et al. 2004). Because of low sample sizes and relatively few studies conducted on the tundra, adult and subadult survival estimates were based on pooled data from tundra, boreal, and montane ecological zones.

Table 11.10-23 Stage Matrix Comprised of Estimated Fecundity (first row of table) and Survival Rates (± 1 SD) of Stages for Female Wolverine

Age Class	Young-of-Year	Yearling (Age 1)	Subadult (Age 2)	Adult
Young-of year	0	0	0	0.397 (0.098)
Yearling (Age 1)	0.68 (0.118)	0	0	0
Subadult (Age 2)	0	0.85 (0.161)	0	0
Adult	0	0	0.85 (0.161)	0.88 (0.127)

Table 11.10-24 Stage Matrix Comprised of Estimated Fecundity (first row of table) and Survival Rates (± 1 SD) of Stages for Male Wolverine

Age Class	Young-of-Year	Yearling (Age 1)	Subadult (Age 2)	Adult
Young of year	0	0	0	0.397 (0.098)
Yearling (Age 1)	0.68 (0.118)	0	0	0
Subadult (Age 2)[(a)]	0	0.85 (0.161)	0	0
Adult	0	0	0.85 (0.161)	0.87 (0.186)

The estimated survival rates do not account for hunting and trapping pressures. To estimate the effect of the annual regulated hunt in the baseline simulations, a harvest rate of 20 wolverine from the subadult and adult population was modelled, but only when the regional population was above 100 wolverine during a simulation. This cut-off likely overestimates effects from regulated hunting given that annual hunts would likely be banned well before the total population approached 100 individuals.

A non-regulated harvest (e.g., subsistence harvest) was also included in the simulation. On average, 118 wolverines have been harvested according to annual reports for the Kitikmeot region of Nunavut that overlaps with the SGP (Mulders 2000). Although the exact number of wolverine currently being harvested from the SGP could not be determined, a total of 118 wolverines should be within the range of harvest estimates. Further, annual subsistence trapping may range from 56 to 175 wolverine based on the reported number of wolverine pelts sold in the NWT from 1995 to 2002 (Statistics Canada 2008, internet site). For simulations, a subsistence harvest rate of 9% was used, which is based on an annual harvest of 118 wolverines and a population of 1,298 wolverines in the SGP. Of the harvest totals, 65% were male and 35% were female (Mulders 2000).

Since 1996, 11 (presumably male) wolverine were found dead (2), accidentally killed (2) or intentionally removed as problem animals (7) over 54 years of combined mining construction and operation phases (i.e., 0.20 wolverine per mine per year) (Table 11.10-4; Section 11.10.2.4). If there are four operating mines on the 2010 landscape, then the estimated total annual direct mine-related mortality is 0.80 wolverines per year. This is likely an overestimate considering that all mines would not concurrently contribute to the mortality of wolverine every year. Given that there are approximately 263 yearling, subadult, and adult males in a population of 680 wolverine (based on initial abundances in a stable age distribution), 0.30% (0.80 / 263) of the modeled male (greater than 1 year of age) wolverine population are removed each year because of direct mine-related mortality. Similar to grizzly bear, the removal of individuals from the population by different mortality agents (i.e., regulated and non-regulated harvest, and mine-related loss) was modeled assuming that mortality was additive on survival rates.

Density Dependence and Carrying Capacity

A simple ceiling model based on the abundance of all stages was used that affected all vital rates. Under the ceiling type of density dependence, the population grows exponentially until it reaches carrying capacity of the landscape. A population that reaches carrying capacity remains at that level until a factor or set of factors causes the abundance of animals to drop below carrying capacity.

Grizzly Bear

Initial abundances were based on previous values reported in McLoughlin et al. (2003b). All simulations started with 800 individuals occupying the study area. For reference (no development) landscapes, carrying capacity (K) was estimated as approximately 1,200 individuals based on the upper (95%) confidence limits of pre-2000 population sizes in McLoughlin et al. (2003b). For current (2010) baseline conditions, K was reduced 9.8% to reflect the cumulative loss of good- and high quality habitats from development on the spring range from reference to 2010 baseline conditions (Table 11.10-18). This reduction was based on the season with the largest decline in preferred habitat for grizzly bears on the landscape.

Wolverine

All simulations started with 1,298 individuals, which was calculated using the mean density of wolverine at Daring Lake, Ekati, Diavik and Kennady Lake in 2005 and 2006 (Boulanger and Mulders 2007) and the study area (ca. 190,000 km^2). For wolverine, reference carrying capacities were calculated by adjusting recent abundance (i.e., density) estimates by the estimated loss of good and high quality habitat from reference to 2010 baseline (existing) conditions during winter (Table 11.10-19). For baseline K, the upper (95%) confidence limit of reported densities was used (Boulanger and Mulders 2007). This value was 1,539 wolverines. Thus, given that the estimated loss of preferred habitat from reference to existing conditions was 14.6%, the reference K was calculated as being 1,802 wolverines (1,539 / 0.854). This reduction was based on the season with the largest decline in preferred habitat for wolverine on the landscape, which is mostly due to disturbance from the 8 to 12 week operation of the winter roads (Section 11.10.4.3.2).

Stochasticity

Random events associated with environmental variation and the unpredictable nature of demographic variation can also influence population sizes. 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, integer 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 lognormal distributions described by fecundity and survival values and their associated standard deviations. The effects of stochasticity on fecundity, survival, and carrying capacity were assumed to be correlated within the populations. Modelling incorporated a coefficient of variation (CV) of 0.2 for population size estimates (N) to increase confidence that the environmental variation in N was not underestimated. In addition, a weather-related catastrophe affecting prey/food abundance (e.g., poor caribou calf production, poor berry crop) was modelled as reducing vital rates in all stages by 10% once every 10 years (Miller and Gunn 2003; Tews et al. 2007).

Sensitivity and Effects Analyses

To determine the relative influences of different model parameters (Table 11.10-20) on population viability, sensitivity analyses were conducted on parameter inputs for the baseline model. 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 abundance decline probabilities and associated risk curves (i.e., risk to population persistence) (Akçakaya et al. 2004). Abundance decline probability was defined as the probability that the population will decline (from 0 to 100%) at the end of the simulation. Here, the decline in abundance is a function of the magnitude of the percent decrease from the initial population size. The Kolmogorov-Smirnov test statistic (D) was used for identifying statistical significance ($P \leq 0.05$) of the maximum difference in the probability of population decline between risk curves for each simulation.

Using the 2010 baseline model, the following sensitivity analyses were completed:

- Sensitivity of vital rates was examined by i) decreasing survival rates of subadults, yearlings, and young-of-year by 10% (i.e., by 0.1 unit), ii) decreasing survival rates of adults by 10% (by 0.1 unit), and iii) decreasing fecundity rates by 10% (by 0.1 unit). These changes may reflect a reduction in habitat quality on the landscape, as well as increases in harvest rates.
- Carrying capacity was decreased by 10% to demonstrate the relative influence of potential further habitat loss caused by human development on the landscape. It is important to note that loss of preferred habitat (for either grizzly bear or wolverine) due to the Project was less than 1%.
- The sensitivity of periodic weather-related events that affect food abundance were examined by increasing the frequency of events by to once every five years for one simulation, and by increasing the intensity of the event to 20% reductions in vital rates for a second simulation.

Effects analyses (tests) also were completed to evaluate the relative change in population viability from different development and harvest rate scenarios. For example, the incremental effects from the Project on the viability of the population were examined by comparing the abundance decline probabilities and associated risk curves between the application model and the 2010 baseline model. Cumulative effects from the Project and other developments on the landscape were evaluated by comparing the future model with the reference model (see below).

Similar to sensitivity tests, differences between abundance decline probabilities and associated risk curves were reported. Non-overlapping 95% confidence intervals indicated strong differences between probabilities. The Kolmogorov-Smirnov test statistic was used for identifying statistical significance ($P \leq 0.05$) of the maximum reported difference in the probability of abundance decline between risk curves for each simulation.

The following landscape scenarios were examined for grizzly bear.

Reference simulation: removed all mine-related mortality (by changing non-regulated harvest from 1.31% to 1.22%) and increased carrying capacity to reference conditions (i.e., to 1,200 bears). This simulation will aid with quantifying the cumulative direct and indirect effects of development on population viability through a comparison of reference versus future simulations.

Application scenario: increased the rate of male bear mine-related mortality from 1.31% to 1.33% to simulate the hypothetical increase in annual loss of problem animals with the addition of the Project to the current (2010) baseline landscape. In addition, current baseline carrying capacity was reduced by an additional 0.8% to simulate the incremental loss of preferred habitat due to the Project. The largest change in area of preferred habitat (from 2010 to application) occurred for the early summer range (Table 11.10-18). This simulation will aid with quantifying the incremental effects of the Project on population viability though a comparison of current (2010) baseline versus application simulations.

Future scenario: increased the rate of male bear mine-related mortality from 1.31% to 1.33% to simulate the hypothetical increase in annual loss of problem animals with the addition of the Project to the current baseline landscape. In addition, current baseline carrying capacity was reduced 2.9% to simulate the loss of preferred habitat due to the Project plus reasonable foreseeable developments (i.e., Taltson Hydroelectric Expansion Project). This simulation will aid in quantifying the cumulative effects from the Project and previous, existing, and reasonably foreseeable developments on population persistence though a comparison of reference versus future scenarios.

Decreased regulated and subsistence harvest scenario: decreased the number of adult bears being harvested annually from the population (for sport and subsistence as part of a regulated hunt in the Kitikmeot region of Nunavut). The harvest was decreased from the current harvest of about 10 bears per year (9 permitted, and one subsistence, Atatahak, personal communication, 2008) to 0 bears per year. This simulation will aid with quantifying the effects of the regulated and subsistence harvest on population viability through a comparison of current baseline versus decreased harvest simulations.

The following landscape scenarios were examined for wolverine.

Reference simulation: removed all mine-related mortality and increased carrying capacity to reference levels (i.e., to 1,801 wolverine). This simulation will aid with quantifying the cumulative direct and indirect effects of human activities and development on population viability through a comparison of reference versus future simulations.

Application scenario: simulated the effects of the Project by increasing the rate of male wolverine mine-related mortality from 0.27% to 0.36%. In addition, current (2010) baseline carrying capacity was reduced by an additional 1.5% to simulate the incremental loss of preferred habitat from the Project. The largest change in area of preferred habitat (from 2010 to application) occurred for the winter range (Table 11.10-19). This simulation will aid with quantifying the incremental effects of the Project on population viability though a comparison of current (2010) baseline versus application simulations.

Future scenario: simulated the effects of the Project by increasing the rate of mine-related mortality from 0.27% to 0.36%. In addition, current baseline carrying capacity was reduced 4.3% to simulate the incremental loss of preferred habitat due to the Project plus reasonably foreseeable developments (i.e., Taltson Hydroelectric Expansion Project). This simulation will aid in quantifying the cumulative effects from the Project and previous, existing, and reasonably foreseeable developments on population persistence though a comparison of reference versus future scenarios.

Decreased regulated harvest scenario: annual regulated harvest of wolverine was reduced from 20 to zero. This simulation will aid with quantifying the effects of the regulated harvest on population persistence through a comparison of current baseline versus decreased harvest simulations.

Again the reader is reminded that the intent of the PVA is to estimate the relative contribution of different natural and human disturbance factors on changes to the abundance and persistence of grizzly bear and wolverine populations. The consensus among many population ecologists is that relative results of PVA, either from sensitivity analyses or comparisons among landscape scenarios, are more reliable for assessing effects than absolute results (McCarthy et al. 2003; Schtickzelle et al. 2005).

The problem with interpretation of absolute results, such as estimates of final abundance, is that they 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 will likely lead to incorrect conclusions. For both grizzly bear and wolverine, there is not enough information on vital rates during long-term changes in population size to accurately predict the number of animals in the near or distant future. In this assessment, abundance decline probabilities (i.e., probabilities of abundance being reduced by a certain percentage) as well as related risk curves are used for relative comparisons of different input parameters among models.

11.10.4.4.2 Results

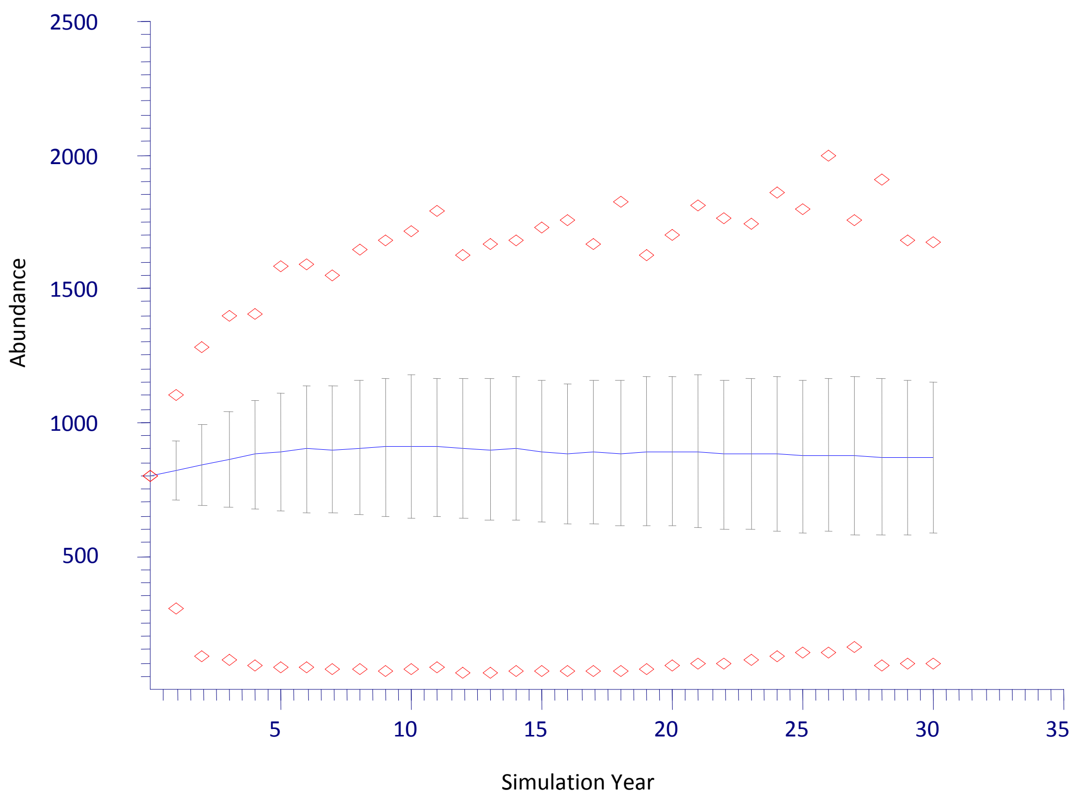
Grizzly Bear

Since 1996, there have been four grizzly bears removed from the population in the SGP due to mining activities (54 mining years among four mines). The mine-related mortality rate is 0.074 bears per mine per year, which is below the range predicted for the Diavik Diamond Mine (0.12 to 0.24 bears per year; DDMI 1998). In 2000, a grizzly bear cub near the Misery camp was put down after it was observed repeatedly foraging from a dumpster. In 2004, a large adult male bear was destroyed following repeated sightings around the Diavik accommodations complex, and two relocations from the East Island over a three-year period. In 2005, two grizzly bears were destroyed at the Ekati Diamond Mine. One was destroyed after multiple attempts at deterring it from camp, and the other was an old bear that was unresponsive to deterrent attempts. All bears were put down following discussions and permission from ENR biologists.

Since exploration (1999), there have been no grizzly bear mortalities at the Snap Lake Mine. Based on the length of time from construction to the end of closure (22 years) and an annual mortality rate of 0.074 bears per mine, it is predicted that 1 to 2 bears may be removed from the population due to the Project. This is a conservative estimate given that the Project will implement waste management and wildlife mitigation procedures similar to that used at the Snap Lake Mine.

Using the estimated vital rates and weather-related inputs, reference simulations (regulated and subsistence harvesting, but no development on the landscape) projected a relatively stable-to-slightly increasing population size, and an abundance decline probability (at 100% decline) equal to 0.0010 (<0.0001 to 0.029 [95% CI]; Figure 11.10-23). Sensitivity analyses showed that all vital rates, weather-related events, and carrying capacity parameters had a statistically significant effect on population viability (P < 0.01). Of the vital rates tested for sensitivity, adult survival was the most sensitive parameter in the stage matrix (D = 0.82; Table 11.10-25). A decrease in survival rate of subadult bears also had a significant influence on population viability. Changes in weather-related events and carrying capacity had similar influences on population declines (D = 0.17 to 0.20). Fecundity was the least sensitive parameter (D = 0.15).

Figure 11.10-23 Reference Population Trajectory of Mean Grizzly Bear Abundance 30 Years into the Future (± 1 SD, and minimum and maximum values as circles)



SD = standard deviation; ± = plus or minus.

Further analysis indicated that the incremental changes to habitat and survival rate (from mine-related mortality) from the Project had no statistical effect on population persistence relative to current baseline conditions (D = 0.05; P = 0.34). Similarly, there was no significant effect on the grizzly bear population from the addition of the Project and the Taltson Hydroelectric Expansion Project (future case) to the current landscape (P = 0.20; Table 11.10-25).

Analysis did suggest that the cumulative changes to habitat and survival from the Project and previous, existing, and future developments had a statistically significant effect on the decline probability curve relative to reference conditions (D = 0.16; P < 0.01). Although the elevations of the curves are different, the shapes of the curves are similar (Figure 11.10-24). There was an 11.1% decrease in the final projected mean abundance from the Project and other developments (772 [503 – 1041]) relative to reference conditions (868 [582 – 1153]), but the large overlap of the 95% confidence intervals with the mean values suggests that the difference is not statistically significant.

Analyses also showed that viability is clearly influenced by the current regulated harvest of grizzly bears. For example, if the regulated harvest is reduced to zero bears (i.e., there are no tags available for the regulated harvest), then the risk curve is significantly different than that associated with current baseline conditions (Table 11.10-25). The magnitude of the change in risk curves from eliminating the regulated harvest (D = 0.18) is similar to the magnitude of the change in simulating increased weather-related events, reductions in carrying capacity, and cumulative effects from development (D = 0.16 to 0.20; Table 11.10-25).

Table 11.10-25 Sensitivity Analyses of Parameter Inputs and Effects Tests for the Barren-ground Grizzly Bear Population Viability Analysis

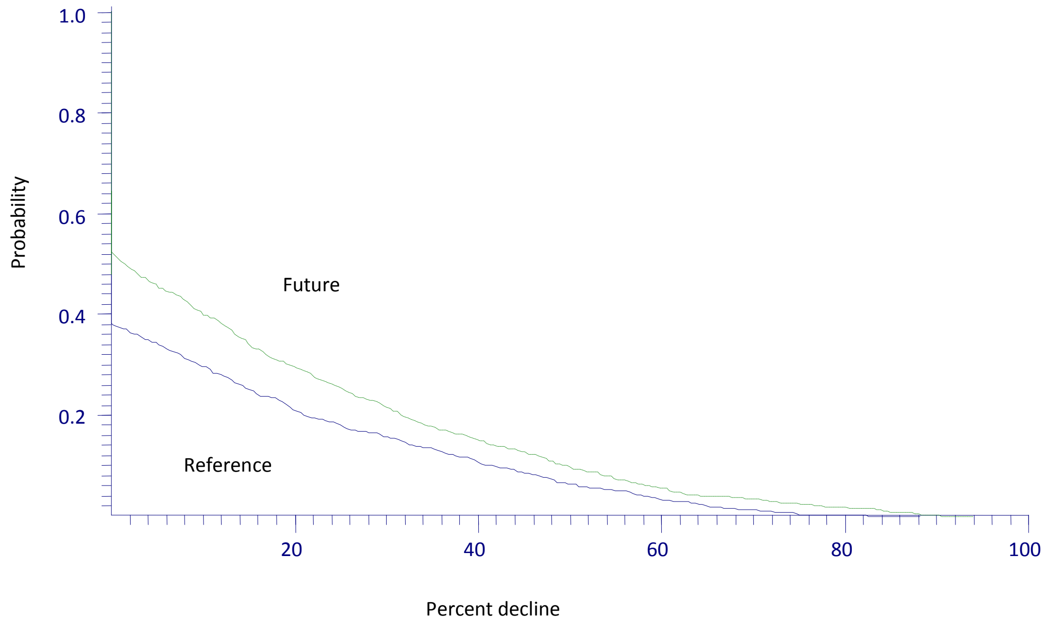
Simulation	Maximum Difference in Decline Probability between Risk Curves	Kolmogorov-Smirnov P-value	Abundance Decline Probability[b]	95% Confidence Interval
Sensitivity Tests for Current Baseline				
Current baseline	n/a	n/a	0.0010	<0.0001-0.0290
10% decrease in adult survival	0.82	<0.0001	0.0010	<0.0001-0.0290
10% decrease in fecundity	0.15	<0.0001	0.0010	<0.0001-0.0290
10% decrease in survival for age < 6 years	0.53	<0.0001	0.0010	<0.0001-0.0290
Increase in weather event frequency (10% to 20%)	0.17	<0.0001	0.0010	<0.0001-0.0290
Increase in weather event intensity (10% to 20%)	0.20	<0.0001	0.0010	<0.0001-0.0290
10% decrease in carrying capacity	0.18	<0.0001	0.0010	<0.0001-0.0290
Incremental Effects Tests				
Future (vs. current baseline)	0.05	0.1995	0.0010	<0.0001-0.0290
Application (vs. current baseline)	0.04	0.3410	0.0010	<0.0001-0.0290
Reduced harvest (vs. current baseline)	0.18	<0.0001	0.0010	<0.0001-0.0290
Cumulative Effects Test				
Reference (vs. future)	[a]0.16	<0.0001[a]	0.0010	<0.0001-0.0290

[a] Cumulative effects assessment that compared risk curves between future and reference scenarios; all other decline probability differences were for comparisons between landscape scenarios and the current baseline simulation.

[b] Abundance decline probability was for 100% decline in abundance.

% = percent; CI = confidence interval; < = less than.

Figure 11.10-24 Risk Curves of Probability of Percent Decline for Reference Simulation (Solid Line) and Future Simulation (Dashed Line) for Grizzly Bear

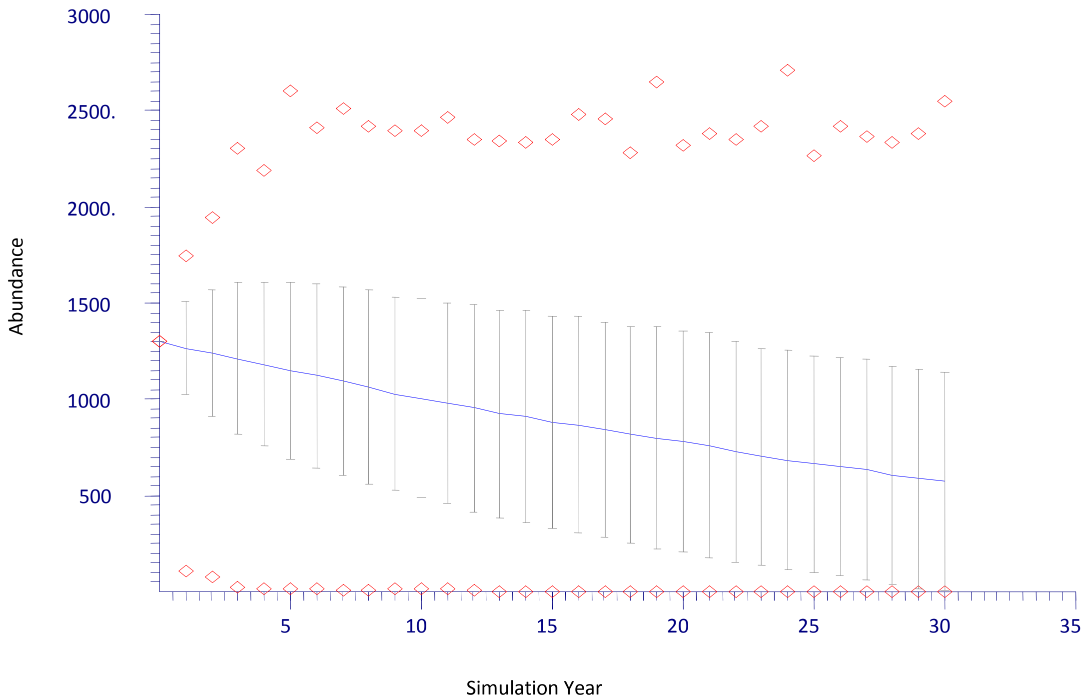


Wolverine

Since 1996, there have been 11 wolverine removed from the SGP population due to direct mine-related mortality, which is equivalent to a mortality rate of 0.204 wolverine per mine per year. In most cases, wolverines were destroyed following a period of unsuccessful deterrent action, and with the permission of ENR. Based on the length of time from construction to the end of closure (22 years) and an annual mortality rate of 0.204 wolverines per mine, it is predicted that 4 to 5 wolverines may be removed from the population due to the Project. This is a conservative estimate given that the Project will implement waste management and wildlife mitigation procedures similar to that used at the Snap Lake Mine where 1 wolverine has been killed during the 12 year period from exploration to current operations (1999 to 2010).

Using the estimated vital rates and weather-related events, the reference simulations (which included regulated and subsistence harvesting, but no development on the landscape) projected a stable but slightly declining population with an abundance decline probability (at 100% decline) equal to 0.004 (<0.0001 to 0.033 [95% CI]; Figure 11.10-25). Sensitivity analyses showed that all vital rates, weather-related events, and carrying capacity parameters had a statistically significant effect on population viability ($P < 0.01$). Sensitivity analyses showed that adult survival was the most sensitive parameter in the stage matrix (D = 0.52; Table 11.10-26). Adult survival rate was almost 1.5-times as sensitive as the second ranking parameter, which was survival of individuals in younger age groups. Changes in weather-related events and carrying capacity had similar influences on population declines (D = 0.06 to 0.12). Fecundity had a moderate influence on population viability relative to other model parameters (D = 0.24).

Figure 11.10-25 Reference Population Trajectory of Mean Wolverine Abundance 30 Years into the Future (± 1 SD, and minimum and maximum values as red circles)



SD = standard deviation.

To evaluate the incremental effects of the Project, risk curves and abundance decline probabilities for application and future scenarios were compared to the current baseline model (Table 11.10-26). Analysis indicated that the incremental changes to habitat and survival rate (from mine-related mortality) from the Project had no statistical effect on population persistence relative to current baseline conditions (D = 0.03; P = 0.83). Similarly, there was no significant effect on the wolverine population from the addition of the Project and the Taltson Hydroelectric Expansion Project (future case) to the current landscape (P = 0.26; Table 11.10-26).

Analysis did suggest that the cumulative changes to habitat and survival from the Project and previous, existing, and future developments had a significant influence on decline probability relative to reference conditions (D = 0.09; P < 0.01) Although the elevations of the curves are different, the shapes of the curves are similar (Figure 11.10-26). There was an 18.6% decrease in the final projected mean abundance from the Project and other developments (467 [7 - 927]) relative to reference conditions (574 [9 – 1140]), but the large overlap of the 95% confidence intervals with the mean values suggests that the difference is not statistically significant.

Analyses also showed that population viability is clearly influenced by the current regulated harvest of wolverines. For example, if the regulated harvest is reduced to zero animals, then the risk curve is significantly different than that associated with current baseline conditions (Table 11.10-26). The magnitude of the change in risk curves from eliminating the regulated harvest (D = 0.27) is 3 to 5 times greater than the magnitude of the change in simulating increased weather-related events, reductions in carrying capacity, and cumulative effects from development (D = 0.06 to 0.12; Table 11.10-26).

Table 11.10-26 Sensitivity Analyses of Parameter Inputs and Effects Tests for the Wolverine Population Viability Analysis

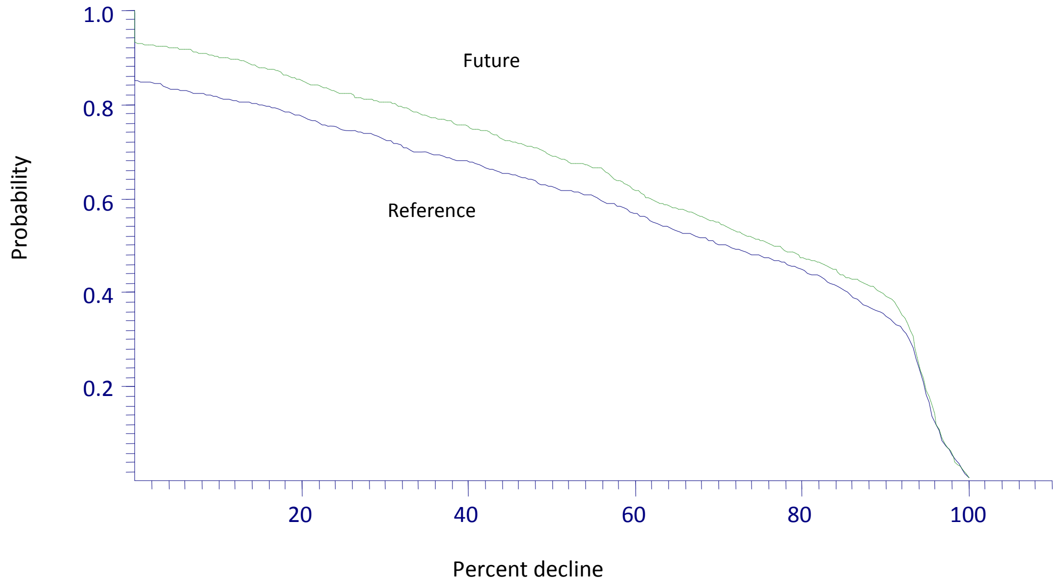
Simulation	Maximum Difference in Decline Probability Between Risk Curves	Kolmogorov-Smirnov P-value	Abundance Decline Probability [b]	95% Confidence Interval
Sensitivity Tests for Current Baseline				
Current baseline	n/a	n/a	0.0040	<0.0001 to 0.0320
10% decrease in adult survival	0.52	<0.0001	0.0160	<0.0001 to 0.0440
10% decrease in fecundity	0.24	<0.0001	0.0080	<0.0001 to 0.0360
10% decrease in survival for subadults to young-of-year	0.37	<0.0001	0.0050	<0.0001 to 0.0330
Increase in weather event frequency (10% to 20%)	0.08	0.0062	0.0040	<0.0001 to 0.0320
Increase in weather event intensity (10% to 20%)	0.12	<0.0001	0.0020	<0.0001 to 0.0300
10% decrease in carrying capacity	0.06	0.0378	0.0030	<0.0001 to 0.0310
Incremental Effects Tests				
Future (vs. current baseline)	0.05	0.2634	0.0070	<0.0001 to 0.0350
Application (vs. current baseline)	0.03	0.8280	0.0050	<0.0001 to 0.0330
Reduced harvest (vs. current baseline)	0.27	<0.0001	0.0010	<0.0001 to 0.0290
Cumulative Effects Test				
Reference (vs. future)	[a]0.09	<0.001[a]	0.0040	<0.0001 to 0.0330

(a) Cumulative effects assessment that compared risk curves between future and reference scenarios; all other decline probability differences were for comparisons between landscape scenarios and the current baseline simulation.

(b) Abundance decline probability was for 100% decline in abundance.

n/a = not applicable; % = percent; CI = confidence interval; < = less than.

Figure 11.10-26 Risk Curves of Probability of Percent Decline for Reference Simulation (Solid Line) and Future Simulation (Dashed Line) for Wolverine



11.10.4.5 Effects from Changes in Prey Availability

Gau et al. (2002) concluded that barren-ground grizzly bears lead a predominantly carnivorous lifestyle and are effective predators of caribou. Caribou was a predominant diet item during spring, mid-summer, and fall. During early summer grizzly bears foraged primarily on green vegetation. Berries increased in dietary importance in late summer.

Similar to the grizzly bear diet, studies of wolverine stomach contents indicated that caribou are their primary source of food. Caribou was found in the stomach contents of 62% of the 277 wolverine sampled from the SGP between 1995 and 1999 (Mulders 2000). Muskoxen and arctic ground squirrel were the next most common items, at 11% and 5%. These data support traditional knowledge that suggests that wolverines are scavengers, but are also known to kill caribou or smaller animals such as mice (LKDFN 1999).

Availability of caribou for the grizzly bear and wolverine populations is related to caribou population size and distribution. The addition of the Project to the existing landscape had no statistical effect on the modelled caribou population projections (Section 7). Cumulative effects from development were predicted to have a moderate effect on caribou abundance, which may change the encounter rates between grizzly bear and caribou. These changes are predicted to approach or slightly exceed the limits of baseline conditions. The number of carcasses available for scavenging by grizzly bears and wolverines also may have decreased during the recent decline in the Bathurst herd. The natural decline in the caribou population also was likely associated with decreased predation rate on caribou by grizzly bears. This change may have influenced adult survival and juvenile recruitment for the grizzly bear and wolverine populations.

Caribou are predicted to change their distribution and reduce habitat use within about 10 to 15 km from the Project (i.e., ZOI). Other developments also are predicted to have local and regional influences on caribou distribution. At the scale of the seasonal range, these changes in distribution are expected to be within the range of baseline conditions (Section 7). There are natural environmental factors that operate over large scales of space and time (e.g., fire, snowfall, food abundance, and quality) that likely have greater influences on regional distributions of caribou relative to effects from the Project and other developments. The Project and other developments are not expected to result in seasonal range shifts in caribou distribution, and should not affect prey distribution for grizzly bear and wolverine.

11.10.4.6 Related Effects on People

Hunting of grizzly bears is not permitted within the SGP (ENR 2010a, internet site), except for a regulated hunt in the Kitikmeot region of Nunavut. Typically, grizzly bear in the NWT may only be killed to defend life and property, and therefore, the Project should not influence the opportunity for people to harvest grizzly bear in the NWT.

The Winter Access Road and the Tibbitt-to-Contwoyto road may increase access to wolverine within the area of the Project when the winter roads are in operation (approximately 8 to 12 weeks each year). Harvesting of wolverine along the Tibbitt-to-Contwoyto Winter Road appears limited; only three kills were reported from 2004 to 2006 (Ziemann 2007, internet site). The number of vehicles travelling for hunting on the Tibbitt-to-Contwoyto Winter Road showed a decline from 573 vehicles in 2004 to 284 vehicles in 2006 (Ziemann 2007, internet site). Decreases in hunting traffic may have been due to high volumes of mine-related vehicles on the road (e.g., 2,543 loaded trucks in 1998 versus 11,656 in 2007). De Beers will also have a no firearms and no hunting policy for staff and contractors on site. Thus, during the winter road season, people at site will not benefit from increased access to the region for the harvesting of wolverine. It is predicted that the number of wolverine harvested in the region from improved access due to the Winter Access Road for the Project will not be detectable from baseline conditions.

The expected change in the regional distribution of grizzly bear and wolverine associated with the zone of influence from the Project (i.e., 15 km) may affect wilderness value associated with grizzly bear presence, and hunting success of wolverine at nearby outpost camps. In particular, Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project, and may experience small decreases in grizzly bear and wolverine encounters. These changes are expected to be within the range of baseline conditions. Martin et al. (2010) found that female brown bears may habituate to disturbance within their home range. In contrast, Artillery Lake Adventures has a camp situated on the west side of Artillery Lake, about 70 km east of the Project, and should not be influenced by the Project.

11.10.5 Effects on Population Size and Distribution of Wolf

The effects analysis considers all primary pathways that result in expected changes to wolves, after implementing environmental design features and mitigation. Thus, the analysis is based on the residual effects from the Project. The general approach to effects analyses described for grizzly bear and wolverine populations (Section 11.10.4.1) also applies to wolves. Residual effects to wolves are analyzed using measurement endpoints and are expressed as effects statements, including:

- effects from changes in habitat quantity and fragmentation; and
- effects from changes in habitat quality, movement, and behaviour.

The magnitude, spatial extent, and duration of changes in measurement endpoints (e.g., habitat quantity and quality) from the Project and other developments are expected to be similar to or greater than the actual effects to the abundance and distribution of populations. Effects statements may have more than one primary pathway that link a Project activity with a change in the wolf population. For example, the pathways for effects on wolf habitat quality, movement, and behaviour include changes due to noise, dust deposition, and the presence of vehicles and mine infrastructure.

Detailed descriptions of the spatial and temporal boundaries, and methods used to analyze residual effects from the Project on wolves 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. Traditional knowledge and community information were incorporated where available. Due to the amount and type of data available, some analyses were qualitative and included professional judgement or experienced opinion.

11.10.5.1 Habitat Quantity and Fragmentation

11.10.5.1.1 Methods

The incremental and cumulative direct habitat effects to the wolf population from the Project footprint and other previous, existing, and future developments in the wolf study area were analyzed through changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics). Trends in all habitat types are described, but emphasis is on changes in the quantity and configuration of esker habitat type. Similar to grizzly bears, wolves also use eskers for dens sites, foraging, and travel (LKDFN 2001b, internet site). The methods applied to wolverine and grizzly bear were also applied to wolf (Section 11.10.4.2.1), and are briefly summarized here.

The study area for wolf is equivalent to the annual range of the Bathurst herd (Section 11.10.1.3.5). The quantity of wolf habitat was classified using a remote sensing Land Cover of Canada (1985 to 2000) provided by the Government of Canada in a GIS platform (Johnson et al. 2004, 2005). The latter 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 SGP dataset used in Johnson et al. (2004, 2005).

The number and type of previous, existing, and reasonably foreseeable developments in the study area are listed in Table 11.10-27 and illustrated in Figure 11.10-21. For each development, an estimated footprint was applied to the land cover classification (Table 11.10-28). The Project footprint was derived from the Project Description, and includes both the terrestrial and aquatic areas of disturbance. For communities, and closed and operating mines, the footprint was digitized from Landsat 7 Imagery from the Government of Canada (CanImage 2007, internet site). Footprints for linear developments (all roads, transmission lines) were based on a 200-m corridor. The area of the footprint for most other developments (except exploration sites) was assumed to be a 200-m radius (12.6 ha).

Table 11.10-27 Previous and Existing Developments in the Study Area That Have the Potential to Affect the Wolf Population

Type of Development	Footprint Area (ha)	Number of Developments	Linear Feature Length (km)
Campground	138.1	11	n/a
Community	5,721.6	8	n/a
Communications (e.g., microwave towers)	62.8	5	n/a
Fuel storage	12.6	1	n/a
Historic remediated and non-remediated site[(a)]	602.8	52	n/a
Lodge (outfitters, tourism)	401.9	32	n/a
Mine	5,570.9	7	n/a
Mineral exploration	14,968.9	176	n/a
Miscellaneous (e.g., bridge / culvert installation)	62.8	5	n/a
Power	157.0	2	n/a
Quarrying	75.3	6	n/a
Staging area (equipment or material storage)	25.1	2	n/a
Transmission line	6,537.1	1	326.8
Winter road segments	37,073.7	140	1,926.8
All-season road segments	1,516.0	17	75.7
Highway segments	3,230.5	86	161.6
Total disturbance	**76,157.1**	**551**	**2,490.8**

(a) Includes moderate and high risk contaminated sites.

ha = hectare; km = kilometre.

Table 11.10-28 Hypothetical Footprints for Previous, Existing and Future Developments in the Study Area for Wolf

Type	Feature Type[(a)]	Footprint Extent (m)
Campground	point	200
Community	polygon	actual
Communications (e.g., microwave towers)	point	200
Fuel storage	point	200
Historic remediated and non-remediated site	point	200
Lodge (outfitters, tourism)	point	200
Mine	polygon	actual
Mineral exploration	point	500
Miscellaneous (e.g., bridge / culvert installation)	point	200
Power	point	500
Quarrying	point	200
Staging area (equipment or material storage)	point	200
Transmission line	line	200
Winter road segments	line	200
All-season road segments	line	200
Highway segments	line	200

(a) Footprint estimated with the exception of mine operations and communities, which were delineated and digitized from remote sensing imagery.

m = metre.

A 500 m radius was used to estimate the area of the footprint for exploration sites (78.5 ha), which 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 x 5 m area) at one location at a time. 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. Footprints with overlapping areas on the landscape were not counted twice.

Landscape metrics were determined for the reference, 2010 baseline, application, and future case in the study area, and for the spring through autumn period and winter period. Fragmentation analysis included the Tibbitt-to-Contwoyto Winter Road, other winter roads, and the Winter Access Road footprint for the winter period only. As mentioned above, reference conditions represent the initial period of baseline conditions (as far back as data are available). Here, the 2010 baseline case includes all previous, existing, and approved developments up to 2010, and includes the Winter Access Road for the Project (which was constructed in 2001, 2002, and 2006).

The incremental and cumulative changes to habitat from the Project and other developments were estimated by calculating the relative difference between the 2010 baseline and reference case, between the application and 2010 baseline case, and between the future and application case. The following equations were used:

- (2010 baseline value – reference value) / reference value
- (application value – 2010 baseline value) / 2010 baseline value
- (future case – application value) / application 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. Alternately, a negative value for mean distance to nearest neighbour indicates an increase in patch connectivity. Appendix 11.10.I (Tables 11.10.I-3 and 11.10.I-4) provides absolute values per habitat type and assessment case (i.e., reference, baseline, application, and future).

11.10.5.1.2 Results

Similar to grizzly bear and wolverine, the assessment of effects to wolves was based on the predicted cumulative changes from reference conditions through application of the Project and reasonably foreseeable future developments. The spatial boundary of the assessment is at the scale of the range of the population (i.e., annual range of the Bathurst caribou herd). Cumulative effects from the Project and other developments influence the entire population range (i.e., beyond local and regional scale effects). In contrast, the geographic extent of incremental changes to habitat quantity from the Project has a local to regional influence on the population range of wolves.

The total area of the Project footprint is estimated to be 1,235 ha. This includes 853.3 ha of mine and infrastructure that will directly affect terrestrial and aquatic resources (Section 11.7). An additional 382.1 ha of water (shallow and deep water) is not expected to be directly altered by the Project during construction and operation. Approximately 68% of the Project footprint is aquatic habitat and 32% is terrestrial habitat.

At the local scale, the Project footprint will alter 4.4% of the baseline LSA. Most of the winter road within the LSA will be over frozen lake areas and not affect terrestrial habitat types (Figure 11.7-3). Terrestrial habitat types that will be disturbed most include tussock-hummock, sedge wetland, and peat bog (all decreased by 0.4%). These habitats are some of the most abundant vegetation communities within the LSA (and RSA). Other terrestrial habitats altered by the Project footprint include heath tundra, heath tundra with bedrock or boulders, birch seep, and riparian tall shrub (all decreased by less than 0.4% relative abundance in the LSA). No esker is expected to be altered. During construction and operation, the Project footprint will decrease the lake surface area within the LSA by 2.2%.

Although progressive reclamation will be integrated into mine planning as part of De Beers' design for closure policy, arctic ecosystems are slow to respond to disturbance. In addition, not all of the areas will be reclaimed. For example, as a result of locally expressed concerns, the Fine PKC Facility will not be vegetated to prevent the facility from becoming attractive to wildlife (Section 11.7). The mine rock piles, Coarse PK Pile and Fine PKC facility will be permanent features on the landscape, covering approximately 302.7 ha of terrestrial habitat.

At the scale of the population range and under reference conditions, the study area was dominated by forest (31%) and heath tundra (20%). Boulder fields and waterbodies (non-vegetated) constituted 15% and 16% of the landscape, respectively. Heath rock, lichen veneer, riparian shrub and burn each accounted for less than 6% of the study area. Eskers represented less than 1% of the landscape.

The largest change in area of a habitat type for spring to autumn was associated with eskers (Table 11.10-29). Relative to reference conditions, previous and existing developments reduced the area of esker habitat by 0.16%. The Project is predicted to not disturb esker habitat. The cumulative disturbance to eskers from previous, existing and reasonably foreseeable developments is estimated to be 0.2%. Similar decreases were noted for number of esker patches. The 2010 baseline landscape had 0.18% fewer esker patches than the reference landscape (Table 11.10-29). Cumulative effects from previous, existing, and potential future developments decreased the number of esker patches by 0.21%.

Previous and existing development footprints also have decreased the quantity, number of patches, and distance between similar patches of other habitat types on the landscape. From reference to 2010 baseline conditions, the reduction in area of a particular habitat (excluding eskers) ranged from 0 to 0.15% (Table 11.10-29). Previous and existing developments have physically altered about 1% of the landscape in the study area. With the addition of the Project, incremental decreases in the area of each habitat were less than 0.01% per habitat type. Overall, the Project is expected to disturb 0.1% of the landscape in the study area. Development of reasonably foreseeable projects (i.e., Taltson Hydroelectric Expansion Project) would be expected to further reduce the quantity of each habitat by less than or equal to 0.1% (Table 11.10-29). The cumulative direct disturbance to the landscape from the Project and other previous, existing and future developments is predicted to be about 1.4% relative to reference conditions.

The number of habitat patches increased by less than 1% for each habitat type from reference to 2010 baseline conditions (Table 11.10-29). Habitat-specific incremental changes from the Project or future projects are also estimated to be less than 1%. For a particular habitat, distance to nearest similar patch decreased by 0 to 3% for 2010 baseline conditions relative to reference conditions (Table 11.10-29). Addition of the Project is estimated to increase distance between heath rock, heath tundra, and riparian shrub habitats by less than 1%. Distances between other habitats are expected to decrease by less than or equal to 0.5%. Habitat-specific changes in the distance between similar habitat patches are estimated to be less than 1% for the future case (Table 11.10-29).

During the winter period, previous and existing developments (which include footprints from the Winter Access Road to the Project and other winter roads) have physically altered about 1.7% of habitats on the landscape relative to reference conditions. This represents a marginal increase in landscape disturbance of 0.7% (from 1.0 to 1.7%) relative to the non-winter period (Table 11.10-29 and Table 11.10-30). Most of the change is associated with the temporary disturbance of frozen lakes from winter roads; however, there was an additional disturbance of 0.2% to esker habitat. Winter roads also produced larger changes (decreases or increases of 1 to 4%) in the number and distance between similar habitat patches for some habitats relative to the non-winter period (Table 11.10-29 and Table 11.10-30).

Application of the Project directly disturbed less than a 0.1% of the existing landscape during winter. Addition of the Taltson Hydroelectric Expansion Project (and associated winter roads during construction) reduced the amount of habitat in the study areas by about 0.6%. Habitat-specific changes in the number and distance between similar habitat patches were less than 1.5% both the application and future cases (Table 11.10-30).

Table 11.10-29 Change (%) in Area and Configuration of Habitat Types from Development within the Study Area for Wolf during Baseline, Application, and Future Conditions in the Spring to Autumn

Habitat	Area (ha)	% Change to			Number of Patches	% Change to			Mean Nearest Neighbour Distance (m)	% Change to		
	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future
Esker	30860	-0.16	0.00	-0.04	6042	-0.18	0.00	-0.03	1702	0.10	-0.08	0.02
Non-vegetated	6323068	-0.07	0.00	-0.01	1317	0.61	-0.08	0.15	2826	-0.74	0.23	-0.18
Forest	12244572	-0.08	0.00	-0.03	1455	0.82	0.34	0.88	1393	-0.60	-0.20	-0.71
Heath rock	1634772	-0.11	0.00	0.00	1237	0.81	-0.16	0.00	1393	-0.60	0.16	0.00
Heath tundra	7901584	-0.08	0.00	-0.04	1026	0.58	0.29	0.58	1816	-1.53	0.95	-0.45
Lichen veneer	465512	-0.07	0.00	0.00	148	0.00	0.00	0.00	3525	0.00	0.00	0.00
Rock assoc.	5940092	-0.15	-0.01	-0.02	1939	0.83	0.36	0.51	1694	-1.71	-0.47	-0.42
Sedge assoc.	228732	-0.05	0.00	-0.02	270	0.00	0.00	0.37	5108	0.00	0.00	-0.49
Low shrub	43360	0.00	0.00	0.00	28	0.00	0.00	0.00	31556	0.00	0.00	0.00
Riparian shrub	2130888	-0.03	0.00	-0.05	1621	0.31	-0.12	0.18	2179	-0.52	0.14	-0.17
Old burn	794720	-0.05	0.00	-0.10	580	0.17	0.00	0.17	3921	-0.23	0.00	-0.18
Young burn	1654876	-0.03	0.00	-0.07	463	0.43	0.22	0.43	3853	-3.13	-0.23	-0.42

Notes: % Change was measured as the relative incremental change from one time period to the next (e.g., reference (no to little development) to 2010 baseline, 2010 baseline to application, and application to future).

Values of 0.00 represent values greater than or equal to zero, but less than 0.005.

ha = hectares; % = percent; m = metres.

Table 11.10-30 Change (%) in Area and Configuration of Habitat Types from Development within the Study Area for Wolf during Baseline, Application, and Future Conditions in the Winter

Habitat	Area (ha)	% Change to			Number of Patches	% Change to			Mean Nearest Neighbour Distance (m)	% Change to		
	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future	Reference	2010 Baseline	Application	Future
Esker	30860	-0.32	0.00	-0.04	6042	-0.33	0.00	-0.03	1702	0.17	0.00	0.02
Non-vegetated	6323068	-0.33	0.00	-0.06	1317	2.13	0.00	0.82	2826	-2.01	0.00	-1.21
Forest	12244572	-0.16	0.00	-0.04	1455	1.58	0.34	1.08	1393	-1.23	-0.18	-1.01
Heath rock	1634772	-0.15	0.00	0.00	1237	1.05	0.00	0.00	1393	-0.91	0.00	0.00
Heath tundra	7901584	-0.13	0.00	-0.05	1026	1.27	0.10	0.87	1816	-2.45	-0.04	-0.66
Lichen veneer	465512	-0.11	0.00	0.00	148	0.00	0.00	0.00	3525	0.00	0.00	0.00
Rock assoc.	5940092	-0.19	-0.01	-0.03	1939	1.65	0.20	0.51	1694	-2.63	-0.19	-0.40
Sedge assoc.	228732	-0.06	0.00	-0.02	270	0.00	0.00	0.37	5108	0.00	0.00	-0.49
Low shrub	43360	-0.05	0.00	0.00	28	3.57	0.00	0.00	31556	-3.40	0.00	0.00
Riparian shrub	2130888	-0.06	0.00	-0.07	1621	0.37	0.00	0.31	2179	-0.63	0.00	-0.28
Old burn	794720	-0.09	0.00	-0.10	580	0.34	0.00	0.17	3921	-0.49	0.00	-0.18
Young burn	1654876	-0.09	0.00	-0.08	463	0.86	0.00	0.64	3853	-3.57	0.00	-0.61

Notes: % Change was measured as the relative incremental change from one time period to the next (e.g., reference (no to little development) to 2010 baseline, 2010 baseline to application, and application to future).

Values of 0.00 represent values greater than or equal to zero, but less than 0.005.

ha = hectares; % = percent; m = metres.

11.10.5.2 Habitat Quality, Behaviour, and Movement

11.10.5.2.1 Local and Regional-scale Effects from the Project

Dust Deposition and Sensory Disturbances

The analyses completed in Section 11.10.4.3.1 for the effects of dust, noise, and sensory disturbances from the Project on grizzly bears and wolverines also applies to wolves. Briefly, the results of the air quality modelling predicted that the maximum annual dust deposition resulting from the Project is 6,292 kg/ha/y within the Project development area boundary (i.e., Project footprint) and 5,520 kg/ha/y outside of the Project development area boundary (Table 11.10-6). The maximum point of dust deposition is predicted to occur within 100 m of the Project footprint. The greatest effects from dust are generally confined to the immediate area adjacent to the dust source (e.g., a haul road) (Everett 1980; Walker and Everett 1987). Walker and Everett (1987) and Everett (1980) reported that effects were confined to a 50-m buffer on either side of a road. Moreover, Meininger and Spatt (1988) found that the majority of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 and 500 m from a road.

At the Project, noise will be generated from mobile and stationary mining equipment, blasting, and aircraft. Recommended ambient background noise levels for undeveloped areas is 40 decibels (dBA), with wind, precipitation, and thunder being the principle sources of increases above ambient levels (Section 7, Appendix 7.II). The results showed that while noise will be generated by the Project, the expected levels at identified noise receptors are within relevant criteria established for remote areas (with the exception of the 40 dBA limit at 1.5 km from the Project due to mine operations) (Table 11.10-13). The analysis of blasting activity indicates the maximum distances at which the criteria for peak ground (12.5 millimetre per second [mm/s]) and airborne vibration levels (120 linear decibels [dBL]) would be met are 596 and 730 m from the Project, respectively.

The distance for noise attenuation to reach background for mining operations (including blasting) is 3.5 km (Table 11.10-14). Aircraft will be used for the movement of personnel and supplies to the Project site year round. Aircraft noise will be limited to a few minutes during takeoff and landings and a maximum of two round-trip flights per day are expected during Project construction and operations. The distance for noise attenuation to reach background levels from the airstrip is 5.5 km. However, disturbance from large aircraft is expected to be infrequent and short-term (less than 5 minutes in duration).

Wildlife are generally considered to avoid noise, but may habituate to noise. Black bear spatial distribution was not found to be affected by noise in a military training area (Telesco and Van Manen 2006). In contrast, results of a telemetry study showed that wolves were found to be attracted to weapons-firing noise (Merrill and Erickson 2003). Two of three wolves studied showed movements towards firing points more often than expected, particularly if wolves were less than 5 km from the firing point when firing began. The authors noted that this was the first study to document wildlife movement towards loud anthropogenic noise, and cited several confounding factors such as sample size, wolf relatedness, and territorial behaviour (Merrill and Erickson 2003). Reproductive rates and pup survival in farmed blue fox were not found to be affected by aviation noise (Pyykoenen et al. 2007). Noise varied from 85 to 120 dBA from aircraft overflights at a fox farm, which was compared to a control farm without aircraft overflights (Pyykoenen et al. 2007).

Long-term monitoring at the Ekati Diamond Mine has detected no negative effects from mining activity on wolf den occupancy and pup production. From 1995 through 2003, the probability of a den being occupied did not change significantly over time (BHPB 2004). There was a weak relationship between den occupancy and distance from the mine. The likelihood of a den being occupied increased for dens that were closer to the mine (BHPB 2004). Over a 12-year period, pup production has showed no decreasing trend during construction and operation of the mine (BHPB 2004, 2007). Further, Frame et al. (2007) concluded that den site disturbance had minimal if any adverse effect on wolf populations. Their results are based on standardized experimental disturbance treatments at 12 unique wolf den sites in the Northwest Territories, between 2002 and 2003.

Effects from Winter Roads

During the two-year construction period, up to 25 trucks are anticipated to be on the Winter Access Road in a 24-hour period (1,500 to 2,000 trucks per year per 12 week period). Traffic is anticipated to decrease to 14 trucks and 3 trucks per 24-hour period on the Winter Access Road during operations and initial closure (two year period), respectively. The predicted noise levels from the winter road are compared with relevant criteria in Table 11.10-13. The results show that while noise will be generated by the Winter Access Road, the expected levels are within relevant criteria established for remote areas. This change in habitat suitability is periodic as winter roads are in operation for an average of 8 to 12 weeks each year.

Noise from the Winter Access Road should diminish to background noise levels within 3 km (Table 11.10-14), based on traffic volume during the construction period, and within 500 m during the operation phase. Although there is potential for trucks passing by a location along the Winter Access Road to alter wolf movement and behaviour, the potential effects will be limited to the seasonal use of the Winter Access Road.

11.10.5.2.2 Effects Beyond the Regional Scale of the Project

Methods

Changes in the quality of wolf habitat near human developments due to sensory disturbances were calculated using similar methods for grizzly bear and wolverine described in Section 11.10.4.3.2. Briefly, the quality of wolf habitat was classified using resource selection function methods with both a human development database (described in Section 11.10.4.2.1) and a remote sensing Land Cover of Canada (1985 to 2000) provided by the Government of Canada in a GIS platform (Johnson et al. 2004, 2005). The latter land cover dataset was modified from 1,000-m cell sizes to a 25-m resolution, and then joined with an esker layer (1:50,000 scale) from the national topographic database (NTDB). Finally, the Land Cover of Canada dataset was resampled to a 200-m resolution and reclassified into 12 classes according to Johnson et al. (2004, 2005).

Using the output from the reclassified dataset, patches of habitat per land cover type were identified such that each patch was as 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 resource selection function (RSF) coefficients and formulas in Johnson et al. (2004, 2005) (Table 11.10-31), resource selection values were generated per cell. Waterbodies were calculated as nil (zero) during the habitat mapping process. Resource selection values were generated using RSF coefficients specific to wolf and for the summer period only. Summer has been identified as a critical period in the dynamics of wolf populations. For example, recruitment to the population may be affected by disturbance to den sites.

Effects of assumed disturbance were used to quantify changes in the relative availability of different quality habitats during different periods of increasing and decreasing development during baseline conditions (i.e., reference, 2000, 2006, and 2010), application of the Project, and future conditions. Values of disturbance coefficients and zones of influence were guided by the published literature (Johnson et al. 2004, 2005; Table 11.10-32). Correlation among disturbance effects could not be statistically controlled, and therefore, the effects of multiple coefficients at the same location were not multiplied. The coefficient with the strongest effect was applied where zones of influence overlapped, which increased certainty that the predicted effect would not be under estimated.

Table 11.10-31 Coefficients and 95% Confidence Intervals from Summer Resource Selection Models for Monitored Wolf of the Canadian Central Arctic

Covariate	Coefficient	Lower 95% CI	Upper 95% CI
Esker density	10.236	-4.179	24.652
Esker patch	0.029	-0.004	0.063
Forest density	3.638	-6.135	13.411
Forest patch	0.026	-0.019	0.071
Heath rock density	8.242	5.166	11.317
Heath rock patch	-0.005	-0.010	0.001
Heath tundra density	7.443	4.226	10.661
Heath tundra patch	<0.001	-0.001	0.053
Lichen density	-8.362	-0.049	37.244
Lichen patch	0.027	0.001	0.053
Peat bog density	18.597	-0.049	37.244
Peat bog patch	0.022	-0.110	0.153
Riparian shrub density	-1.014	-7.583	5.555
Riparian shrub patch	0.020	-0.008	0.048
Rock density	-3.501	-7.333	0.332
Rock patch	0.018	0.006	0.031
Sedge density	-0.595	-5.437	4.248
Sedge patch	0.031	0.024	0.039

Source: Johnson et al. (2004, 2005).
% = percent; CI = confidence interval; < = less than.

Table 11.10-32 Disturbance Coefficients and Associated Zones of Influence for Development Activities in the Study Area for Wolf

Disturbance Type	Feature Type	Footprint		ZOI Range 1		ZOI Range 2		ZOI Range 3	
		Extent (m)	DC	Range[c] (km)	DC	Range (km)	DC	Range (km)	DC
Campgrounds	point	200	0.00	NA	NA	NA	NA	NA	NA
Communications (e.g. microwave towers)	point	200	0.00	0 to 1	0.90	NA	NA	NA	NA
Community	polygon	actual[b]	0.00	0 to 1	0.05	1 to 5	0.50	5 to 15	0.75
Fuel storage	point	200	0.00	NA	NA	NA	NA	NA	NA
Historic remediated and non-remediated sites[a]	point	200	0.00	NA	NA	NA	NA	NA	NA
Lodge (outfitters, tourism)	point	200	0.00	0 to 5	0.10	NA	NA	NA	NA
Mine	polygon	actual[b]	0.00	0 to 1	0.05	1 to 5	0.50	5 to 15	0.75
Mineral exploration	point	500	0.00	0 to 1	0.50	1 to 5	0.75	NA	NA
Miscellaneous (e.g., bridges and culverts)	point	200	0.00	0 to 1	0.90	NA	NA	NA	NA
Power (plant)	point	500	0.00	0 to 1	0.50	NA	NA	NA	NA
Quarry	point	200	0.00	0 to 5	0.75	NA	NA	NA	NA
Staging area / barge landings	point	200	0.00	0 to 5	0.75	NA	NA	NA	NA
Transmission line	line	200	0.25	0 to 1	0.50	1 to 5	0.75	NA	NA
All-season road	line	200	0.00	0 to 1	0.05	1 to 5	0.75	NA	NA

Note: Values were guided by published literature (Johnson et al. 2005).
[a] From INAC contaminated sites database (classified as medium and high risk sites).
[b] Activities estimated with the exception of mine operations and communities, which were delineated and digitized from remote sensing imagery.
[c] From edge of measured or hypothetical footprint.
n/a = not applicable; DC = disturbance coefficients; ZOI = zone of influence; m = metres; km = kilometre.

After habitat maps and modelling were completed, raster cells (ranging 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 area, 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 reference condition within the baseline case.

The following equations were used to calculate the relative change in the amount of different quality habitats for each seasonal-range for different conditions on the landscape:

- (2000 baseline area – reference area) / reference area x 100
- (2006 baseline area – 2000 baseline area) / 2000 baseline area x 100
- (2010 baseline area – 2006 baseline area) / 2006 baseline area x 100
- (application case area – 2010 baseline area) / 2010 baseline area x 100
- (future case area – application case area) / application case area x 100

Results

Changes to preferred habitats (i.e., good and high quality habitats) were evaluated through use of RSF maps of the wolf population range (i.e., study area). The relative changes in the area of good and high quality habitats between landscape conditions are described to assess the incremental and cumulative effects from the Project and other developments in the study area on the wolf population (see figures in Appendix 11.10.II).

In general, the amount of high and good quality habitats for wolf in the study area decreased from reference to 2010 baseline conditions (Table 11.10-33). Most of the decline in habitat quality occurred from 2000 to 2006 and was associated with the increasing number of exploration sites on the landscape (Figure 11.10-22). Relative to 2006, the availability of quality habitats in the study area increased in 2010 (Table 11.10-33), which was due to the decrease in the number of active developments.

Previous and existing developments decreased preferred habitat by 7.7% in 2010 relative to a landscape with no development (Table 11.10-33). With the addition of the Project, there was an incremental decline in preferred habitat of 0.9%. Under future conditions, the Taltson Hydroelectric Expansion Project may result in a further 2.4% reduction of high and good quality habitats. Thus, the cumulative change from the Project and other developments decreased preferred habitat by 11.1% from reference to future conditions.

Table 11.10-33 Relative Changes in the Availability of Habitats for Wolf from Reference to Reasonably Foreseeable Projects

Season / Habitat Category	Reference (ha)	% Change Reference to 2000 Baseline	% Change 2000 to 2006 Baseline	% Change 2006 to 2010 Baseline[(a)]	% Change 2010 to Application	% Change Application to Future	Cumulative % Change Reference to Future
Spring-Autumn							
High	9055981	-2.77	-2.28	1.38	-0.70	-1.22	-5.59
Good	7888712	-3.41	-2.38	1.76	-0.22	-1.22	-5.47
Low	5745001	-2.61	-1.52	1.42	-0.07	-2.14	-4.91
Poor	9246092	7.24	4.71	-3.16	0.81	3.13	12.73
nil (water)	6109046						
Total	38044833						

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous time period (analyses exclude nil habitat). Cumulative values may not exactly sum due to rounding.

Reference landscapes (no development) were compared to maps modified by hypothetical disturbance coefficients and zones of influence (i.e., assumed disturbance) for active developments.

2000, 2006, and 2010 Baseline = incremental changes from previous and existing developments.

Application case = Gahcho Kué Project plus 2010 baseline conditions; Future case = Taltson Hydroelectric Expansion Project plus application case.

(a) Increases in low to high quality habitats are due to expiration of exploration permits and absence of a zone of influence (i.e., no activity and only direct effects from physical footprint).

ha = hectares; % = percent.

11.10.5.3 Effects from Changes in Prey Availability

A key prey item for wolf is caribou and their availability is a critical determinant of wolf distributions (Walton et al. 2001; Cluff et al. 2002; McLoughlin et al. 2004). Similar to grizzly bear and wolverine, availability of caribou for the wolf population is related to caribou population size and distribution. The addition of the Project to the existing landscape had no statistical effect on the modelled caribou population projections (Section 7). Cumulative effects from development were predicted to have a moderate effect on caribou abundance, which may change the encounter rates between wolves and caribou. These changes are predicted to approach or slightly exceed the limits of baseline conditions. The natural decline in the caribou population also was likely associated with decreased predation rate on caribou by wolves. This change may have influenced adult survival and juvenile recruitment for the wolf population.

Caribou are predicted to change their distribution and reduce habitat use within approximately 10 to 15 km from the Project (i.e., ZOI). Other developments also are predicted to have local and regional influences on caribou distribution. At the scale of the seasonal range, these changes in distribution are expected to be within the range of baseline conditions (Section 7). There are natural environmental factors that operate over large scales of space and time (e.g., fire, snowfall, food abundance, and quality) that likely have greater influences on regional distributions of caribou relative to effects from the Project and other developments. The Project and other developments are not expected to result in seasonal range shifts in caribou distribution, and should not affect prey distribution for wolves.

11.10.5.4 Related Effects on People

Wolves in the NWT are classified as both a big game species and a furbearer. Currently in the NWT, wolves are managed mostly by controlling the hunting season for resident and non-resident hunters (ENR 2010b, internet site). Residents are allowed to harvest any number of wolves in accordance with the number of tags held. Non-residents must hunt with a licensed outfitter and only in specific areas. Most outfitters that guide wolf hunts are in the Mackenzie Mountains. General Hunting Licence holders may hunt during any season. Table 11.10-34 contains wolf harvest numbers collected by ENR.

Table 11.10-34 Resident and Non-resident Wolf Harvest, 1992 to 2004

Year	Harvest	Average Price per Pelt	Total Value
1992/1993	93	$167	$15,562
1993/1994	121	$215	$26,057
1994/1995	119	$218	$25,989
1995/1996	59	$243	$14,355
1996/1997	86	$286	$24,601
1997/1998	175	$173	$30,376
1998/1999	62	$270	$16,746
1999/1900	75	$144	$10,834
2000/2001	95	$223	$21,267
2001/2002	170	$297	$50,504
2002/2003	79	$176	$13,977
2003/2004	143	$169	$24,200

Source: ENR 2010b.

The Winter Access Road and the Tibbitt-to-Contwoyto road may increase access to wolf within the area of the Project when the winter roads are in operation (approximately 8 to 12 weeks each year). The number of vehicles travelling for hunting on the Tibbitt-to-Contwoyto Winter Road showed a decline from 573 vehicles in 2004 to 284 vehicles in 2006 (Ziemann 2007, internet site). Decreases in hunting traffic may have been due to high volumes of mine-related vehicles on the road (e.g., 2,543 loaded trucks in 1998 versus 11,656 in 2007). De Beers will also have a no firearms and no hunting policy for staff and contractors on site. Thus, during the winter road season, people at site will not benefit from increased access to the region for the harvesting of wolf. It is predicted that the number of wolf harvested in the region from improved access due to the Winter Access Road for the Project will not be detectable from baseline conditions.

The expected change in the regional distribution of wolves associated with the zone of influence from the Project (i.e., 15 km) may affect wilderness value and hunting success at nearby outpost camps. In particular, Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project, and may experience small decreases in encounters with wolves. These changes are expected to be within the range of baseline conditions. In contrast, Artillery Lake Adventures has a camp situated on the west side of Artillery Lake, about 70 km east of the Project, and should not be influenced by the Project.

11.10.6 Residual Effects Summary

11.10.6.1 Habitat Quantity and Fragmentation

Approximately 68% of the Project footprint is aquatic habitat and 32% is terrestrial habitat. At the local scale, the Project footprint will alter 4.4% of the baseline LSA. Terrestrial habitat types that will be disturbed most include tussock-hummock, sedge wetland, and peat bog (all decreased by 0.4%). These habitats are some of the most abundant vegetation communities within the LSA (and RSA). Other terrestrial habitats altered by the Project footprint include heath tundra, heath tundra with bedrock or boulders, birch seep, and riparian tall shrub (all decreased by less than 0.4% relative abundance in the LSA). No esker is expected to be altered.

Although progressive reclamation will be integrated into mine planning, arctic ecosystems are slow to recover from disturbance. In addition, not all of the areas will be reclaimed. For example, as a result of locally expressed concerns, the Fine PKC Facility will not be vegetated to prevent the facilities from becoming attractive to wildlife. The mine rock piles, Coarse PK Pile, and Fine PKC Facility will be permanent features on the landscape, covering approximately 302.7 ha of terrestrial habitat. Thus, direct disturbance to habitat from previous and existing developments and the Project was assumed to be permanent (not reversible within the temporal boundary of the assessment).

For spring to autumn, previous and existing developments have physically altered approximately 1.6% of the study area for grizzly bear and wolverine (i.e., SGP), and 1% of the study area for the wolf population (i.e., annual range of the Bathurst caribou herd). Overall, the Project is expected to disturb less than 0.1% of landscape in the study areas. The cumulative direct disturbance to the landscape from the Project and other previous, existing, and future developments is predicted to be about 2% and 1.4% for the SGP and wolf study area, respectively, relative to reference conditions.

Traditional and scientific knowledge are aware that esker habitat is of particular importance for grizzly bears and wolves. For grizzly bears, the area of esker habitat in the study area has declined 0.9% since reference landscape conditions. The cumulative changes from the previous, existing and future developments are expected to reduce the area of esker habitat by approximately 1%. For wolves, previous and existing developments reduced the area of esker habitat by 0.16%. The cumulative disturbance to eskers from previous, existing and reasonably foreseeable developments is estimated to be 0.2%.

Increasing development on the landscape has also resulted in changes to the number and location of habitat patches in the population ranges of grizzly bear, wolverine, and wolf during the spring to autumn period. For the SGP, habitat-specific changes in the number and distance between similar habitat patches (including eskers) were less than or equal to 0.3% for reference to 2010 baseline conditions. Habitat-specific incremental changes from the Project or reasonably foreseeable developments (Taltson Hydroelectric Expansion Project) were less than 0.1%.

For the wolf study area, the number of habitat patches increased by less than 1% for each habitat type from reference to 2010 baseline conditions. Habitat-specific incremental changes from the Project or future projects are also estimated to be less than 1%. For a particular habitat, distance to nearest similar patch decreased by 0 to 3% for 2010 baseline conditions relative to reference conditions. Addition of the Project is estimated to change the distance between habitats by less than 1%. Habitat-specific changes in the distance between similar habitat patches are estimated to be less than 1% for the Taltson Hydroelectric Expansion Project.

During the winter period, previous and existing developments (which include footprints from the Winter Access Road, Tibbitt-to-Contwoyto Winter Road, and other winter roads) have physically altered about 2.3% of the landscape in the SGP for wolverine, and 1.7% of the wolf study area. Application of the Project resulted in less than a 0.1% decrease in habitat in the study areas during winter. Addition of the Taltson Hydroelectric Expansion Project (and associated winter roads during construction) reduced the amount of habitat in the study areas by less than 1%. Habitat-specific changes in the number and distance between similar habitat patches were less than 0.1% for the SGP and less than 1.5% in the wolf study area for both the application and future cases. Direct effects of habitat fragmentation to carnivore movement from the Winter Access Road are regional and predicted to be reversible within 5 years following initial closure (i.e., near the end of final closure).

11.10.6.2 Habitat Quality, Movement, and Behaviour

It was assumed that the geographic extent of combined incremental changes from noise, dust deposition, and sensory disturbance on habitat quality was 15 km from the Project footprint (i.e., the ZOI). This distance is conservative given the results from the dust deposition and noise analyses. For example, air quality modelling predicted that the maximum predicted dust deposition rate would occur within 100 m of the Project footprint. Walker and Everett (1987) and Everett (1980) reported that the largest effects from dust are associated with primary sources (e.g., haul roads), and typically confined to a 50-m buffer on either side of a road. Moreover, Meininger and Spatt (1988) found that the majority of effects occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road.

Noise will be generated from mobile and stationary mining equipment, blasting, and aircraft at the Project. The distance for noise attenuation to reach background levels for mining operations (including blasting) is predicted to be 3.5 km. Aircraft noise will be limited to a few minutes during takeoff and landings and a maximum of two round-trip flights per day are expected during Project construction and operations. The distance for noise attenuation to reach background levels from the airstrip is 5.5 km. However, disturbance from large aircraft is expected to be infrequent and short-term (less than five minutes in duration). The effects from noise and other sensory disturbances on the movement and behaviour of carnivores are anticipated to stop after closure of the Project (i.e., the effect will likely last a few years after closure).

Noise from the Winter Access Road is expected to diminish to background noise levels at 3 km, based on traffic volume during the construction period, and to 500 m during normal operations. Although there is potential for trucks passing by a location along the Winter Access Road to alter wolverine and wolf movement and behaviour, the potential effects will be limited to the seasonal use of the winter roads (approximately 8 to 12 weeks each year). Use of the Winter Access Road is predicted to stop in year two of closure, and effects are predicted to be reversible within 5 years following initial closure (i.e., near the end of final closure).

Although the combined direct and indirect changes from the Project on habitat are local to regional in geographic extent, the effects extend to the population as animals interact with the Project and other developments during their seasonal movements. Using a combination of spatially-explicit databases and resource selection functions, availability of preferred habitat (combined high and good quality habitats) was calculated for several landscape scenarios from reference to future conditions. In general, the amount of high and good quality habitats in the study areas decreased from reference to 2010 baseline conditions. Most of the decline in habitat quality occurred from 2000 to 2006 and was associated with the increasing number of exploration sites on the landscape (Figure 11.10-22). Relative to 2006, the availability of quality habitats in the study area increased in 2010, which was due to the decrease in the number of active developments.

For grizzly bear, the largest cumulative decline in preferred habitat across seasons was during spring (12.4%). Current (2010) baseline landscapes had 9.8% less area of preferred habitats than on reference landscapes. There was very little (0.1%) incremental change from the Project on the area of preferred habitats for grizzly bear during the spring season. The largest incremental change from the Project on the area of preferred habitat was recorded for the early summer period, where preferred habitats declined by 0.8%. Cumulative changes from the Project and previous, existing, and future developments reduced preferred habitat during the early summer period by 9.5%.

For wolverine, the largest recorded decline in preferred habitat was during winter. The 2010 baseline landscape had 14.6% less preferred habitat than the reference landscape. The incremental change from the Project was a reduction in area of preferred habitat by 1.5%. The cumulative change from the developments through to future conditions was a reduction in area of preferred habitat by 18.8%. However, most of this decrease (10%) is related to the temporary disturbance from winter roads on the landscape for 8 to 12 weeks during the winter period.

For the summer period, previous and existing developments decreased preferred wolverine habitat by 7.4% relative to a landscape with no development. With the addition of the Project, there was an incremental decline in preferred habitat of 0.9%. During summer, the cumulative change from the Project and previous, existing, and future developments decreased high and good quality habitat by 10.6%.

For wolves, the results indicated that preferred habitat has declined 7.7% from reference to 2010 baseline conditions. With the application of the Project, preferred habitat is estimated to decline an additional 0.9%. The cumulative change from the Project and previous, existing, and future developments is predicted to reduce the amount of high and good quality wolf habitat by 11.1% relative to a landscape with no development. For all seasonal periods and carnivore populations, the change in habitat quantity and quality is well below the 40% threshold value for habitat effects associated with anticipated declines in bird and mammal species (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002; Swift and Hannon 2010).

At the regional scale, reductions in preferred habitats due to the zone of influence from development also may result in an increase in the density of carnivores where habitat is suitable and there are a lower number of developments. However, the cumulative effects from development are not predicted to result in measurable shifts (e.g., east or west) or contractions in the distribution of carnivores at the scale at which population processes operate (i.e., seasonal and annual ranges). The change in the distribution of carnivores associated with the zone of influence from the Project and other developments is expected to be within the range of baseline conditions. There are natural environmental factors that operate over large scales of space and time (e.g., natural cycles in prey abundance) that likely have greater influences on distributions of carnivores relative to effects from the Project and other developments. The duration of indirect changes to preferred habitat and in the population ranges of grizzly bear, wolverine, and wolf from the cumulative effects of the Project and other development is anticipated to occur over a 27 to 32 year period (i.e., effects should be reversed within 5 to 10 years following Project closure).

11.10.6.3 Population Viability of Grizzly Bear and Wolverine

Previous mining activities have led to grizzly bear and wolverine mortality in the study area. There have been four grizzly bear mortalities due to mining activities in the SGP since 1996 (including one adult male at Diavik mine, and one cub and two adult males at Ekati mine, and none at Jericho mine or Snap Lake Mine). The annual direct mine-related mortality is approximately 0.074 bears per mine per year. Assuming a 22-year lifespan between the beginning of construction and the end of mining activities at the Project, this mortality rate predicts that approximately one to two grizzly bears may be destroyed as a direct result of the Project.

Since 1996, there have been 11 wolverine removed from the SGP population due to direct mine-related mortality, which is equivalent to a mortality rate of 0.204 wolverine per mine per year. In most cases wolverine were destroyed following a period of unsuccessful deterrent action, and with the permission of ENR. Assuming a 22-year lifespan for the Project, this mortality rate predicts that approximately four to five wolverines may be destroyed as a direct result of the

Project. These predicted direct Project-related mortalities to grizzly bear and wolverine are likely overestimates as the Project will implement waste management and wildlife mitigation procedures similar to that used at the Snap Lake Mine where here has been one wolverine mortality and no grizzly bear mortality during 12 years from construction through current operation.

Population viability analyses (PVA) were used to determine the relative changes in the risk to population persistence of grizzly bear and wolverine for different landscape scenarios or conditions. Local and regional changes from the Project and other developments on habitat quantity and quality, direct mine-related mortality, other human-conflict kills, and harvest rates were incorporated into model simulations. The PVA models were used to estimate the incremental and cumulative effects from the Project and other developments relative to the influence of natural factors and harvest activities on the population trajectories for grizzly bear and wolverine.

It is emphasized that the models were not used to predict the number of grizzly bear or wolverine in 5 years, 10 years, or 30 years from now. For both grizzly bear and wolverine, there is not enough information on vital rates during long-term changes in population size to accurately predict the number of animals in the near or distant future. The consensus among many population ecologists is that relative results of PVA, either from sensitivity analyses or comparisons among landscape scenarios, are more reliable for assessing effects than absolute results (McCarthy et al. 2003; Schtickzelle et al. 2005).

Sensitivity analyses for the grizzly bear models indicated that adult survival rate was the most sensitive parameter in determining changes to the persistence of the population. Other input parameters such as survival rates of younger age groups, periodic weather-related events that influence survival rates, and carrying capacity also influenced population persistence. The least sensitive parameter for grizzly bear was fecundity. For wolverine, adult survival rate was the most sensitive parameter in determining population viability. Changes to survival rates of younger age groups and weather-related effects on survival rates also influence the likelihood of wolverine population persistence. Carrying capacity was the least sensitive parameter.

Both the grizzly bear and wolverine analyses could not detect a statistically significant ($P > 0.30$) incremental effect from the Project on population viability relative to 2010 baseline conditions. In other words, incremental changes to habitat and survival rate (from mine-related mortality) from the Project had no statistical effect on population persistence relative to current baseline conditions. Similarly, there was no significant ($P > 0.19$) effect on the risk to the persistence of the populations from the addition of the Project and the Taltson Hydroelectric Expansion Project (future case) to the current landscape.

Analysis did suggest that the cumulative changes to habitat and survival from the Project and previous, existing, and future developments had a significant ($P < 0.01$) influence on decline probability relative to reference conditions (subsistence and regulated hunting, but no development). The risk curves indicated that the differences were more apparent for low-to-moderate declines in abundance. There was an 11.1% and 18.6% decrease in the final projected mean abundance from the Project and other developments on grizzly bear and wolverine, respectively, relative to reference conditions. However, the large overlap of the 95% confidence intervals with the mean values suggests that the difference is not statistically significant.

The results indicate that previous, existing, and proposed developments on the landscape and current harvest of bears and wolverines can influence the persistence of grizzly bear and wolverine populations. Importantly, analyses showed that population viability is clearly influenced by the current regulated harvest of animals. If the regulated harvest is reduced to zero animals, then the risk curves were significantly different than those associated with current baseline conditions. For grizzly bears, the magnitude of the change in risk curves from eliminating the regulated harvest in the Kitikmeot region was similar to the change associated with cumulative effects from development. For wolverine, the magnitude of the change in risk curves from removing the regulated harvest was three times greater than the magnitude of the change in simulating the cumulative effects from development

11.10.6.4 Related Effects on People

Hunting of grizzly bears is not permitted within the SGP, except for a regulated hunt in the Kitikmeot region of Nunavut. Typically, grizzly bear in the NWT may only be killed to defend life and property, and therefore, the Project should not influence the opportunity for people to harvest grizzly bear in the NWT.

The Winter Access Road and the Tibbitt-to-Contwoyto Winter Road may increase access to wolverine and wolves within the area of the Project when the winter roads are in operation (about 8 to 12 weeks each year). De Beers will have a no firearms and no hunting policy for staff and contractors on site so that people at site will not benefit from increased access to the region for the harvesting of wolverine and wolves. Therefore, it is predicted that the number of wolverine and wolf harvested in the region from improved access due to the Winter Access Road for the Project will not be detectable from baseline conditions.

The expected change in the regional distribution of carnivores associated with the zone of influence from the Project (i.e., 15 km) may affect wilderness value associated with grizzly bear presence, and hunting success of wolverine and wolf at nearby outpost camps. In particular, Aylmer Lake Lodge operates an outpost camp on Cook Lake, about 25 km southeast of the Project, and may experience small decreases in carnivore encounters. These changes are expected to be within the range of baseline conditions. Effects are expected to last from construction until 5 to 10 years after Project closure (i.e., 27 to 32 years). In contrast, Artillery Lake Adventures has a camp situated on the west side of Artillery Lake, about 70 km east of the Project, and should not be influenced by the Project.

11.10.7 Residual Impact Classification

The purpose of the residual impact classification is to describe the residual effects from the Project on carnivores using a scale of common words (rather than numbers or units). The use of common words or criteria is a requirement in the Terms of Reference for the Project (Gahcho Kué Panel 2007). The following criteria must be used to assess the residual impacts from the Project:

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency;
- likelihood; and
- ecological context.

Generic definitions for each of the residual impact criteria are provided in Section 6.7.2.

11.10.7.1 Methods

In the EIS, the term “effect” used in the effects analyses and residual effects summary is regarded as an “impact” in the residual impact classification. Therefore, in the residual impact classification for this section, all residual effects are discussed and classified in terms of impacts to carnivores.

The effects analyses and residual effects summary presented both the incremental and cumulative changes from the Project on the environment, carnivores, and use of carnivores by people. Incremental effects represent the Project-specific changes relative to baseline values in 2010. 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 [i.e., ZOI]).

Cumulative effects are the sum of all changes from initial baseline (reference) values through application of the Project and reasonably foreseeable developments. In contrast to Project-specific (incremental) effects, the geographic extent of cumulative effects is determined by the distribution of the defined population. Carnivores occupy large home ranges, and as such, can be influenced by the Project and other developments on the landscape.

For carnivores, the assessment and classification of residual impacts was based on the predicted cumulative changes from reference conditions through application of the Project (and into the future case). The spatial boundary of the assessment is at the scale of the range of the populations, which is a requirement in the Terms of Reference (Gahcho Kué Panel 2007). The incremental effects from the Project relative to 2010 baseline conditions are also classified. Essentially, the only difference in the outcome of impact criteria between cumulative and incremental effects from the Project is in the magnitude and geographic extent of impacts. The magnitude for cumulative impacts involves changes from reference conditions through application of the Project (and into the future case), while incremental impacts are based on changes from the Project relative to 2010 baseline values. Cumulative impacts from the Project and other developments influence the entire population range (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 population range of carnivores.

The predicted scales for the remaining impact criteria (direction, duration, reversibility, frequency, likelihood, ecological context) are equivalent for assessing the incremental and cumulative effects from the Project. The results from this impact classification are then used to determine environmental significance from the Project on carnivores and the use of carnivores by people.

Effects statements are used to focus the analysis of changes to carnivores that are associated with one or more primary pathways. The residual effects summary (Section 11.10.7) presents a numerical assessment for criteria such as magnitude, geographic extent, duration, and frequency. From the summary of residual effects, pathways associated with each effects statement are then classified using scales (categorical values such negligible, low, or high) for each impact criterion (e.g., magnitude).

To provide transparency in the EIS, the definitions for these scales were ecologically or logically based on carnivore populations. Although professional judgement is inevitable in some cases, a strong effort was made to classify impacts using scientific principles and supporting evidence. The scale for the residual impact criteria for classifying effects from the Project are specifically defined for carnivores, and definitions for each criterion are provided in Table 11.10-35. More detailed explanations for magnitude, geographic extent, and duration are provided below.

Table 11.10-35 Definitions of Criteria Used in the Residual Impact Classification of Pathways for Effects on the Population Size and Distribution of Grizzly Bear, Wolverine, and Wolf

Direction	Magnitude[(a)]	Geographic Extent	Duration	Frequency	Reversibility[(b)]	Likelihood
Negative: a decrease relative to baseline values **Positive:** an increase relative to baseline values	**Negligible:** no expected detectable change from baseline values **Low:** impact is expected to be within the range of baseline values **Moderate:** impact is expected to be at or slightly exceeds the limits of baseline values **High:** impact is expected 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 impacts from the Project (e.g., footprint, physical hazards, dust deposition, and lake dewatering) **Regional:** the predicted maximum spatial extent of combined direct and indirect impacts from the Project that exceed local-scale effects (can include cumulative direct and indirect impacts from the Project and other developments at the regional scale) **Beyond Regional:** cumulative local and regional impacts from the Project and other developments extend beyond the regional scale	**Short-term:** impact is reversible at end of construction **Medium-term:** impact is reversible at end of closure (i.e., upon completion of refilling Kennady Lake) **Long-term:** impact is reversible within a defined length of time (e.g., animal life spans) beyond closure	**Isolated:** impact confined to a specific discrete period **Periodic:** impact occurs intermittently but repeatedly over the assessment period **Continuous:** impact will occur continually over the assessment period	**Reversible:** Impact will not result in a permanent change of state of the population compared to "similar" environments not influenced by the Project **Irreversible:** impact is not reversible (i.e., duration of impact is unknown or permanent)	**Unlikely:** the impact is likely to occur less than one in 100 years **Possible:** the impact will have at least one chance of occurring in the next 100 years **Likely:** the impact will have at least one chance of occurring in the next 10 years **Highly Likely:** the impact is very probable (100% chance) within a year

(a) Baseline includes range of expected values from reference conditions (no development) through 2010 baseline conditions.

(b) "similar" implies an environment of the same type, region, and time period.

11.10.7.1.1 Magnitude

Magnitude (i.e., intensity of the impact) for Project-specific (incremental) effects is scaled to the predicted change (quantified or qualified) from 2010 baseline conditions to application of the Project. Magnitude for cumulative effects is scaled to the predicted quantified and/or qualified cumulative change from reference conditions (no development) through application of the Project and potential future developments. Baseline conditions represent the historical and current environmental selection pressures that have shaped the observed patterns in carnivores. Environmental selection pressures include both natural (e.g., weather, changes in gene frequencies, predation, and competition) and human-related factors (e.g., mineral development, traditional harvest, and sport hunting).

Depending on which selection pressures are currently driving changes in carnivores and the system, baseline conditions typically fluctuate within a range of variation through time and space. Relative to ecological time and space, baseline conditions are in a constant state of change due to the pushing and pulling of environmental selection pressures. Thus, baseline conditions can be thought of as a distribution of probability values, and the location of the value (e.g., middle or ends of the distribution) is dependent on which environmental factors are currently playing a key role in the trajectory of the carnivore populations.

The approach used to classify the magnitude of changes in measurement endpoints (and related impacts) was based on scientific literature and professional opinion, and incorporated conservatism. Other environmental assessments often use the universal effect size approach for categorizing magnitude such as negligible changes (0 to 10%), small changes (10 to 25%), and medium changes (25 to 40%) (Munkittrick et al. 2009). Ideally, effect threshold values would be known, and measurement endpoints could be quantified accurately with a high degree of confidence. However, little is known about ecological thresholds, and biological parameters are typically associated with large amounts of natural variation. Therefore, the classification of magnitude included a level of conservatism so that the impacts would not be underestimated.

The definition of magnitude provided in Table 11.10-35 is applicable for more qualitative results (e.g., impacts on carnivore movement and behaviour, and related impacts to people). For quantitative analyses and results (e.g., loss and fragmentation of habitat, changes to habitat suitability, and changes to population viability), the following definition for magnitude is applied:

- negligible: less than a 1% change from the Project relative to baseline values;
- low: 1 to 10% change from the Project relative to baseline values;
- moderate: greater than 10% to 20% change from the Project relative to baseline values; and
- high: more than 20% change from the Project relative to baseline values.

The proposed scale is consistent with the 20% rule for the severity of effects from chemical exposure on varying spatial scales of ecological effects (i.e., a 20% change in a measurement endpoint constitutes an ecological effect) (Suter et al. 1995). The scale is also consistent with and below thresholds identified by empirical and theoretical work on the relationship between loss of suitable habitat and the likelihood of population decline (Andrén 1994, 1999; Fahrig 1997; Mönkkönen and Reunanen 1999; Flather and Bevers 2002). These studies suggested that critical thresholds for changes in population parameters in non-tropical bird and mammal species occur between 10% and 60% of original habitat. In other words, a measurable decrease in species abundance and diversity may be observed when the amount of suitable habitat that is lost exceeds a threshold value of 40%. In a recent review, Swift and Hannon (2010) found that most empirical studies demonstrated negative effects on insects, plants, birds, and mammals when remaining habitat cover ranged from 10 to 30% (i.e., more than 70% habitat loss).

11.10.7.1.2 Geographic Extent

Geographic extent is the area or distance influenced by the direct and indirect effects from the Project, and is different from the spatial boundary (i.e., study area) for the effects analysis and impact assessment. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement (i.e., population boundary) of carnivores (Section 11.10.1.3).

However, the geographic extent of impacts can occur on a number of scales within the spatial boundary of the assessment. As defined in Table 11.10-35, geographic extent for classifying impacts is based on three scales: local, regional, and beyond regional. Local-scale impacts mostly represent incremental (Project-specific) changes to carnivore population size and distribution that are directly related to the Project footprint and activities (e.g., physical disturbance to vegetation (habitat), mortality of individual animals). Local impacts may also include small-scale indirect effects such as dust deposition on vegetation.

Changes at the regional scale are largely associated with incremental indirect impacts from the Project on carnivores and are defined by the predicted maximum distance or area (i.e., ZOI) of the effect from the Project (e.g., changes to grizzly bear behaviour and movement from sensory disturbance). However, at the scale of the population, the cumulative local and regional impacts from the Project and other developments, and natural factors are beyond regional (which is the study area or spatial boundary for the assessment). Individuals within the population travel large distances during their daily and seasonal movements and can be affected by the Project, and several additional projects. Cumulative effects from the Project also occur beyond the regional scale for traditional and non-traditional land use of carnivores.

11.10.7.1.3 Duration

Duration has two components. It is the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the impact to be reversible. Essentially, duration is a function of the length of time that carnivores are exposed to Project activities, and reversibility.

Although it is common to describe construction, operation, and closure as discreet phases, these activities will overlap at Kennady Lake. For example, there is less than one year when construction activities are the only activities at the Project site. Progressive closure and reclamation activities will begin during operation, and continue for eight years at the end of operation, which will include the initial refilling of Kennady Lake. The time from construction to initial closure is 16 years. The total length of the Project (i.e., end of final closure) is 22 years.

By definition, impacts that are short-term, medium-term, or long-term in duration are reversible. Project activities may end at closure, but the impact on carnivores may continue beyond Project closure. Some impacts may be reversible soon after removal of the stressor, such as effects on air quality from power generation and equipment operation (e.g., medium-term impact).

For carnivores, the amount of time required for the impact to be reversed (i.e., duration of the effect) is presented in context of the number of life spans that the species are influenced. The anticipated duration of effects on carnivores are then used to determine the number of human generations that may be affected by the related changes to traditional and non-traditional land use practices (e.g., hunting wolves for their pelts). In this manner, the impact assessment links the duration of Project impacts on carnivores to the amount of time that human use of ecological resources may be influenced.

For impacts that are permanent, the duration of the effect is determined to be irreversible. An example of an irreversible impact includes the localized loss of vegetation and habitat due to the mine rock piles, Coarse PK Pile and Fine PKC Facility. The loss of a grizzly bear or wolverine from direct Project-related mortality also is irreversible at the level of the individual, but likely reversible at the population level.

11.10.7.2 Residual Impacts to Carnivores

Direct incremental impacts from the Project footprint (i.e., habitat loss) are predicted to be local in spatial extent. At the local scale, the magnitude of incremental impacts from the Project footprint on carnivore populations is anticipated to be low (i.e., the Project will alter 4.4% of the LSA). The incremental impact from the Project footprint is predicted to occur continuously throughout the temporal boundary of the assessment (Tables 11.10-36 to 11.10-38). The impacts from changes to carnivore habitats are highly likely to occur.

Cumulative impacts related to direct habitat loss and fragmentation from the Project and other developments are beyond regional in geographic extent as the impacts occur throughout the spatial boundaries of the populations (i.e., grizzly bear and wolverine, and wolf study areas). The magnitude of incremental and cumulative impacts from habitat loss and fragmentation are predicted to be negligible to low (Tables 11.10-36 to 11.10-38). During the spring to autumn period, the Project is expected to disturb less than 0.1% of landscape in the study areas. The cumulative direct disturbance to the landscape from the Project and other previous, existing, and future developments is predicted to be about 2% and 1.4% for the SGP and wolf study area, respectively, relative to reference conditions. However, arctic ecosystems are slow to recover from disturbance. In addition, not all of the areas associated with the Project will be reclaimed (i.e., mine rock piles, Coarse PK Pile, and Fine PKC Facility); therefore, development footprints and related loss of habitat on the landscape was assumed to be permanent (i.e., not reversible within the temporal boundary of the assessment).

Table 11.10-36 Summary of Residual Impact Classification of Primary Pathways for Incremental and Cumulative Effects on Population Size and Distribution of Grizzly Bears and Related Effects to People

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Physical footprint decreases habitat quantity and causes fragmentation	negative	negligible to low	negligible to low	local	beyond regional	permanent	continuous	irreversible	highly likely
The combined indirect effects (i.e. dust deposition, noise, and human activity-sensory effects) from the Project changes the amount of different quality habitats, and alters movement and behaviour	negative	negligible to low	low to moderate	local to regional	beyond regional	long-term	continuous	reversible	highly likely
Attraction of grizzly bear to the site (e.g., food waste, oil products) may increase human-carnivore interactions, resulting in mortality of individuals	negative	negligible	low	local	beyond regional	long-term	continuous	reversible	likely
Effects on population size and distribution changes the availability of grizzly bears for traditional and non-traditional use	negative	negligible	low	regional	beyond regional	long-term	continuous	reversible	likely

Table 11.10-37 Summary of Residual Impact Classification of Primary Pathways for Incremental and Cumulative Effects on Population Size and Distribution of Wolverine and Related Effects to People

Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Physical footprint decreases habitat quantity and causes fragmentation	negative	negligible to low	negligible to low	local	beyond regional	permanent	continuous	irreversible	highly likely
Winter road footprint causes habitat fragmentation, which changes behaviour and movement, and reduces carrying capacity.	negative	negligible	low	regional	beyond regional	medium-term	periodic (winter season only)	reversible	likely
The combined indirect effects (i.e., dust deposition, noise, and human activity-sensory effects) from the Project and the Winter Access Road changes the amount of different quality habitats, and alters movement and behaviour	negative	negligible to low	moderate	local to regional	beyond regional	long-term	continuous	reversible	highly likely
Attraction of wolverine to the site (e.g., food waste, oil products) may increase human-carnivore interactions, resulting in mortality of individuals	negative	negligible	low	local	beyond regional	long-term	continuous	reversible	likely
Effects on population size and distribution changes the availability of wolverine for traditional and non-traditional use	negative	negligible	low	regional	beyond regional	long-term	continuous	reversible	likely

Table 11.10-38 Summary of Residual Impact Classification of Primary Pathways for Incremental and Cumulative Effects on Population Size and Distribution of Wolf and Related Effects to People

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Physical footprint decreases habitat quantity and causes fragmentation	negative	negligible to low	negligible to low	local	beyond regional	permanent	continuous	irreversible	highly likely
Winter road footprint causes habitat fragmentation, which changes behaviour and movement, and reduces carrying capacity.	negative	negligible	low	regional	beyond regional	medium-term	periodic (winter season only)	reversible	likely
The combined indirect effects (i.e., dust deposition, noise, and human activity- sensory effects) from the Project and the Winter Access Road changes the amount of different quality habitats, and alters movement and behaviour	negative	negligible to low	moderate	regional	beyond regional	long-term	continuous	reversible	highly likely
Effects on population size and distribution changes the availability of wolf for traditional and non-traditional use	negative	negligible	low	regional	beyond regional	long-term	continuous	reversible	likely

Increasing development on the landscape has also resulted in changes to the number and location of habitat patches in the population ranges of grizzly bear, wolverine, and wolf during the spring to autumn period. For the SGP, habitat-specific changes in the number and distance between similar habitat patches (including eskers) ranged from 0.1 to 0.3% (negligible magnitude) among the development scenarios (i.e., existing baseline, application of the Project, and future conditions [Taltson Hydroelectric Expansion Project]). For the wolf study area, habitat-specific changes in the number and distance between similar habitat patches (including eskers) ranged from 0 to 3% (negligible to low magnitude) among the development scenarios.

During the winter period, the magnitude of incremental and cumulative habitat impacts from the Project and other developments on wolverine and wolf populations is expected to be negligible and low, respectively (Tables 11.10-37 and 11.10-38). Application of the Project resulted in less than a 0.1% decrease in habitat in the study areas during winter. Previous and existing developments (which include footprints from the Winter Access Road, Tibbitt-to-Contwoyto Winter Road, and other winter roads) and the Taltson Hydroelectric Expansion Project reduced the amount of habitat in the SGP and wolf study area by approximately 3.3% and 2.7%, respectively. Habitat-specific changes in the number and distance between similar habitat patches were less than 0.1% for the SGP and less than 1.5% in the wolf study area for both the application and future cases. Direct impacts of habitat fragmentation to carnivore movement from the Winter Access Road are regional and predicted to be reversible in the medium term (i.e., near the end of final closure). Impacts to the movement and behaviour of carnivores from the Winter Access Road, Tibbitt-to-Contwoyto Winter Road, and other winter roads are beyond regional, and should be limited to the seasonal use of the roads (i.e., periodic frequency) (Tables 11.10-37 and 11.10-38).

It was assumed that the geographic extent of combined incremental changes from noise, dust deposition, and other sensory disturbances on habitat quality was 15 km from the Project footprint (i.e., the ZOI). This distance is likely conservative given the results from the dust deposition and noise analyses. For example, most of the impacts from dust deposition are anticipated to be within 100 m of the Project footprint. The predicted distance for noise attenuation to background levels for mining operations (including blasting) and the airstrip is 3.5 km and 5.5 km, respectively. Noise from the Winter Access Road is expected to diminish to background levels at 3 km, based on traffic volume during construction, and 500 m during normal operations. The magnitude of local and regional impacts from dust and noise are predicted to be within the range of baseline conditions (low magnitude).

Although the combined direct and indirect changes from the Project on habitat are local to regional in geographic extent, the impacts extend to the population because animals interact with the Project and other developments during their seasonal movements. Impacts on the population size and distribution of carnivores from changes in habitat quality are predicted to be reversible over the long term and within five to ten years following final closure (27 to 32 years) (Tables 11.10-36 to 11.10-38). For grizzly bear, the magnitude of the incremental impact from the Project on habitat quality ranged from 0.1 to 0.8% (negligible) (Table 11.10-36). The magnitude of cumulative declines in preferred habitat across seasons varied from 9.5 to 12.4% (low to moderate). The duration of the impact may be over one grizzly bear life span (assuming the average life span for a grizzly bear is 30 years [McLoughlin 2003b]).

Incremental decreases from the Project on preferred habitat for wolverine ranged from 0.9 to 1.5% (negligible to low magnitude). The cumulative change from the Project and previous, existing, and future developments decreased high and good quality habitats by 10.6% and 18.8% during the summer and winter periods, respectively (moderate magnitude) (Table 11.10-37). However, most of the decrease during the winter (10%) is related to the temporary disturbance from winter roads on the landscape for an 8 to 12 week period. Assuming an average life span of 6 years for wolverine (Pasitschniak-Arts and Larivère 1995), the duration of the impact is predicted to occur over 5 to 6 lifespans (i.e., reversible in the long term).

The magnitude of the incremental impact to wolves is predicted to be negligible as the Project reduced preferred habitat by an additional 0.9% relative to existing (2010) baseline conditions (Table 11.10-38). The cumulative change from the Project and previous, existing, and future developments is predicted to reduce the amount of high and good quality wolf habitat by 11.1% relative to a landscape with no development (moderate magnitude). The duration of the impact may be over three life spans for wolf (assuming the average life span for a wolf is 10 years [Mech 1974]).

Data from five active mine sites during 1996 through 2009 were used to estimate direct mine-related mortality rates for grizzly bear and wolverine. Estimated direct mine-related grizzly bear and wolverine mortality rates were 0.074 and 0.204 individuals per mine per year, respectively. These values represent approximately 0.05% and 0.15% of the estimated populations for grizzly bear and wolverine. Assuming a 22-year lifespan for the Project, these mortality rates predict that about one to two grizzly bears and four to five wolverines may be removed from the populations as a direct result of the Project. Therefore, the magnitude of the incremental impact of mine-related mortality from the Project on grizzly bear and wolverine populations is predicted to be negligible

(Tables 11.10-36 and 11.10-37). The cumulative impact from the Project and other developments is expected to be of low magnitude (i.e., within the range of current baseline conditions). Impacts are predicted to be reversible within 3 to 6 years following final closure (i.e., estimated age of reproduction for wolverine and grizzly bear, respectively).

Both the grizzly bear and wolverine analyses could not detect a statistically significant ($P > 0.30$) incremental effect from the Project on population viability relative to existing conditions. In other words, incremental changes to habitat and survival rate (from mine-related mortality) from the Project had no statistical effect on population persistence relative to current baseline conditions (negligible magnitude). Similarly, there was no significant ($P > 0.19$) effect on the risk to the persistence of the populations from the addition of the Project and the Taltson Hydroelectric Expansion Project (future case) to the current landscape.

Analysis did suggest that the cumulative changes to habitat and survival from the Project and previous, existing, and future developments had a significant ($P < 0.01$) influence on population persistence relative to reference conditions (which includes subsistence and regulated hunting, but no development). The risk curves indicated that the differences were more apparent for low-to-moderate declines in abundance. There was an 11.1% and 18.6% (moderate magnitude) decrease in the final projected mean abundance from the Project and other developments on grizzly bear and wolverine, respectively, relative to reference conditions. However, the large overlap of the 95% confidence intervals with the mean values indicates that the difference is not statistically significant.

Changes in the abundance and distribution of carnivores associated with the Project and other activities may influence harvesting opportunities (except for grizzly bear, where there is only a regulated harvest in the Kitikmeot region of Nunavut). Results from the habitat and population analyses indicate that the Project should have a negligible impact on wolverine and wolf. Similarly, the magnitude of the Winter Access Road on the regional abundance and distribution of wolverine and wolf populations is expected to be negligible. Cumulative impacts from the Tibbitt-to-Contwoyto Winter Road and other winter roads on the populations are anticipated to be of low magnitude. Subsequently, the magnitudes of the incremental and cumulative impacts to traditional and non-traditional harvests of carnivores are predicted to be negligible and low, respectively (Tables 11.10-37 and 11.10-38).

Changes in the population size and distribution of carnivores may also influence wilderness value and wildlife viewing opportunities for traditional and non-traditional land users. The Cook Lake outpost camp for Alymer Lake Lodge is located 25 km southeast of the Project. The Project is likely to have a negligible impact on the regional wilderness value and wildlife viewing opportunities for this camp (Tables 11.10-36 to 11.10-38). The magnitude of the cumulative impacts from the Project and other developments on the wilderness value of the landscape is predicted to be low. The duration of the impacts to traditional and non-traditional use of carnivores is expected to occur over 27 to 32 years or 1.5 human generations (assuming the generation time for people is 20 years). The impact is reversible in the long term (Tables 11.10-36 to 11.10-38).

11.10.8 Environmental Significance

11.10.8.1 Approach and Method

The Terms of Reference require that “the developer must provide its views on the significance of impacts” (Section 3.2.2; Gahcho Kué Panel 2007). Environmental significance was used to evaluate the significance of incremental and cumulative impacts from the Project and other developments on carnivores, and by extension, on the use of carnivores by people. The evaluation of significance was based on ecological principles, to the extent possible, but also involved professional judgment and experienced opinion.

The classification of residual impacts on primary pathways provides the foundation for determining environmental significance from the Project on the persistence of carnivore populations. Magnitude, geographic extent, and duration are the principal criteria used to predict significance (Section 6.7.3). Other criteria, such as frequency, ecological context, and likelihood are used as modifiers (where applicable) in the determination of significance.

Frequency may or may not modify duration, depending on the magnitude of the impact. Because the EIS assesses impacts to key VCs of concern, the ecological context is high, by definition. However, ecological context may be used to modify the environmental significance if the societal value is associated with traditional land use.

Likelihood will also act as a modifier that can influence environmental significance. Environmental impact assessment considers impacts that are likely or highly likely to occur; however, within the definition of likelihood there can be a range of probabilities that impacts will occur. In special circumstances, the environmental significance may be lowered if an impact is considered to have a very low likelihood of occurring, and increased for impacts with a very high likelihood of occurring.

Duration of impacts, which includes reversibility, is a function of ecological resilience, and these ecological principles are applied to the evaluation of significance. Although difficult to measure, resilience is the capacity of the system to absorb disturbance, and reorganize and retain the same structure, function, and feedback responses (Section 6.7.3). Resilience includes resistance, capability to adapt to change, and how close the system is to a threshold before shifting states (i.e., precariousness). Resistance is the ability of a population or system to retain the same path or trajectory following a disturbance.

The adaptive capability of a system is related to the evolutionary history and adaptations accumulated by communities, species, and populations while experiencing a range of disturbances and fluctuations through space and time (Section 6.7.3). If the frequency, duration, geographic extent, and/or intensity (magnitude) of a disturbance are beyond that historically encountered by the system, and outside the adaptive capability of a species, then the likelihood of a regime shift increases. Regime shifts and changes in state of the population or ecosystem can be reversible or irreversible.

Reversibility is a function of resilience. Due to the complex relationships among biophysical components and unpredictable events, the recovery of the system following disturbance can result in the same or an altered state (Section 6.7.3). In other words, the exact nature of ecosystem properties and services, and human uses may be different following recovery from the disturbance. In some cases, the shift in ecological properties and services may not be reversible and will have a consequence to socio-economics and land use.

The evaluation of significance for carnivores considers the entire set of primary pathways that influence the assessment endpoint (persistence of carnivore populations). The relative contribution of each pathway is used to determine the significance of the Project on carnivores, which represents a weight of evidence approach (Section 6.7.4). For example, a pathway with a high magnitude, large geographic extent, and long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative impact from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the persistence of carnivore populations would also be assumed to contribute the most to the determination of environmental significance.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to carnivores. The following definitions are used for assessing the significance of impacts on the persistence of carnivore populations, and the associated continued opportunity for traditional and non-traditional use of carnivores.

Not significant – impacts are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to population persistence.

Significant – impacts are measurable at the population level and likely to decrease resilience and increase the risk to population persistence. A number of high magnitude and irreversible impacts at the population level would likely be significant.

11.10.8.2 Results

The results predict that the incremental and cumulative impacts from the Project and other developments should not significantly influence the persistence of carnivore populations. For all primary pathways influencing population size and distribution of grizzly bear, wolverine, and wolf, cumulative impacts were determined to be beyond regional in geographic extent, which implies that at least some portion of the populations are affected. For incremental impacts, the geographic extent of pathways ranged from local to regional. Local changes to habitat were associated with the Project footprint, dust deposition, and noise, and will continuously influence individuals that travel through or occupy habitats within 1 to 3.5 km from the Project site, and periodically up to 5.5 km (e.g., during take-off and landing of aircraft). Regional impacts to habitat, movement, and behaviour were related to the Winter Access Road and the combined changes from dust deposition, noise, lights, and human activities from the Project.

The likelihood of the impacts occurring is expected to be possible to highly likely for all pathways (Tables 11.10-36 to 11.10-38), which does not change the expected magnitude and duration (or environmental significance). Similarly, the frequency of most impacts is anticipated to occur continuously throughout the life of the Project, except for impacts from winter roads, which occur seasonally (periodically) during the life of the Project (Tables 11.10-36 to 11.10-38).

Overall, the duration of the impacts from the different pathways were expected to be reversible in the medium to long term for carnivore assessment endpoints. An exception was the incremental and cumulative direct disturbance impacts to populations from development footprints, which were assumed to be irreversible within the temporal boundaries of the assessment (Tables 11.10-36 to 11.10-38). Sensory disturbance impacts associated with influences of exploration and mining activities on carnivore populations are anticipated to be reversible over the long term (27 to 32 years). Impacts from winter roads on populations and traditional and non-traditional use of carnivores are expected to be reversible in the medium term (5 years after initial closure).

The magnitude for the primary pathways impacting grizzly bear, wolverine, and wolf populations ranged from negligible to moderate. The magnitude of the cumulative impact from direct habitat loss associated with the Project and previous, existing, and reasonably foreseeable future developments is expected to be about 1.4 to 2% relative to reference conditions. At a habitat-specific level, incremental and cumulative direct disturbance was estimated to be less than 1%.

Cumulative impacts on the population size and distribution of grizzly bear, wolverine, and wolves from changes in the amount of preferred habitats was low to moderate in magnitude (Tables 11.10-36 to 11.10-38). The maximum change in preferred habitats is predicted to be 12.4% for grizzly bear, 11.1% for wolf, and 18.8% for wolverine. However, most of this decrease (10%) in the wolverine study area is due to the temporary disturbance from winter roads for 8 to 12 weeks during the winter period. The incremental impact from changes in habitat quantity and quality from the Project is less than 1% for grizzly bear and wolf, and 1.5% for wolverine. Incremental and cumulative changes to the behaviour and movement of carnivores from winter roads are expected to be within the range of baseline conditions.

Incremental and cumulative impacts from direct mine-related mortality on grizzly bear and wolverine are expected to be of negligible and low magnitude (Tables 11.10-36 and 11.10-37). Estimated direct mine-related grizzly bear and wolverine mortality rates were 0.074 and 0.204 individuals per mine per year, which represent approximately 0.05% and 0.15% of the estimated populations. Both the grizzly bear and wolverine analyses could not demonstrate a statistically significant incremental effect from the Project on population viability relative to 2010 baseline conditions. The incremental changes to habitat and survival rates (from mine-related mortality) from the Project had no statistical effect on population persistence.

Analyses also suggested that the probability of abundance declines differed significantly between future and reference scenarios, but primarily for low to moderate declines in population abundance. The results indicate that changes in habitat and survival from previous, existing, and proposed developments and the current harvest of bears and wolverines can influence the persistence of populations. There was an 11.1% and 18.6% (moderate magnitude) decrease in the final projected mean abundance from the Project and other developments on grizzly bear and wolverine, respectively, relative to reference conditions. However, the large overlap of the 95% confidence intervals with the mean values indicates that the difference is not statistically significant. In addition, analyses showed that population viability is strongly influenced by the current regulated harvest of animals.

There is a moderate to high degree of confidence in the predictions of environmental significance from the incremental and cumulative impacts of development on carnivores. Monitoring studies at the Ekati and Diavik mines during the past 10 to 12 years have continued to record frequent observations of grizzly bears (males, and females with cubs), wolves, and wolverine in the study areas (Section 11.10.2.3). No effects from mining activity on wolf den occupancy and productivity have been detected at the Ekati Diamond Mine. Monitoring of waste management and wildlife mitigation policies and practices have shown an increase in effectiveness at reducing the number of grizzly bear and wolverine destroyed from being attracted to mine sites. This is particularly the case at the Snap Lake Mine where there has been one wolverine and no grizzly bears killed during the 12 years from construction through current operation. The Project will implement waste management and wildlife mitigation procedures similar to that used at the Snap Lake Mine. In addition, habitat and population models contained conservative parameters for influences from development to increase confidence that the assessment would not underestimate impacts (Section 11.10.9).

The weight of evidence from the analysis of the primary pathways predicts that the incremental and cumulative impacts from the Project and other developments should not have a significant negative influence on the resilience and persistence of carnivore populations. Wolf and wolverine populations have moderate reproductive rates, which provide resistance to current mine-related mortality rates, and the capacity for the populations to respond quickly to natural changes in the density of caribou and other prey species (e.g., moose and muskoxen). Annual wolverine harvest numbers for the Kitikmeot region also suggest that populations of wolverine are resilient to much higher mortality rates than the current rates at mine sites, and the impacts from development should be reversible. Although grizzly bears are less resistant to increases in mortality rates (due to low reproductive rates), current mine-related mortality should not decrease the resilience of the grizzly bear population in the SGP.

Incremental impacts from the Project on carnivores should have a negligible influence on opportunities for hunting and trapping, and viewing grizzly bear, wolverine, and wolves in the region. Similarly, changes to traditional and non-traditional use of carnivores from the cumulative impacts of development and current harvesting are expected to be within the range of baseline conditions. Subsequently, cumulative impacts from development also are not predicted to have a significant adverse effect on continued opportunities for use of carnivores by people that value these animals as part of their culture and livelihood.

11.10.9 Uncertainty

The purpose of the uncertainty section is to identify the key sources of uncertainty and to discuss how uncertainty has been addressed to increase the level of confidence that the impacts are not worse than predicted. Confidence in the assessment of environmental significance is related to the following elements:

- 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 (e.g., survival and reproduction rates);
- incomplete understanding or simplified representation of a system being modelled either numerically (e.g., grizzly bear and wolverine population models), or conceptually (e.g., behavioural response to a stressor);
- understanding of Project-related impacts on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence carnivores); and
- knowledge of the effectiveness of the environmental design features (mitigation) for reducing or removing impacts (e.g., revegetation of habitat).

Like all scientific results and inferences, residual impact predictions must be tempered with uncertainty associated with the data and current knowledge of the system. It is anticipated that the baseline data is sufficient for understanding current conditions and future changes not related to the Project, and that there is a moderate to high level of understanding of Project-related impacts on the ecosystem. During the past 10 to 12 years, monitoring studies at operating diamond mines, and government and university research programs have provided good information on the response of carnivores to development-related effects. Traditional knowledge studies and recommendations from Elders about how to mitigate impacts from mines has also increased during this time. This information increased the confidence in model inputs, carnivore-project interactions, and the understanding the success of mitigation policies and practices for limiting impacts to carnivores. Although direct disturbance to habitats from cumulative developments were calculated to represent less than 2.3% of carnivore study areas, there remains a high degree of uncertainty in the effectiveness of revegetation techniques for reversing the impact of direct disturbance from development on wildlife habitat.

Reasonably Foreseeable Developments

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 developments such as the Taltson Hydroelectric Expansion Project and the proposed East Arm National Park also generate uncertainty in impact predictions.

The Taltson Hydroelectric Expansion Project will be a transmission line linking the Twin Gorges hydroelectric station on the Taltson River with the existing and proposed mines north of Great Slave Lake. The transmission line would be about 700 km long. Infrastructure required for the Taltson Hydroelectric Expansion Project in the study areas includes the placement of transmission towers, several substations, and the clearing of a 30-m corridor in areas where trees have the potential to interfere with the transmission line. The magnitude of incremental changes to carnivore habitat quantity and quality from the Taltson Hydroelectric Expansion Project was predicted to be negligible to low. Most impacts from the Taltson Hydroelectric Expansion Project should be associated with localized changes in movement and behaviour of carnivores during the construction phase.

The proposed national park at the East Arm of Great Slave Lake is representative of the North Western Boreal Uplands. At its closest point, the study area for the proposed park comes to within 1 km of the Project. Depending upon the length of time for the feasibility study, 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 uncertainty in predicting the status of the existing fishing and hunting lodges and camps in the proposed park. The assessment assumes that the existing lodges would no longer allow hunting, but would remain as tourist lodges. Overall, the proposed East Arm National Park would likely be beneficial to carnivores from a conservation perspective.

There are four additional reasonably foreseeable developments that could affect abundance and distribution of wolves:

- Yellowknife Gold Project;
- Nechalacho Project;
- Damoti Lake Gold Project; and
- NICO Project.

Except for the Taltson Hydroelectric Expansion Project (for which the anticipated footprint is known), effects analyses for the future case are mostly qualitative due to the large degree and number of uncertainties. There are uncertainties in the direction, magnitude, and spatial extent of future fluctuations in the abiotic and biotic components of the environment, independent of Project effects. There are also uncertainties associated with the rate, type, and location of developments in the study area. For example, the Yellowknife Gold Project (Tyhee NWT Corporation), and the Damoti Lake Gold Project (Merc International Minerals Inc.) currently have no operation start date, an assessment of the economic feasibility of the project, or a mine plan. Life spans of the proposed developments may range from eight to 18 years or longer.

Impacts from the Yellowknife Gold Project and the Nechalacho Project (Avalon Rare Metals Inc.) are difficult to anticipate, but may be negligible in magnitude. The Yellowknife Gold Project is located 90 km north of the City of Yellowknife on the former Discovery Mine site, an existing contaminated area (Tyhee 2010, internet site). Access would be via an existing winter road route and by air. Use of a pre-existing footprint and transportation infrastructure would be a key design feature that will assist with limiting impacts to wildlife. For the Nechalacho Mine, a rare elements deposit, the footprint will be limited by using underground mining. This property will be located approximately 100 km southeast of the City of Yellowknife near Hearne Channel on the East Arm of Great Slave Lake. A key design feature for limiting the decrease in wildlife habitat quantity and quality will be the use of Great Slave Lake for transportation. Mining products will be loaded into bulk transport containers, hauled to the seasonal dock facility along the north shore of Great Slave Lake and barged during the summer to a purpose-built hydrometallurgical plant, possibly located near the site of the old Pine Point mine on the south shore of Great Slave Lake (Avalon 2010, internet site).

The property for the Damoti Lake Gold Project is located approximately 20 km south of the Colomac Mine (Merc 2010, internet site), and will be accessed via the winter road to Colomac and Wekweètì. As the Project is currently in the exploration stage and a mine plan has not yet been developed, there is uncertainty regarding the size and duration of the Project. However, the impact of this development may be similar to that anticipated for the NICO Project (Fortune Minerals Ltd.). The NICO Project is a cobalt, gold and bismuth deposit located in the Tłįchǫ region, approximately 50 km northwest from the community of Whatì. Mining will follow open-pit and underground methods. The NICO Project would require an all-season road connection to Highway 3 near Behchokǫ̀. Gold would be extracted from the ore at the NICO site, but cobalt and bismuth concentrate would be trucked to a purpose-built smelter in Saskatchewan (Fortune 2010, internet site). The NICO Project is currently undergoing an environmental assessment by the Mackenzie Valley Review

Board. It is anticipated that most impacts to wildlife populations should be negligible to low in magnitude.

Ecological Conservatism

Understanding and predicting the behaviour of populations within ecosystems requires the aggregation and simplification of available knowledge, retaining what is essential and disregarding that which is not essential at the particular scale of interest. Ecological models (conceptual or quantitative) represent an attempt to create a simplified approximation of reality that can be used as a predictive tool. These models are essential for anticipating how carnivores may respond to a changing landscape, and for predicting residual impacts from the Project and other developments. However, the complexity of the dynamics of populations and the environment means that processes are not completely reducible to their components, and that predictions contain uncertainty (Boyce 1992; Walther et al. 2002; Wu and Marceau 2002).

A critical approach to this assessment was to link spatial patterns of the natural and human-developed landscapes to the population dynamics of carnivores. Conceptual and quantitative habitat models were used to determine the direct and indirect changes from development on carnivore habitats. Results from the habitat models were used as input parameters in population models. The population models were used to determine the relative contribution of the cumulative effects from development, incremental effects from the Project, and other factors (extreme weather events, and harvesting) on changes in grizzly bear and wolverine population size and persistence.

Although quantitative and less biased than habitat models based on expert opinion, the resource selection function-based habitat maps used in this assessment have sources of uncertainty. These include the structure of the models, the accuracy and precision of underlying data layers, and biases associated with the chosen GIS algorithms (Burgman et al. 2005). Further, habitat maps were a static view between carnivores and the environment, ignoring changes over time with ecological succession and natural disturbances such as climatic events. However, sources of uncertainty were reduced by using multiple habitat mapping methods (Burgman et al. 2005) and population viability analysis. For example, the assessment included both fragmentation analyses and the use of habitat quality models, which together limit bias and imprecision in predictions. In addition, the following conservative assumptions were applied to the habitat models:

- Footprint (area of direct habitat disturbance) for all exploration sites was a 500 m radius (78.5 ha).

- A 5 km zone of influence was applied to all active exploration permits for the entire five-year period, and over the entire year.
- A 15 km zone of influence was applied to all active mine sites (including the Project), regardless of the size of the footprint or the level of activity for each mine.
- Disturbance coefficients (used for reducing habitat quality in the zones of influence) with the greatest effect were applied in cases where zones of influenced overlapped, rather than using the average of two or more coefficients.

Thus, throughout the carnivore assessment, conservative estimates were used in conceptual and quantitative models to increase confidence that impacts were not underestimated. In addition, the spatial boundary of the assessment (geographic extent) was based on a large study area that would encompass a population or subpopulation that would be affected by the Project, and included all known previous and existing developments that may influence the population. Within the study area, smaller scale impacts were also assessed such as individual responses to estimated zones of influence. All of these attributes provide confidence that the assessment has not underestimated the environmental significance of the incremental and cumulative impacts from the Project and other developments on carnivores, and the people that value carnivores as part of their culture and livelihood.

11.10.10 Monitoring and Follow-up

Upon approval of the Project, a wildlife effects monitoring program (WEMP) will be implemented to test impact predictions and further reduce any uncertainty related to each prediction. The principal goal of the WEMP is to provide information required for the Project's Environmental Management System to adaptively manage the Project to protect wildlife and wildlife habitat. In this context, data collected on measurement endpoints will be used to evaluate the impacts from the Project on the persistence of carnivore populations, and the continued opportunity for traditional and non-traditional use of carnivores (i.e., assessment endpoints). Based on the definitions of monitoring in the Terms of Reference (Section 3.2.7, Gahcho Kué Panel 2007), the WEMP would consist of environmental monitoring and follow-up programs.

Measurement endpoints for testing impact predictions (i.e., monitoring effects) from the Project will likely include:

- direct habitat effects (changes in habitat quantity from the Project footprint);

- indirect habitat effects (changes in habitat quality, and animal abundance and distribution from sensory disturbance within the predicted zone of influence); and
- direct mine-related mortality (i.e., number of interactions, injuries, mortality) linked to Project infrastructure and activities.

Specific objectives of the WEMP would be:

- to verify the accuracy of impact predictions made in the EIS, and identify unanticipated effects;
- to implement a wildlife effects mitigation and management plan designed to reduce the risks and disturbance to wildlife and wildlife habitats;
- to determine the effectiveness of the wildlife effects mitigation and management plan;
- to consider and incorporate, where possible, traditional knowledge (TK) into the WEMP;
- to design studies and data collection protocols that are consistent with other monitoring programs in the Arctic (e.g., Snap Lake Mine, Diavik Diamond Mine, and Ekati Diamond Mine), and can be used to understand and manage cumulative effects, and participate in regional and/or collaborative programs;
- to develop and review the WEMP in collaboration with the Department of the Environment and Natural Resources, Canadian Wildlife Service (Environment Canada), and the communities; and
- to provide an annual report that will satisfy the appropriate government agencies responsible for wildlife, and will provide the opportunity for feedback from communities, governments, and the public.

Species selected for effects monitoring would be based on recent and current environmental assessments and monitoring programs in the NWT and Nunavut, and may include grizzly bears and wolverines. Following the principals of adaptive management, species selected for monitoring may be periodically reviewed by government, community, and regulatory agencies, and changed as necessary.

Similarly, study designs and sampling protocols would follow the current methods accepted for monitoring effects on wildlife and habitat at mine sites in Nunavut and the NWT. By consistently using standardized and up-to-date methods, direct comparisons can be made among projects that differ in the spatial extent of the footprint and level of mining activity. Such a meta-analysis can be used to help understand and manage the cumulative effects from development on wildlife population size and distribution.

The WEMP represents an adaptive approach to understanding the effects of the Project on the landscape and the species that live there. In this context, the WEMP is considered as a continually evolving process that relies not only on the efficiency of data collection and analytical results, but is also dependent on feedback from the communities, government, and the public. Having an adaptive and flexible program allows for appropriate and necessary changes to the design of monitoring studies, and the mitigation and management plans. Some changes may come about through the observation of unanticipated effects. Other changes may result from ecological knowledge acquired through working with Aboriginal community members.

De Beers is committed to considering and incorporating TK into the WEMP. The incorporation of TK would occur throughout all stages of the WEMP, including identification of mitigation practices and policies, data collection, and follow-up programs to obtain feedback Results of any relevant community-based monitoring studies would be incorporated into the annual WEMP report (with permission from the communities). As with all aspects of the WEMP, the incorporation of TK would be a continuously evolving process.

Community members will be invited to participate in data collection programs. This includes specific species monitoring programs (e.g., surveys for caribou, grizzly bears, and wolverine). The involvement of community members in field data collection is expected to contribute to overall efficiency as well as provide feedback and ideas. For example, sampling methods may be changed based on knowledge of wildlife behaviour or ecology provided by community participants during the field programs. Where appropriate, elders may be brought on site to further contribute to field monitoring programs.

11.10.11 References

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11.10.12 Acronyms and Glossary

11.10.12.1 Acronyms and Abbreviations

CCME	Canadian Council of Ministers of the Environment
DC	disturbance coefficients
De Beers	De Beers Canada Inc.
DNA	deoxyribonucleic acid
EIS	environmental impact statement
ELC	ecological land classification
ENR	Department of Environment and Natural Resources
GIS	geographic information system
GPS	global positioning system
INAC	Indian and Northern Affairs Canada
Leq	equivalent continuous sound and noise level
LKDFN	Łutselk'e Dene first Nation
Lmax	maximum sound and noise level
LSA	local study area
MVEIRB	Mackenzie Valley Environmental Impact Review Board
MVLWB	Mackenzie Valley Land and Water Board
NO_2	nitrogen dioxide
NOx	nitrogen oxide
NWT	Northwest Territories
NAG	non-acid generating
NRCAN	Natural Resources Canada
PAG	potentially acid-generating
PAI	potential acid input
PK	processed kimberlite
PKC	processed kimberlite containment
PVA	population viability analyses
PM	particulate matter
PM_{10}	particulate matter with particle diameter nominally smaller than 10 µm
$PM_{2.5}$	particulate matter with particle diameter nominally smaller than 2.5 µm
Project	Gahcho Kué Project
RSF	resource selection function
RSA	regional study area
SGP	Slave Geological Province
SD	standard deviation
SE	standard error
SARA	*Species at Risk Act*
SO2	sulphur dioxide
Terms of Reference	Terms of Reference for the Gahcho Kué Environmental Impact Statement
TK	traditional knowledge

TKD	tracks per kilometre per day
TSP	total suspended particulates
VC	valued component
WEMP	Wildlife Effects Monitoring Program
ZOI	zone of influence

11.10.12.2 Units of Measure

%	percent
≤	less than or equal to
<	less than
>	greater than
≥	greater than or equal to
$\mu g/m^3$	micrograms per cubic metre
dBA	decibels
dBL	linear decibels
ha	hectare
keq/ha/y	kiloequivalent per hectare
kg/ha/y	kilograms per hectare per year
km	kilometre
km^2	square kilometres
m	metre
mm	millimetre
mm/s	millimetres per second

11.10.12.3 Glossary

Ambient air	The surrounding air of the environment, open or outdoor air.
Annual home range	The area traversed by animals in its normal activities of food gathering, mating and caring for young. Occasional sallies outside the area, perhaps exploratory in natures, should not be considered part of the home range. An alternative, statistical explanation is the smallest sub-region which accounts for a specified proportion of its total utilization over the course of the year.
Anthropogenic	Human-related, often referring to an activity, development or disturbance on the landscape.
Barren kimberlite	Kimberlite that does not contain diamonds.
Baseline	The case that includes existing environmental conditions as well as existing and approved projects or activities, prior to the construction of the Project in question, acts as reference against which data from construction and operational phases of development will be compared.
Berms	a level space, shelf, or raised barrier separating two areas.
CALPUFF	California puff model, a air quality model used to develop a three-dimensional meteorological parameters field to emulate the spatial transport, dispersion and chemical transformation of emitted substances.

Carnivore	An animal that preys on other animals; especially any mammal of the Order Carnivora including wolves, bears and wolverine.
Carrying Capacity	The maximum population of a given organism that a particular environment or habitat can sustain; implies continuing yield without environmental damage.
Coefficient of Variation for Patch Area	The ratio of standard deviation divided by the mean for a given sample; used to measure the spread of the data or the distribution around the mean for patch area.
Covariate	An independent variable, or predictor variable, in a statistical model. Also, a secondary variable that can affect the relationship between the dependent variable and independent variables of primary interest in a statistical model.
Critical load	A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.
Density dependence	In population ecology, describes a situation in which population growth is curtailed by crowding because an increased density means an increase in intraspecific competition. Greater competition means an individual has a decreased contribution to the next generation i.e. offspring.
Drawdown	A lowering of the water level in a reservoir or other body of water.
Drumlins	A long narrow hill, made up of till, which points in the direction of the glacier movement.
Environmental Impact Statement	A report that documents the information required to evaluate the environmental impact of a project.
Esker	Linear structures of loose sand and gravel, formed by glacial rivers. They provide critical habitat for carnivores and ungulates in the arctic.
Eutrophication	The process whereby a body of water becomes rich in dissolved nutrients through natural or man-made processes. This often results in a deficiency of dissolved oxygen, producing an environment that favours plant over animal life.
Exposure ratio	Health risks are estimated by comparing the predicted exposure(s) to the acceptable toxicity reference values. For threshold-acting contaminants, the human and non-human risk estimate is expressed as an exposure ratio (ER), such that, ER = (predicted exposure)/(exposure limit).
Freshet	A sudden overflow of a stream caused by heavy rain or nearby thawing of snow or ice.
Fugitive dust	Particulate matter suspended in the air by wind action and human activities.
Glaciofluvial deposits	Glaciofluvial deposits were left behind by rivers that helped drain melting glaciers.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Habitat	The physical space within which an organism lives, and the abiotic and biotic entities (e.g., resources) it uses and selects in that space.
Habitat Fragmentation	A process by which habitats are increasingly subdivided into smaller units, resulting in their increased restriction as well as an overall loss of habitat area and biodiversity.
Headwater	The source or upper part of a stream or river; where a river begins.
Health tundra	A closed mat plant community that grows on moderate to well drained soils, covering most of the upland areas. Plants generally belong to the heath family, the Ericaceae. The vegetation layer forms a mat of low shrubs dominated by dwarf birch and Labrador tea.
Kames	Steep-sided mounds of stratified material deposited against an ice-front.

Key Line of Inquiry	Areas of the greatest concern that require the most attention during the environmental impact review and the most rigorous analysis and detail in the Environmental Impact Statement. Their purpose is to ensure a comprehensive analysis of the issues that resulted in significant public concern about the proposed development.
Landscape	Mosaic of patches that differ in ecologically important properties.
Lichen veneer	A continuous mat of lichen that appears as a “veneer”. These sites are windswept and dry, allowing very little other plant growth. Lichen veneer consists mainly of Iceland moss, several other species of Cetraria, green and black hair lichens, grey mealy lichen, worm lichens and other species.
Microtine	Of the rodent subfamily Microtinae-for example, lemmings.
Natal den	A lair, typically underground, used for the birthing and initial rearing of young; often occur in esker complexes.
Open-water season	Summer season when lakes, rivers and streams are free of ice (generally June or July to October).
PAH	Class of large aromatic molecules composed of several benzene rings fused together; a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances.
PAI	Potential Acid Input (PAI) is an air quality indicator (calculated from numerous atmospheric, ground/vegetation surface characteristics, and chemical variables – all requiring model input assumptions, or actual field sampling and analysis and measurements) to collectively express the acidification potential resulting from sulphur (mainly SO_2) and nitrogen (mainly NO_x) depositions to water and soil, including the countering acidification effects of alkaline constituents in the exhaust and in the ambient air. PAI is not a directly measurable property of emissions or ambient air characteristics.
Patch	A particular unit of habitat with identifiable boundaries that differs from its surroundings in one or more ways. These can be a function of vegetative composition, structure, age or some combination of the three.
Peat bog	Sphagnum or forest peat materials formed in an ombrotrophic environment due to the slightly elevated nature of the bog, which tends to disassociate it from the nutrient-rich groundwater or surrounding mineral soils. Characterized by a level, raised or sloping peat surface with hollows and hummocks. Mineral-poor, acidic and peat-forming wetlands that receives water only from precipitation.
PVA	Population viability analysis is a comprehensive analysis of the many environmental and demographic factors that affect survival of a population. It brings together species characteristics and environmental variability to forecast population health and to ensure that the population of a species is self-sustaining over the long term.
Recruitment	The influx of new organism members into a population due to reproduction (i.e., the number of caribou calves born and surviving to reproductive age).
Resource Selection Models or resource selection functions (RSFs)	Statistical functions that quantify the relationship between the observed distribution of a focal species and covariates representative of habitats and human disturbance. The models are used to identify critical resources for animal populations and to predict species occurrence. Typically, the model consists of a number of coefficients that quantify selection for or avoidance of some environmental feature.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.
Runoff	The portion of precipitation or irrigation water that moves across land as surface flow and enters streams or other surface receiving waters.

Standard deviation (SD)	A measure of the spread or dispersion of a set of data. It is calculated by taking the square root of the variance.
Standard error (SE)	A measure of the sampling variability or precision of an estimate. The SE of an estimate is expressed in the same units as the estimate itself. It is calculated as the standard deviation divided by the square root of the number of observations.
Sedge	A grass-like plant with a triangular stem often growing in wet areas. Sedge wetland habitats are typically wet sedge meadows and other sedge associations of non-tussock plant species. Sedge species such as *Carex aquatilis* and *C. bigelowii*, and cotton grass (*Eriophorum angustifolium*) are the dominant vegetation types. Plant species occupy wet, low lying sites where standing water is present throughout much of the growing season.
Sedimentation	The process by which suspended particles in waste water settle to the bottom.
Sensitive	Sites or organisms that are particularly vulnerable to harmful effects. A general status rank for a species with one or more of the following indicators: a small population size or restricted distribution, a declining population trend and/or moderate threats to its population of habitats. in statistics, parameter sensitivity refers to a series of tests in which different parameter values are set to see how a change in the parameter causes a change in the dynamic behaviour of the system in question (e.g., how much does a change in adult female survival affect population growth of a caribou herd).
Stochastic	Involving or containing a random variable or variables; involving chance or probability.
Swale	An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water.
Taiga	The northern edge of the boreal forest.
Terms of Reference	Written requirements governing environmental impact assessment implementation, consultations to be held, data to be produced and form/contents of the environmental impact assessment report.
Test Den	A den constructed by carnivores which was not ultimately used for over-wintering or raising offspring.
Till	Unstratified soil deposited by a glacier; consists of sand and clay and gravel and boulders mixed together.
Total Edge	The perimeter of a patch, or the total distance of the edge of a patch of habitat.
Traditional Knowledge	The knowledge, innovations and practices of indigenous people; refers to the matured long-standing traditions and practices of certain regional, indigenous, or local communities.
Treeline	An area of transition between the tundra and boreal forest to the south.
Tundra	A type of ecosystem dominated by lichens, mosses, grasses, and woody plants; a treeless plain characteristic of the arctic and sub-Arctic regions.
Tussock - hummock	A tussock is a tuft of grass or grass like plants like sedges. Tussock –hummock refers to a type of tundra consisting of acre upon acre of sedge tussocks, usually located on flat, poorly drained land or gentle slopes.
Ungulate	A hoofed, grazing mammal (e.g., caribou, muskoxen, deer, moose).
Upland areas	Ground elevated above the lowlands along rivers or between hills; highland or elevated land; high and hilly country.
Valued Component	Represent physical, biological, cultural, and economic properties of the social-ecological system that are considered to be important by society.
Vegetation type	Habitat types classified based on the plant community present.
VOCs	Volatile Organic Compound (that boils below a temperature of about 100^{o}C), excluding methane.

Watershed	A region draining into a river, river system, or other body of water.
Wetlands	An area of land where the water table is at or above the mineral soil for the entire year.
Yearling	An animal in its second year.
Young-of-year	An animal younger than one year of age (i.e., born within the year).
Zone of Influence	The surrounding area of a development site in which animal occurrence is reduced or increased, possibly due to avoidance or attraction.

APPENDIX 11.10.I

ABSOLUTE VALUES FOR CHANGES IN LANDSCAPE METRICS IN THE STUDY AREAS FOR GRIZZLY BEAR, WOLVERINE, AND WOLF

Table 11.10.I-1 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) and Developments in the Study Area for Grizzly Bear and Wolverine (Spring to Autumn)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	88,220	87,388	87,388	87,344	9,707	9,681	9,681	9,678	1,080	1,083	1,083	1,084
Non-vegetated	6,667,012	6,661,868	6,661,096	6,659,908	90,108	90,117	90,132	90,163	486	486	486	486
Forest	402,820	402,724	402,720	402,592	10,770	10,764	10,763	10,761	726	726	725	725
Peat Bog	62,420	62,380	62,380	62,348	8,630	8,625	8,625	8,622	695	695	695	695
Heath rock	3,208,956	3,205,732	3,205,668	3,203,996	93,409	93,394	93,395	93,422	509	509	509	509
Heath tundra	4,328,192	4,324,664	4,324,352	4,322,176	82,406	82,399	82,404	82,466	513	513	513	513
Lichen veneer	607,216	606,924	606,852	606,628	33,085	33,067	33,062	33,059	704	704	704	704
Rock association	1,440,404	1,439,408	1,439,408	1,439,296	45,304	45,274	45,274	45,263	678	678	678	679
Sedge association	2,071,948	2,070,092	2,070,084	2,069,268	94,458	94,407	94,405	94,428	555	555	555	555
Low shrub	323,088	323,004	323,004	322,948	20,017	20,003	20,003	20,001	826	827	827	826
Riparian shrub	101,664	101,648	101,648	101,592	13,747	13,744	13,744	13,737	917	917	917	917
Old burn	46,208	46,208	46,208	46,208	2,942	2,942	2,942	2,942	785	785	785	785
Young burn	25,392	25,392	25,392	25,392	156	156	156	156	4,031	4,031	4,031	4,031

ha = hectares; m = metres

Table 11.10.I-2 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) and Developments in the Study Area for Grizzly Bear and Wolverine (Winter)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	88,220	87,304	87,304	87,264	9,707	9,680	9,680	9,676	1,080	1,083	1,083	1,083
Non-vegetated	6,667,012	6,647,132	6,646,412	6,643,472	90,108	90,211	90,226	90,279	486	486	486	486
Forest	402,820	402,492	402,488	402,296	10,770	10,767	10,766	10,760	726	726	725	726
Peat Bog	62,420	62,360	62,360	62,304	8,630	8,623	8,623	8,621	695	695	695	695
Heath rock	3,208,956	3,204,820	3,204,756	3,202,900	93,409	93,399	93,400	93,429	509	509	509	509
Heath tundra	4,328,192	4,322,592	4,322,316	4,320,020	82,406	82,436	82,439	82,498	513	513	513	512
Lichen veneer	607,216	606,816	606,744	606,512	33,085	33,062	33,057	33,053	704	704	704	704
Rock association	1,440,404	1,439,196	1,439,196	1,439,048	45,304	45,271	45,271	45,259	678	678	678	678
Sedge association	2,071,948	2,069,228	2,069,220	2,068,252	94,458	94,417	94,415	94,440	555	555	555	555
Low shrub	323,088	322,912	322,912	322,844	20,017	19,996	19,996	19,991	826	827	827	827
Riparian shrub	101,664	101,608	101,608	101,516	13,747	13,742	13,742	13,728	917	917	917	917
Old burn	46,208	46,188	46,188	46,188	2,942	2,938	2,938	2,938	785	786	786	786
Young burn	25,392	25,392	25,392	25,392	156	156	156	156	4,031	4,031	4,031	4,031

ha = hectares; m = metres

Table 11.10.I-3 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) and Developments in the Study Area for Wolf (Spring to Autumn)

Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	30,860	30,812	30,812	30,800	6,042	6,031	6,031	6,029	1,702	1,704	1,702	1,703
Non-vegetated	6,323,068	6,318,652	6,318,708	6,318,100	1,317	1,325	1,324	1,326	2,826	2,805	2,812	2,807
Forest	12,244,572	12,235,116	12,234,516	12,231,080	1,455	1,467	1,472	1,485	1,393	1,385	1,382	1,372
Heath rock	1,634,772	1,633,044	1,633,076	1,633,036	1,237	1,247	1,245	1,245	1,393	1,384	1,387	1,387
Heath tundra	7,901,584	7,895,160	7,894,904	7,891,684	1,026	1,032	1,035	1,041	1,816	1,789	1,806	1,798
Lichen veneer	465,512	465,168	465,188	465,188	148	148	148	148	3,525	3,525	3,525	3,525
Rock association	5,940,092	5,931,448	5,931,072	5,929,880	1,939	1,955	1,962	1,972	1,694	1,665	1,657	1,650
Sedge association	228,732	228,628	228,628	228,576	270	270	270	271	5,108	5,108	5,108	5,084
Low shrub	43,360	43,360	43,360	43,360	28	28	28	28	31,556	31,556	31,556	31,556
Riparian shrub	2,130,888	2,130,232	2,130,216	2,129,224	1,621	1,626	1,624	1,627	2,179	2,168	2,171	2,167
Old burn	794,720	794,324	794,316	793,552	580	581	581	582	3,921	3,912	3,912	3,905
Young burn	1,654,876	1,654,312	1,654,304	1,653,152	463	465	466	468	3,853	3,732	3,724	3,708

ha = hectares; m = metres

Table 11.10.I-4 Reference, Baseline, Application, and Future Landscape Metrics for Vegetation Communities (Ecotypes) and Developments in the Study Area for Wolf (Winter)

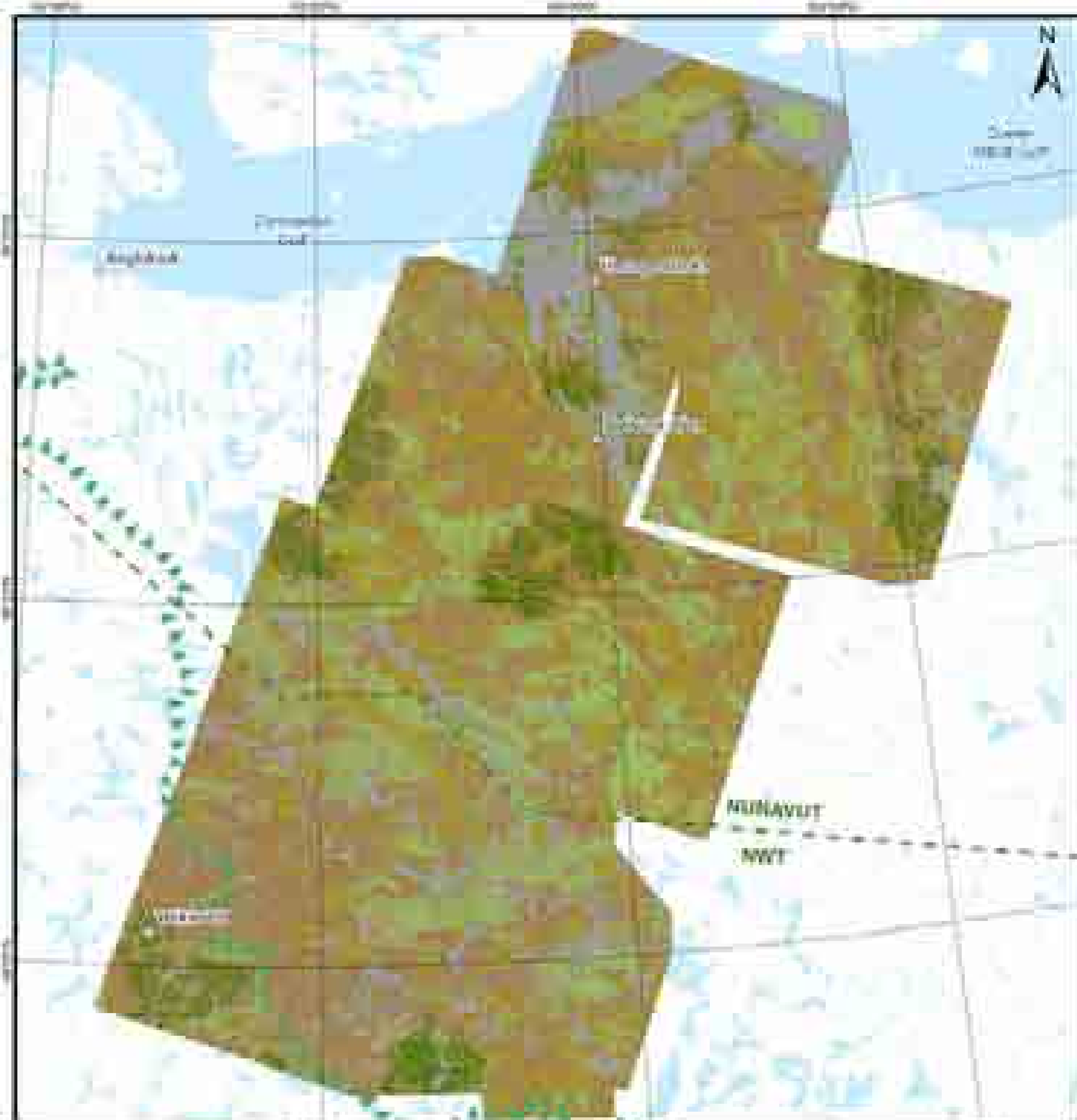
Habitat Type	Area (ha)				Number of Patches				Mean Distance to Nearest Neighbour (m)			
	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future	Reference	Baseline	Application	Future
Esker	30,860	30,760	30,760	30,748	6,042	6,022	6,022	6,020	1,702	1,705	1,705	1,705
Non-vegetated	6,323,068	6,301,928	6,301,912	6,298,144	1,317	1,345	1,345	1,356	2,826	2,770	2,770	2,736
Forest	12,244,572	12,224,932	12,224,356	12,219,912	1,455	1,478	1,483	1,499	1,393	1,376	1,374	1,360
Heath rock	1,634,772	1,632,368	1,632,368	1,632,328	1,237	1,250	1,250	1,250	1,393	1,380	1,380	1,380
Heath tundra	7,901,584	7,891,600	7,891,380	7,887,700	1,026	1,039	1,040	1,049	1,816	1,772	1,771	1,759
Lichen veneer	465,512	464,996	464,996	464,996	148	148	148	148	3,525	3,525	3,525	3,525
Rock association	5,940,092	5,928,776	5,928,436	5,926,948	1,939	1,971	1,975	1,985	1,694	1,650	1,646	1,640
Sedge association	228,732	228,588	228,588	228,536	270	270	270	271	5,108	5,108	5,108	5,084
Low shrub	43,360	43,340	43,340	43,340	28	29	29	29	31,556	30,482	30,482	30,482
Riparian shrub	2,130,888	2,129,524	2,129,524	2,128,048	1,621	1,627	1,627	1,632	2,179	2,166	2,166	2,160
Old burn	794,720	794,044	794,044	793,276	580	582	582	583	3,921	3,901	3,901	3,894
Young burn	1,654,876	1,653,408	1,653,408	1,652,096	463	467	467	470	3,853	3,715	3,715	3,692

ha = hectares; m = metres

APPENDIX 11.10.II

RESOURCE SELECTION FUNCTION MAPS FOR GRIZZLY BEAR, WOLVERINE, AND WOLF SEASONAL HOME RANGES DURING BASELINE, APPLICATION, AND FUTURE SCENARIOS

De Beers Canada Inc.



LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

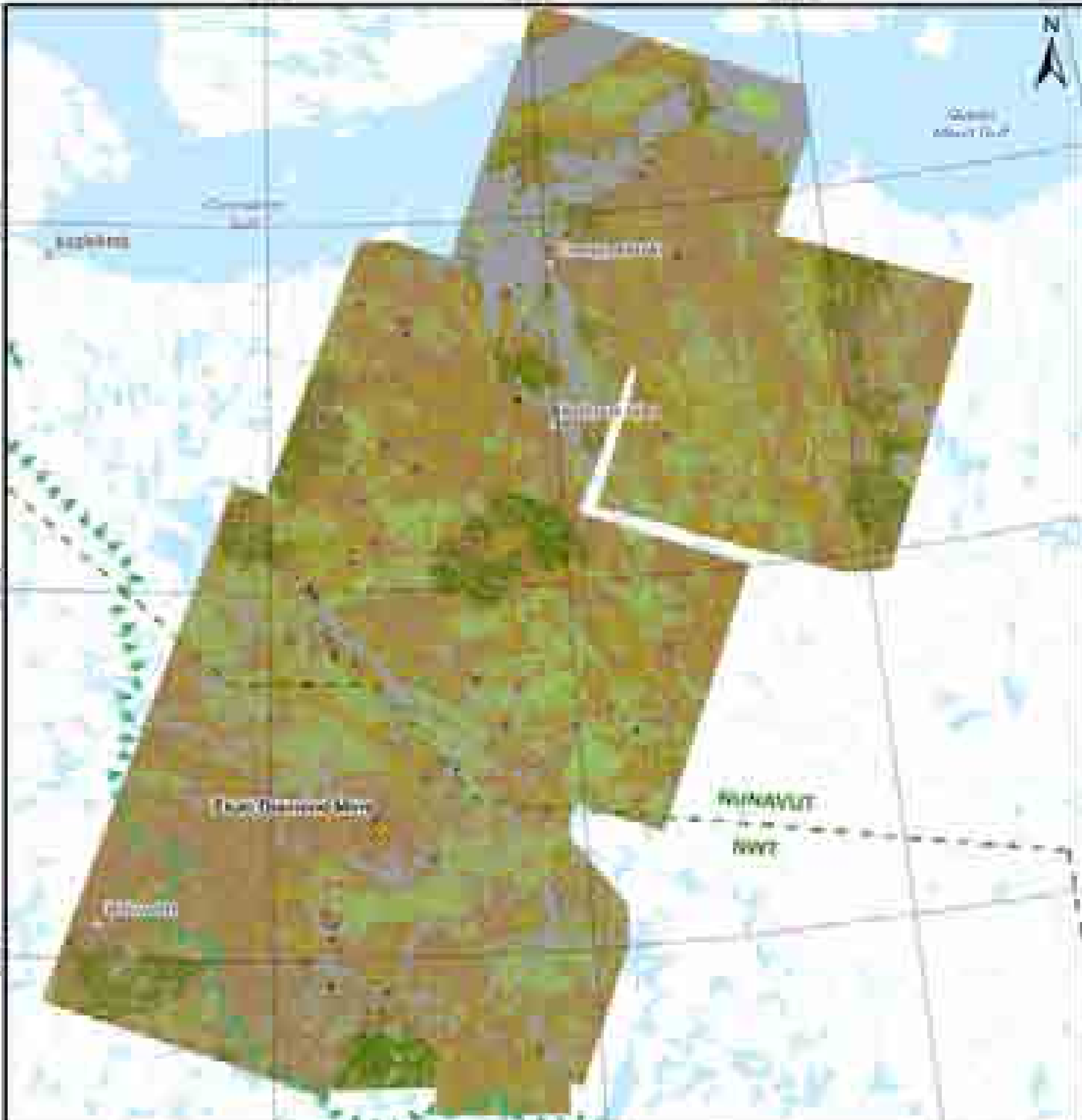
GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Spring: Reference Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
Scale	1:3,100,000
FILE NO	SON-11-10-004-GIS
DATE	October 29, 2010
JOB NO	09-1365-1004
REVISION NO	3
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

De Beers Canada

Figure 11.10.II-1



LEGEND

- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Spring: 2000 Baseline Conditions

PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

Scale 1:3,100,000

SON-11-10-005-GIS

October 29, 2010

JOB NO.	REVISION NO.
09-1365-1004	2

OFFICE	DRAWN	CHECK
GOLD-SAS	ANK	JV

Figure 11.10.II-2

LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

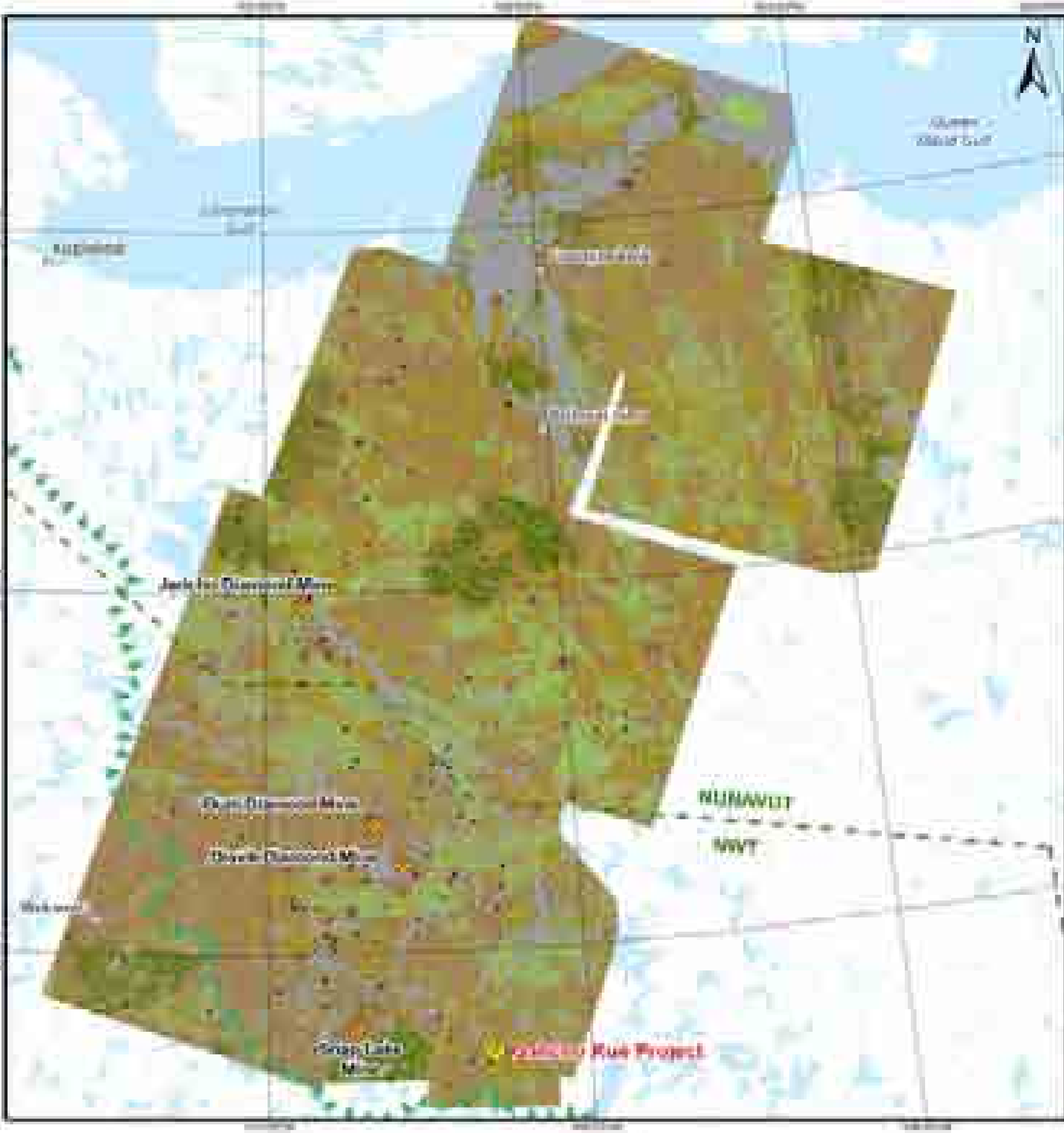
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Spring: 2006 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: SON-11-10-006-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	**Figure 11.10.II-3**



LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function
- High
- Good
- Low
- Poor
- Nil

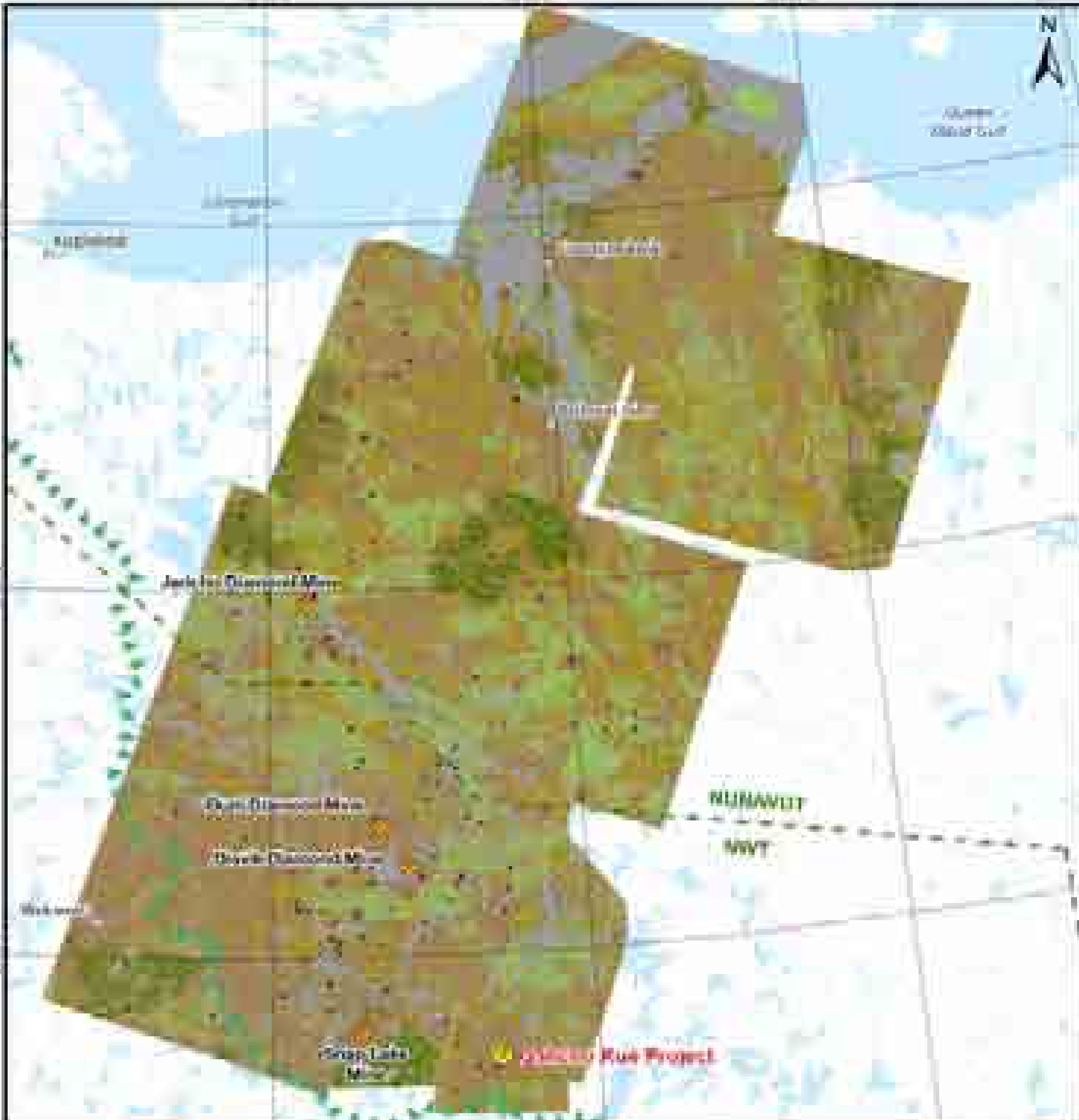
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Spring: 2010 Baseline Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
	SON-11-10-043-GIS
DATE	October 29, 2010
JOB NO	09-1365-1004
REVISION NO	1
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Figure 11.10.II-4



LEGEND
Gahcho Kue Project
Existing Mine
Populated Place
Watercourse
Waterbody
Territorial/Provincial Boundary
Treeline
Development Location
Resource Selection Function
High
Good
Low
Poor
Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Spring: Application Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: SON-11-10-044-GIS			DATE: October 29, 2010
JOB NO: 09-1365-1004	REVISION NO: 1		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 11.10.II-5

LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Proposed Taltson Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Spring: Future Case

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
Scale	1:5,100,000
FILENAME	SON-11-10-045-GIS
DATE	October 29, 2010
JOB NO.	09-1365-1004
REVISION NO.	1
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

De Beers

Figure 11.10.II-6

LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Early Summer: Reference Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE NO: SON-11-10-007-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	

Figure 11.10.II-7

LEGEND

- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

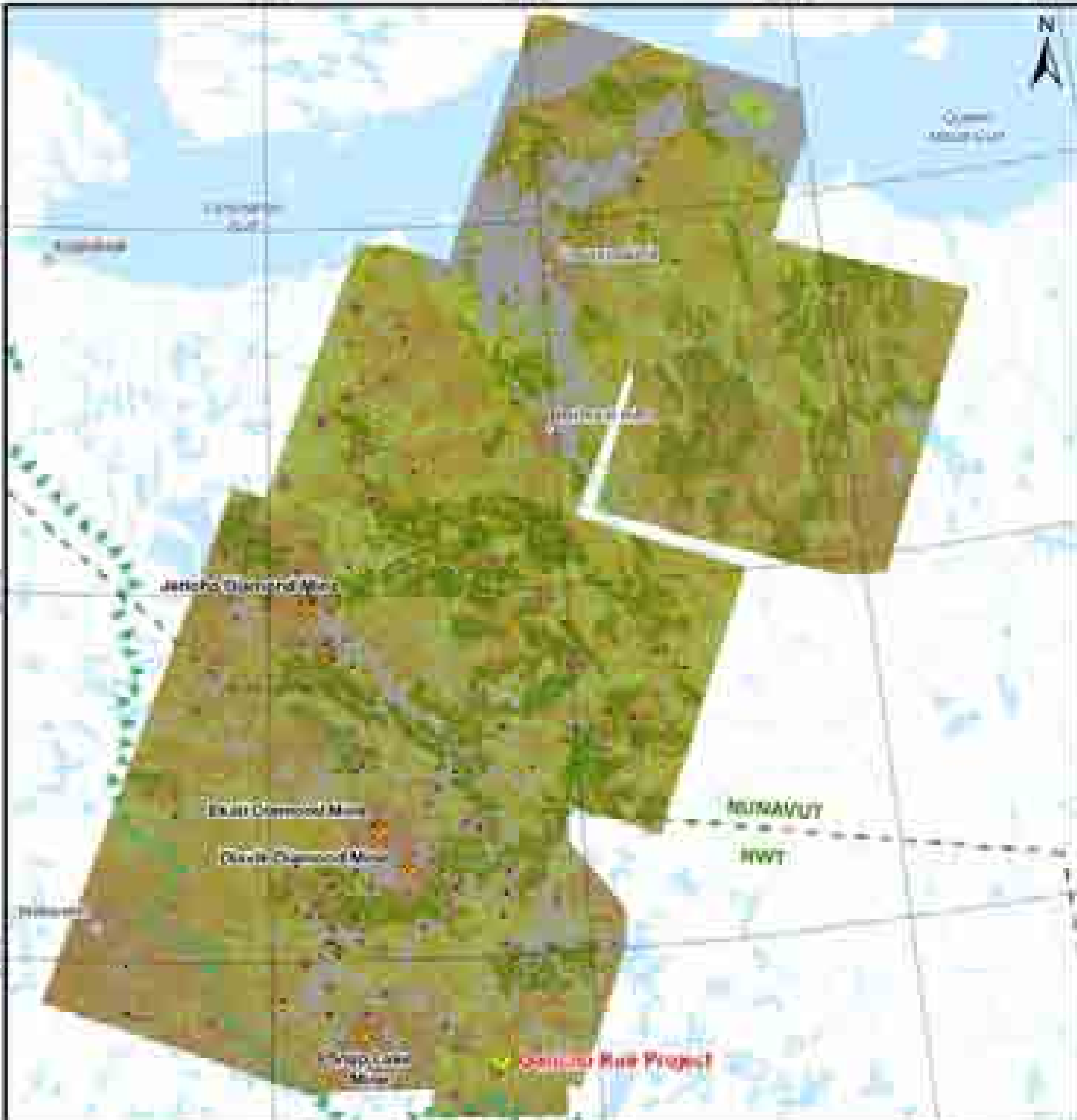
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Early Summer: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE NAME: SON-11-10-008-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	Figure 11.10.II-8



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

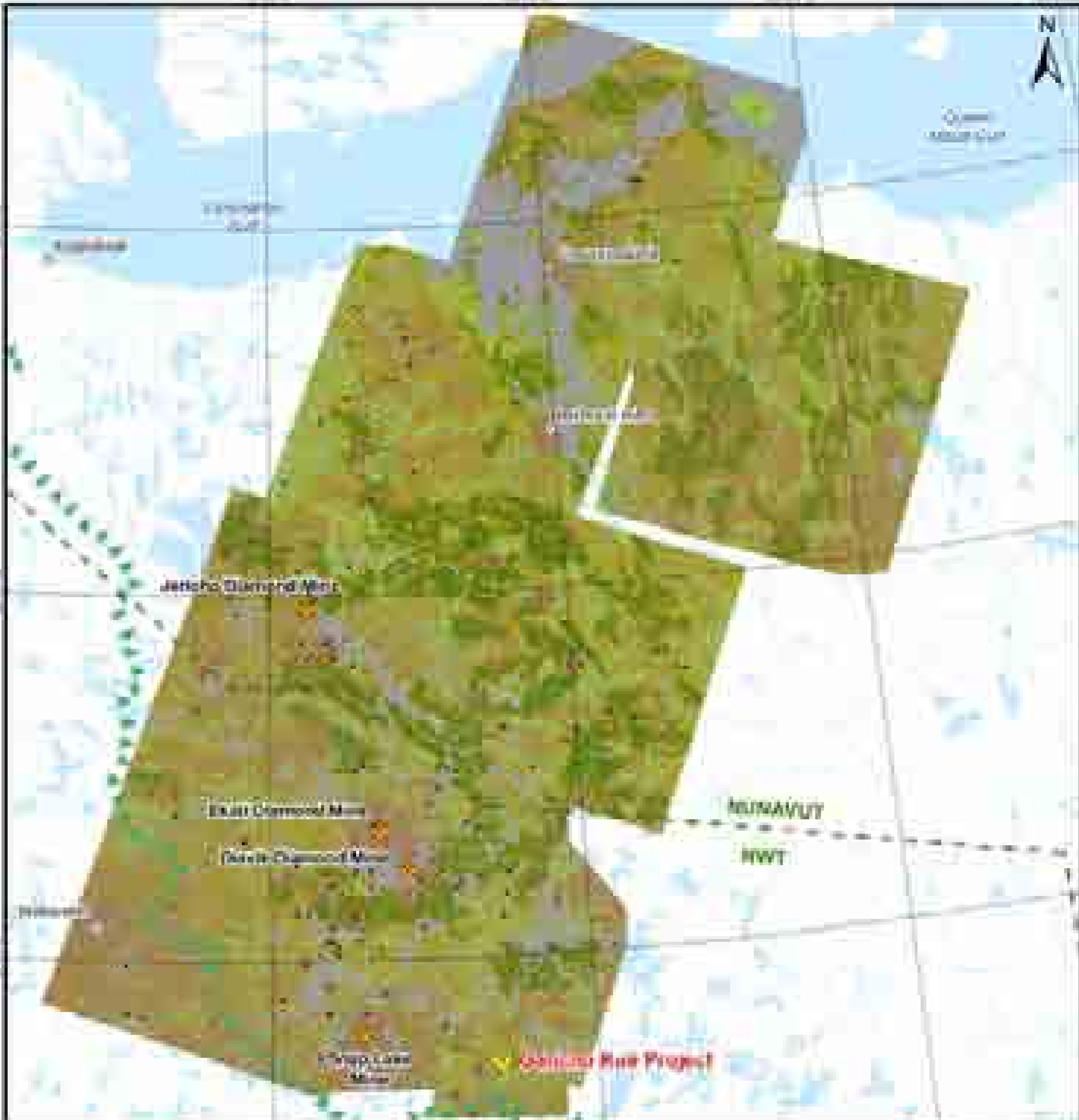
GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Early Summer: 2006 Baseline Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
Scale	1:1,100,000
	SON-11-10-009-GIS
DATE	October 29, 2010
JOB NO.	09-1365-1004
REVISION NO.	4
OFFICE	GOLD-SAS
DRAWN	MK
CHECK	JV

De Beers

Figure 11.10.II-9



LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Early Summer: 2010 Baseline Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
	SON-11-10-046-GIS
DATE	October 29, 2010
JOB NO.	09-1365-1004
REVISION NO.	1
OFFICE	GOLD-SAS
DRAWN	MK
CHECK	JV

Figure 11.10.II-10

LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

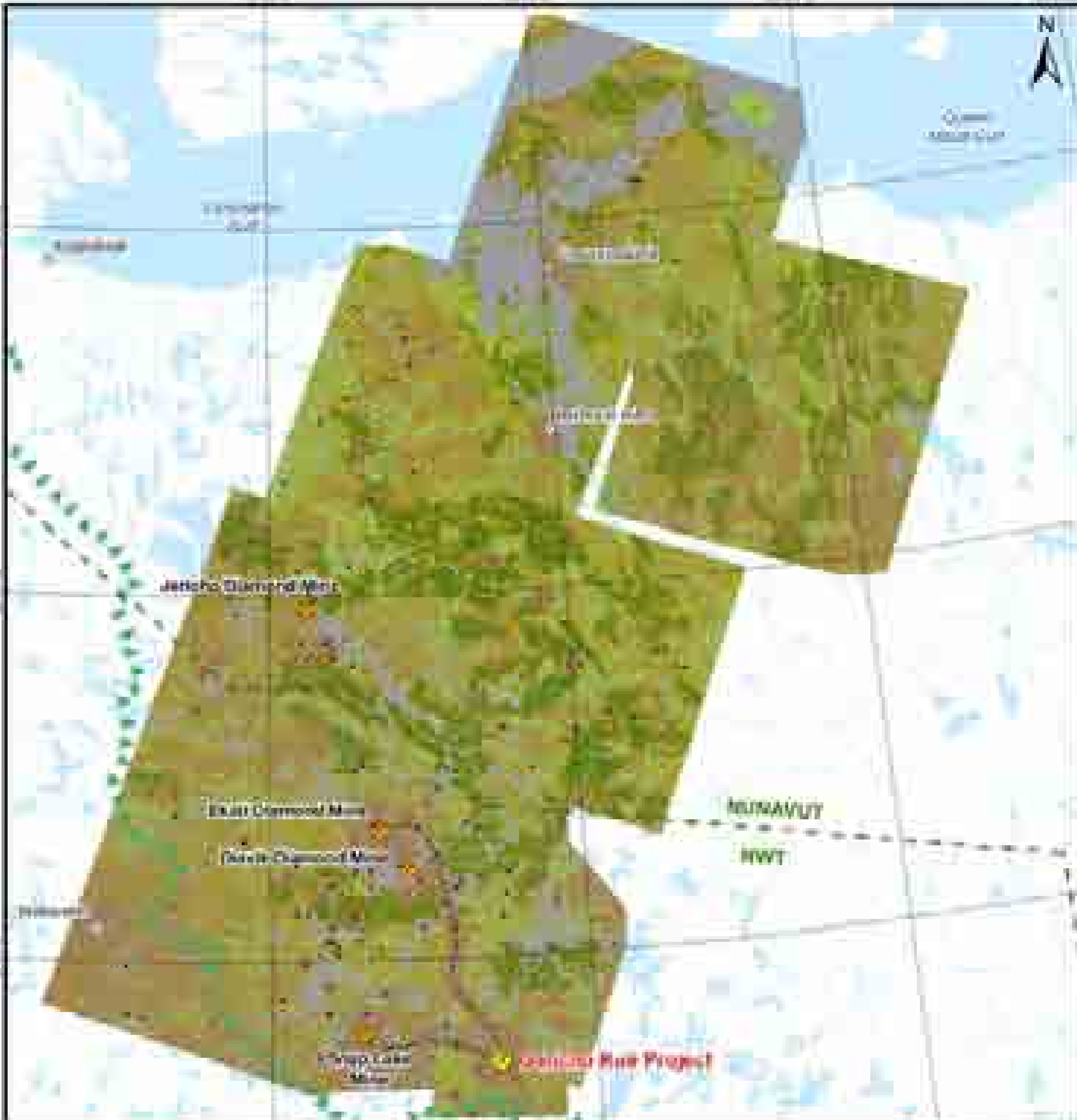
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Early Summer: Application Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: SON-11-10-047-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	**Figure 11.10.II-11**



LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Proposed Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Early Summer: Future Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
Scale 1:3,100,000			
SON-11-10-048-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	**Figure 11.10.II-12**

LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

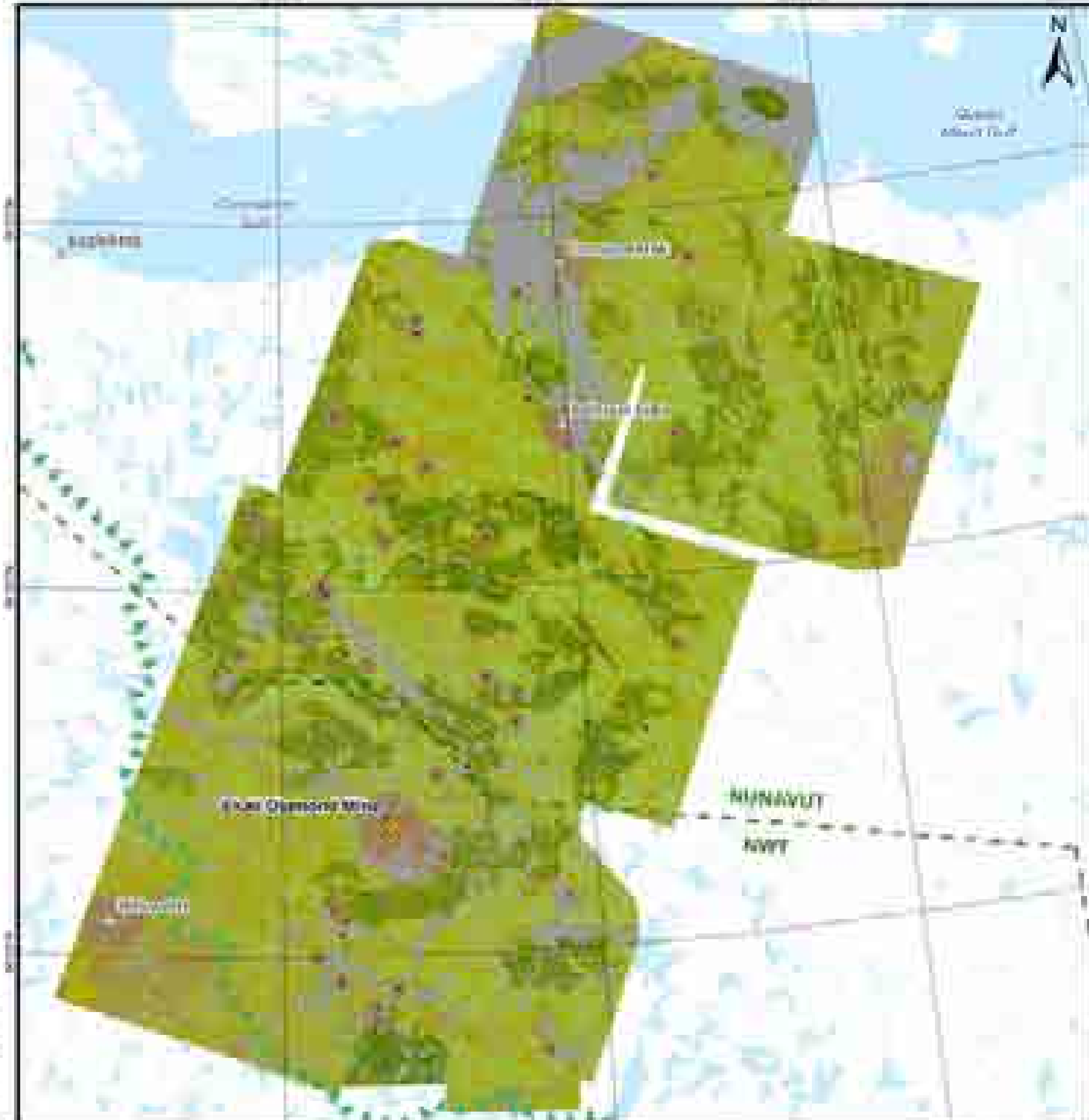
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Late Summer: Reference Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: SON-11-10-010-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 3		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 11.10.II-13



LEGEND

- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

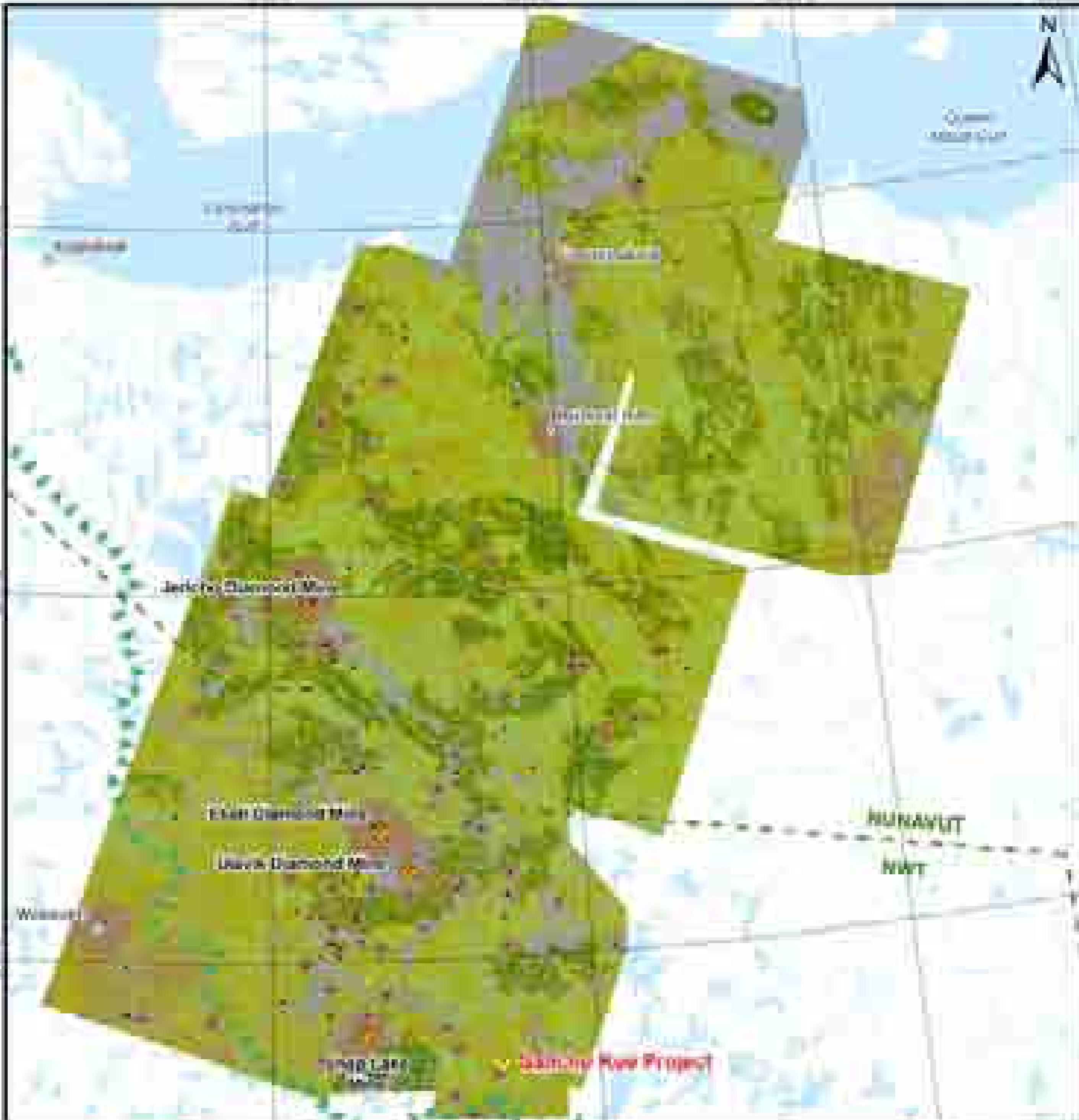
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Late Summer: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No.: SON-11-10-011-GIS		DATE: October 29, 2010	
JOB NO.: 09-1365-1004	REVISION NO.: 4		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	

Figure 11.10.II-14



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Late Summer: 2006 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE NO: SON-11-10-012-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 4		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	

Figure 11.10.II-15

LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Late Summer: 2010 Baseline Conditions

PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

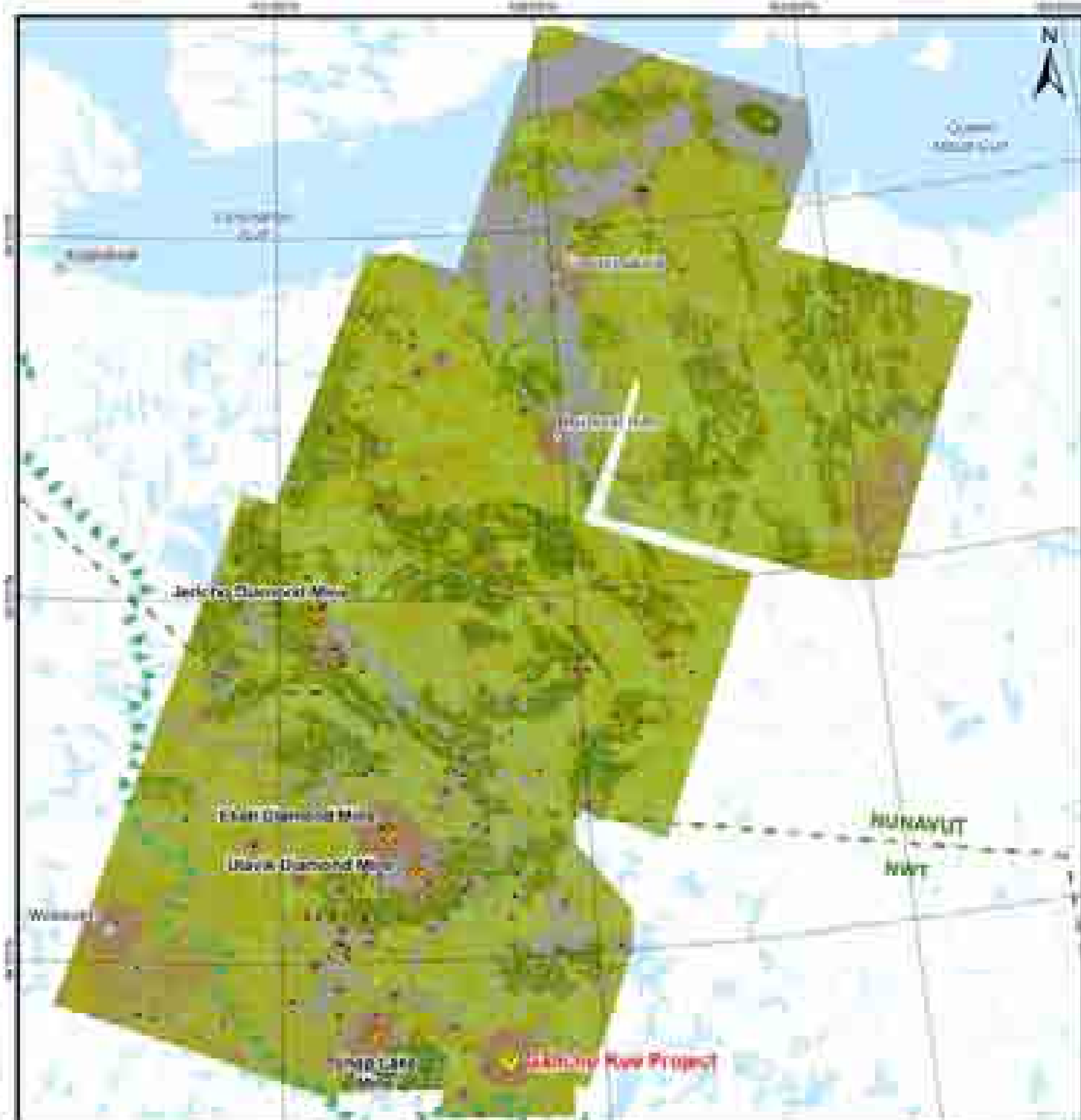
Kilometres

FILE NO.	DATE
SON-11-10-049-GIS	October 29, 2010

JOB NO.	REVISION NO.
09-1365-1004	2

OFFICE	DRAWN	CHECK
GOLD-SAS	MK	JV

Figure 11.10.II-16



LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

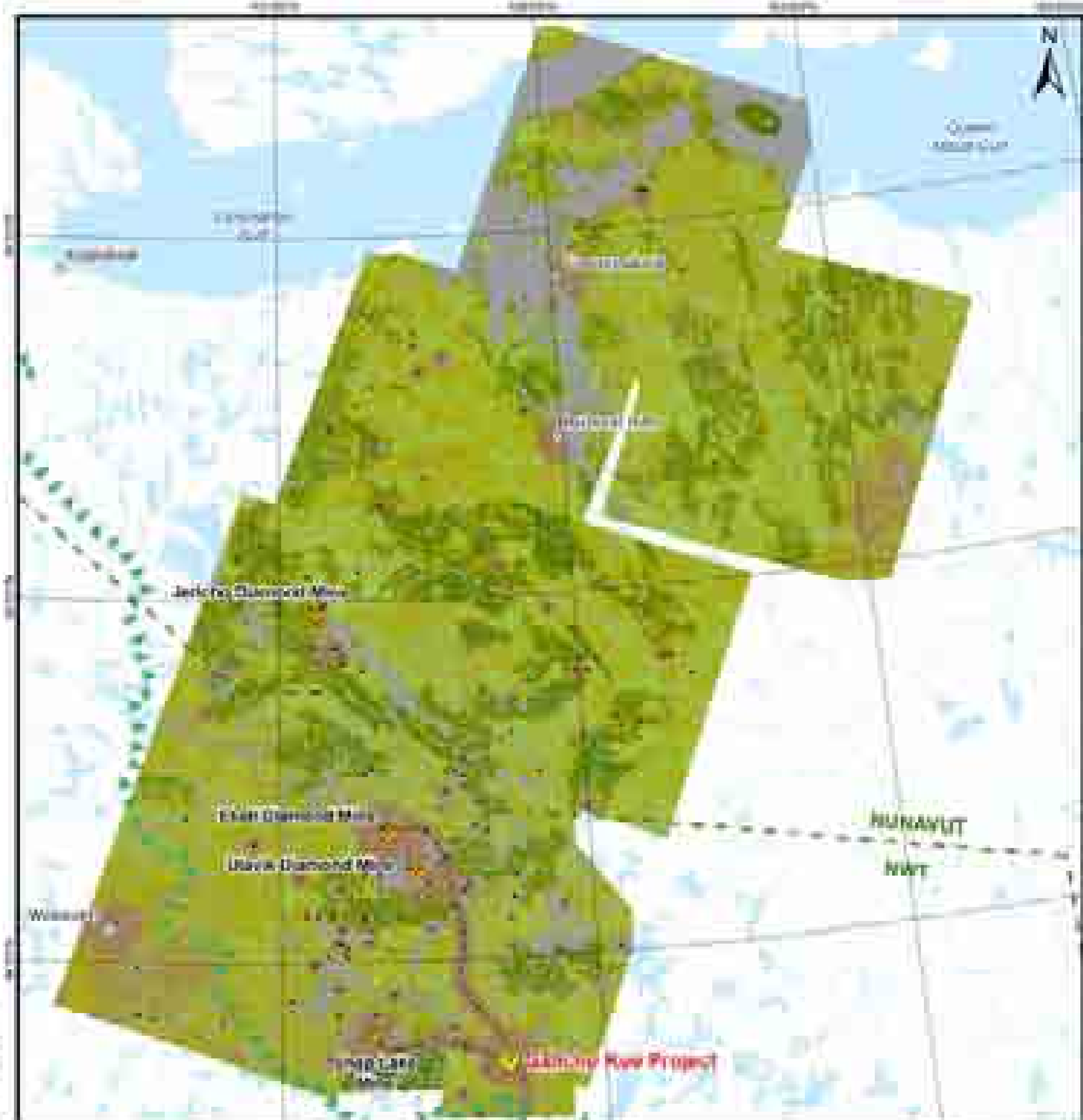
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Late Summer: Application Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: SON-11-10-050-GIS			DATE: October 29, 2010
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	**Figure 11.10.II-17**



LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Proposed Taltson Transmission Line

Resource Selection Function

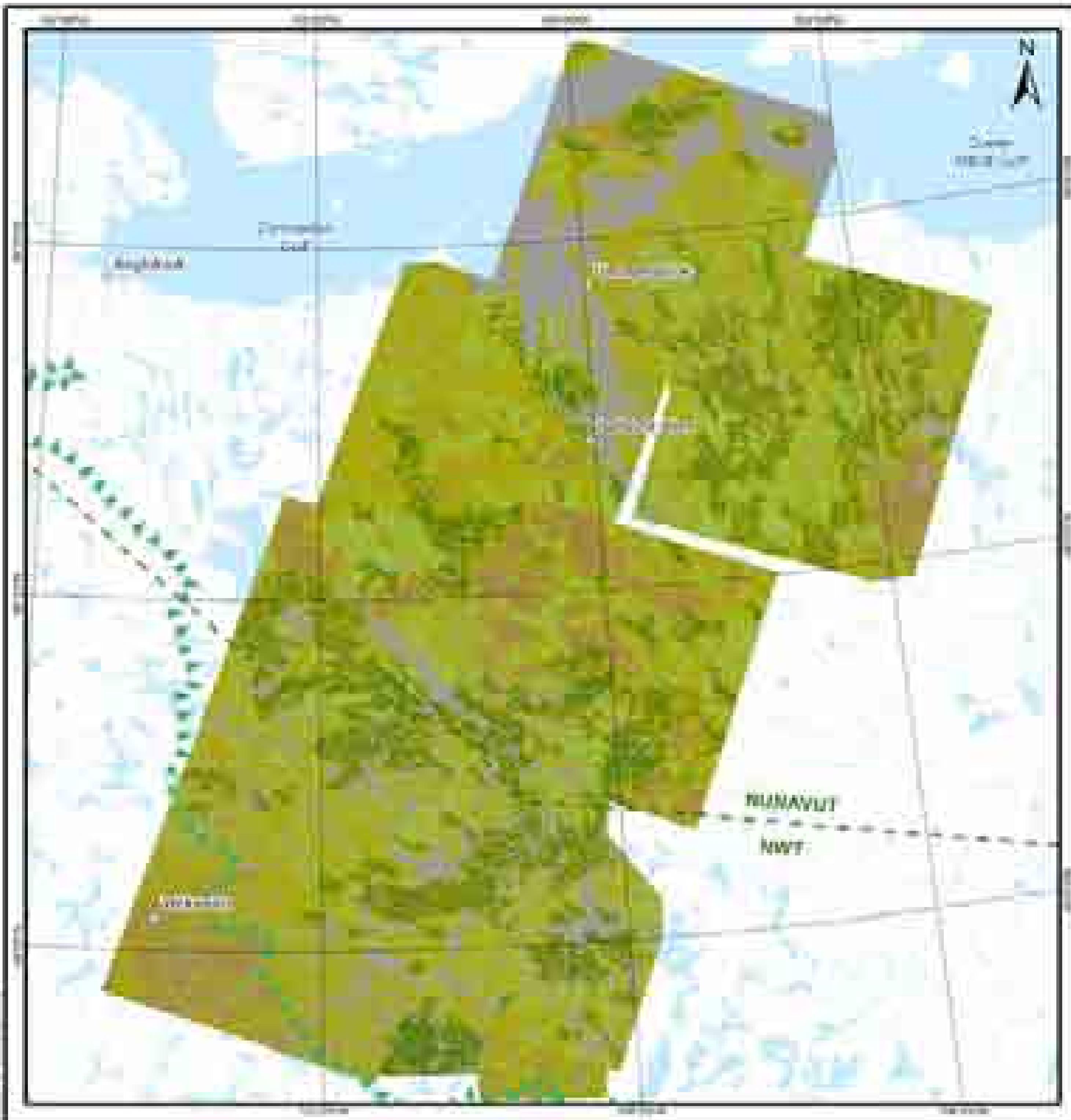
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Late Summer: Future Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
Scale 1:3,100,000			
SON-11-10-051-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	**Figure 11.10.II-18**



LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

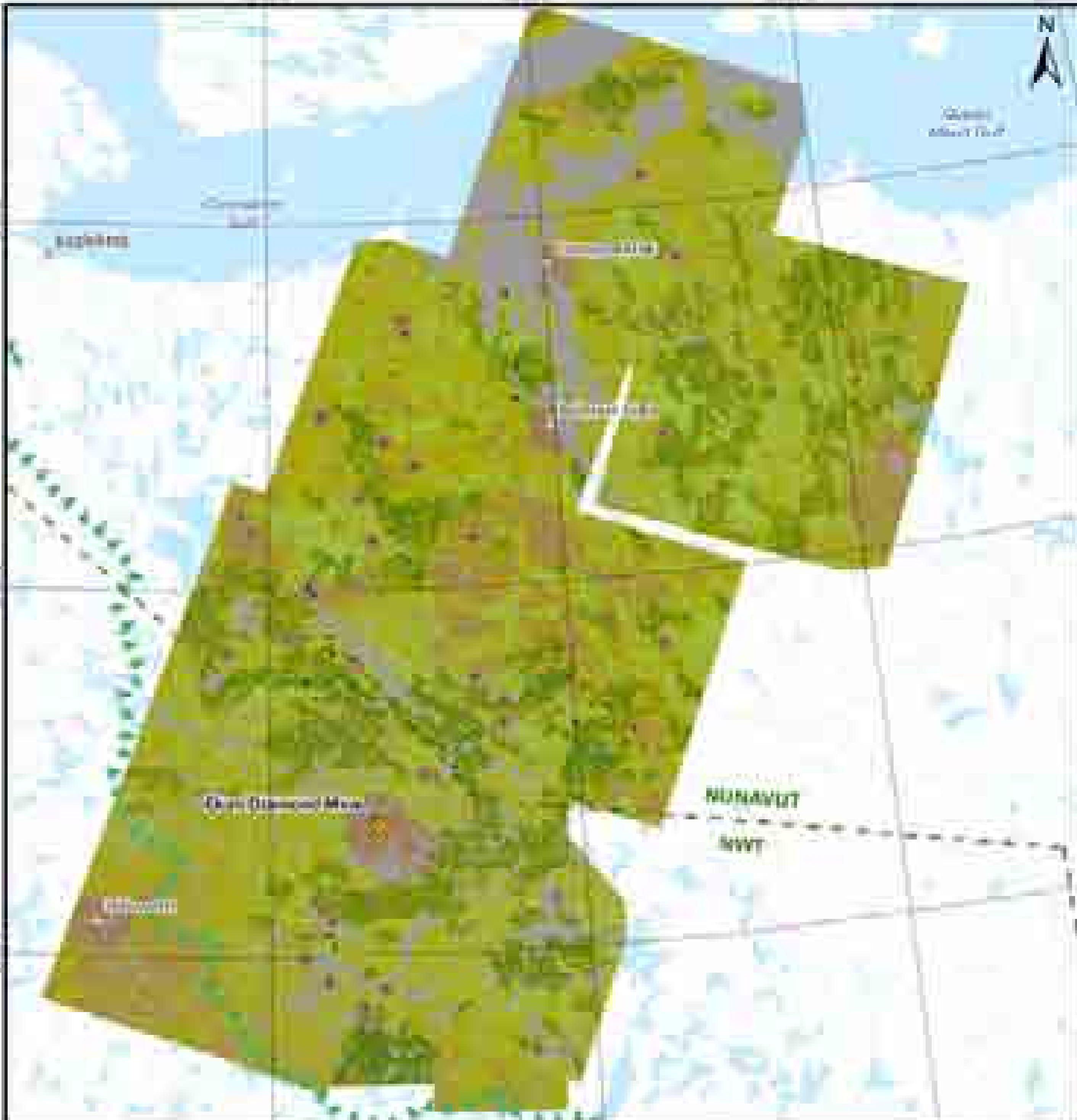
NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Autumn: Reference Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		De Beers Canada
Scale 1:3,100,000			
SON-11-10-013-GIS			DATE: October 29, 2010
JOB NO: 09-1365-1004	REVISION NO: 3		Figure 11.10.II-19
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	



LEGEND

- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

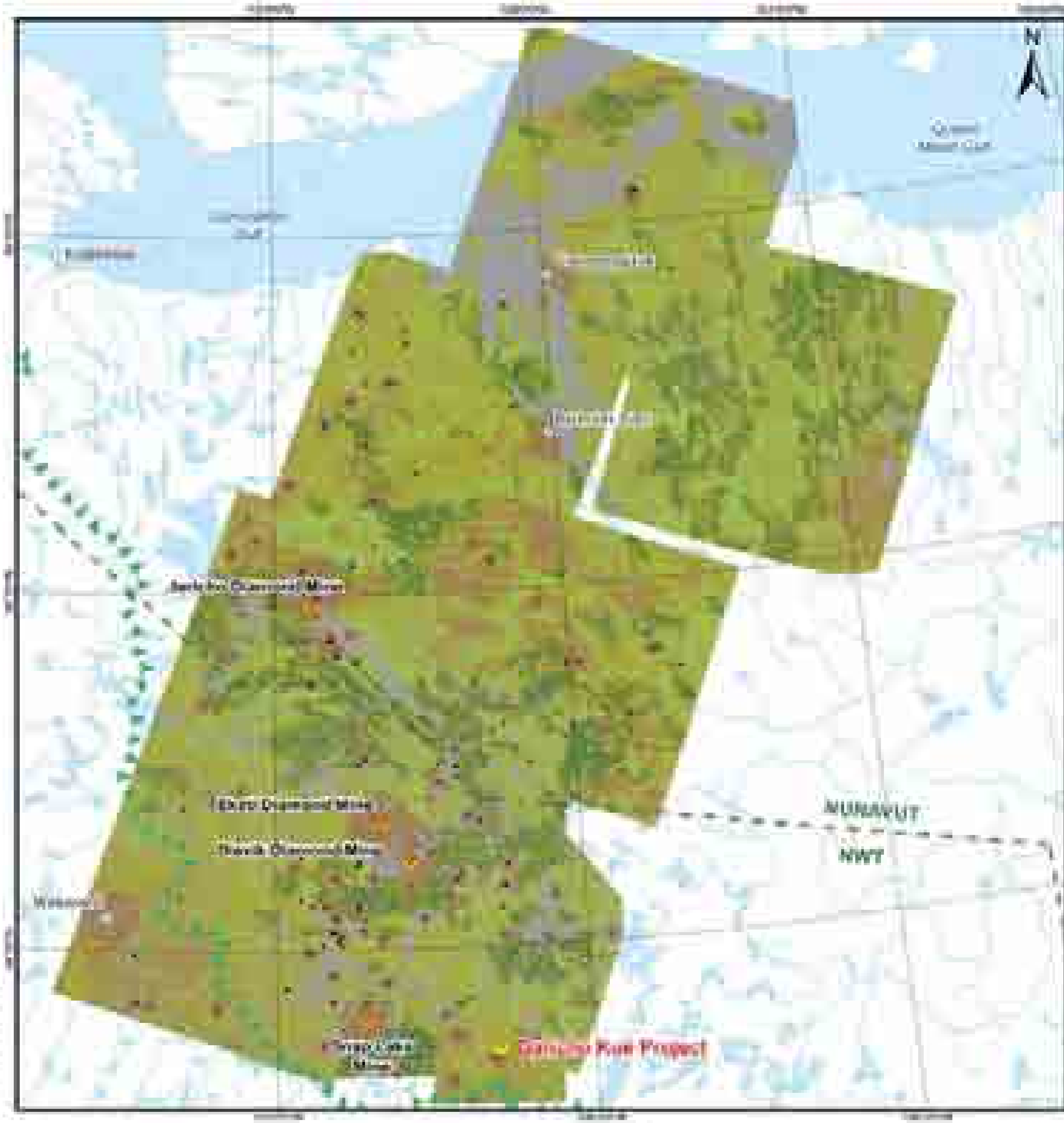
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Autumn: 2000 Baseline Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
FILE NAME	SON-11-10-014-GIS
DATE	October 29, 2010
JOB NO.	09-1365-1004
REVISION NO.	4
OFFICE	GOLD-SAS
DRAWN	MK
CHECK	JV

Figure 11.10.II-20



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Autumn: 2006 Baseline Conditions

PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

Scale 1:5,000,000

De Beers Canada

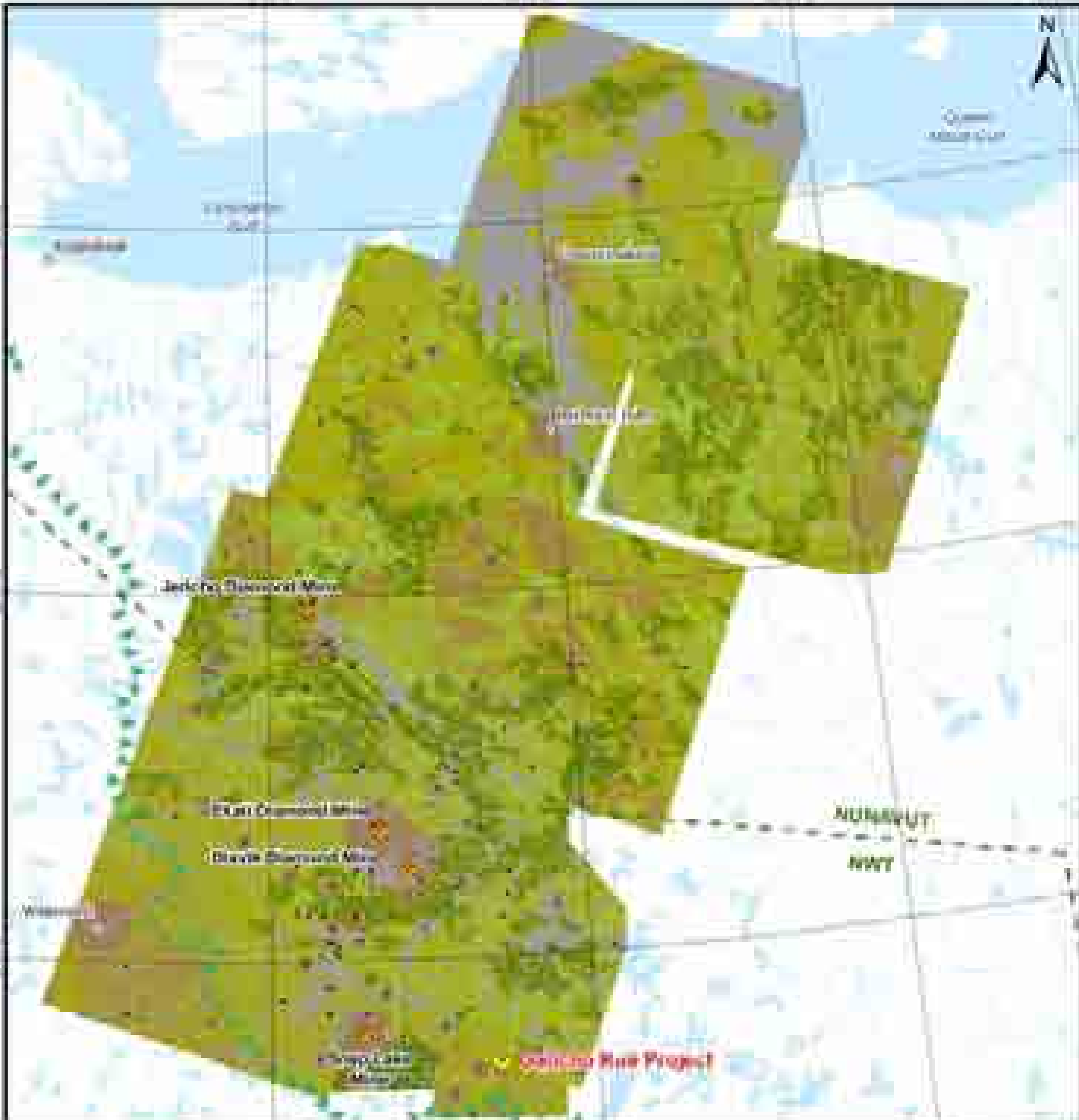
SON-11-10-015-GIS

DATE: October 29, 2010

JOB NO.	REVISION NO.
09-1365-1004	4

OFFICE	DRAWN	CHECK
GOLD-SAS	MK	JV

Figure 11.10.II-21



LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

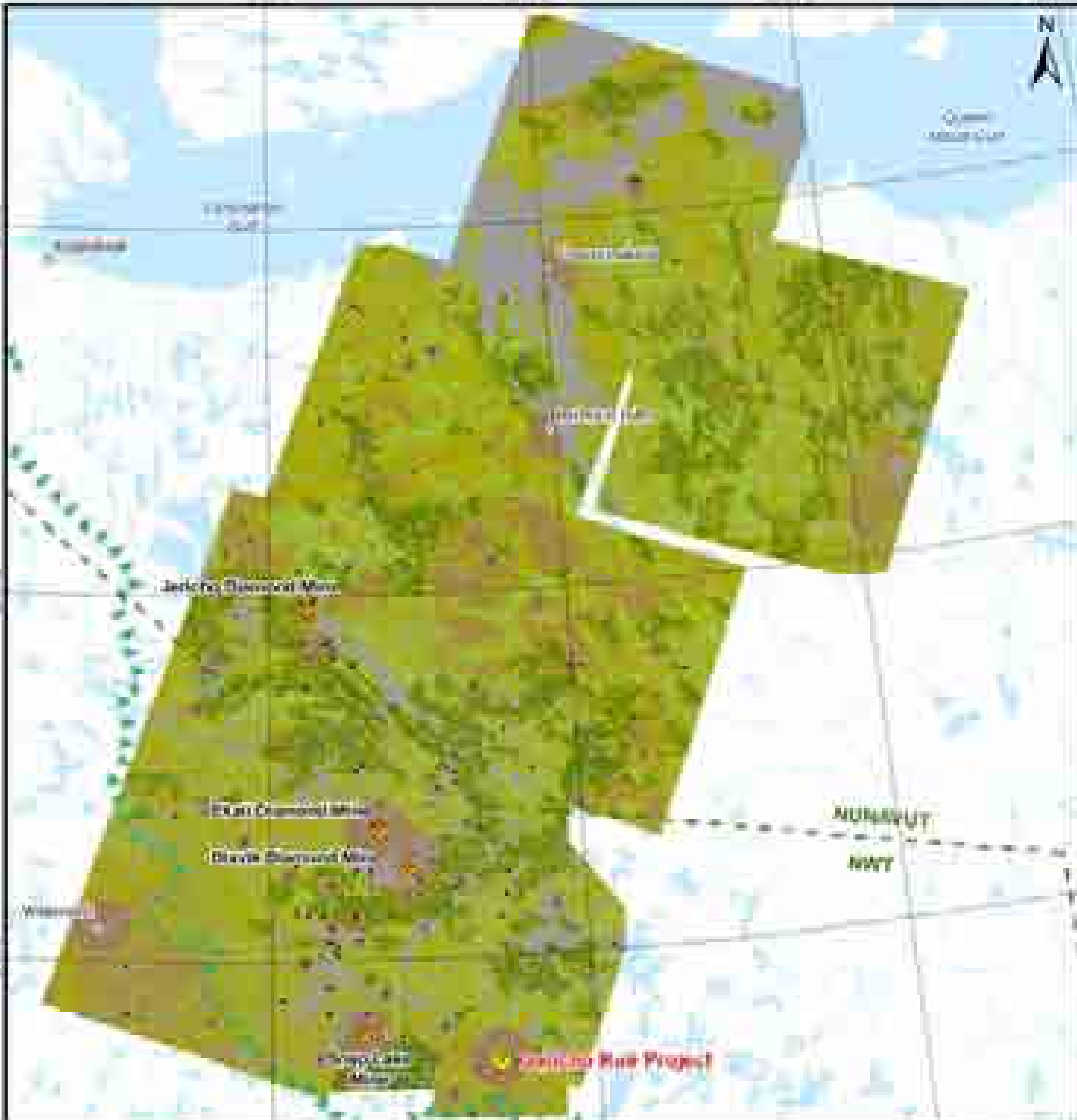
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Autumn: 2010 Baseline Conditions

PROJECTION: Canadian Lambert Conformal Conic	DATUM: NAD83		
FILE NO: SON-11-10-052-GIS		DATE: October 29, 2010	
JOB NO: 09-1365-1004	REVISION NO: 2		
OFFICE: GOLD-SAS	DRAWN: MK	CHECK: JV	**Figure 11.10.II-22**



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Autumn: Application Case

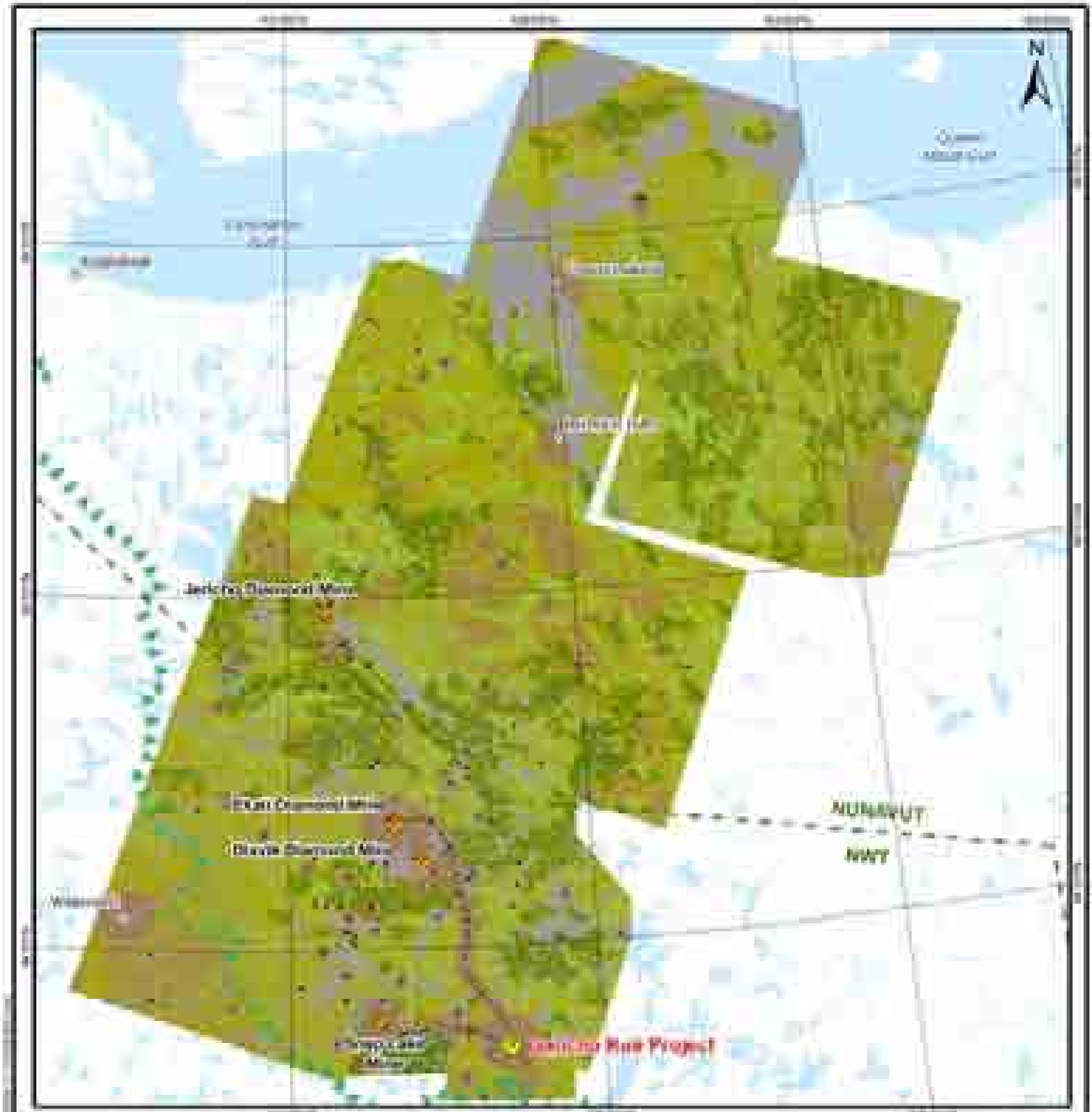
PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

Kilometres

FILE No.	DATE
SON-11-10-053-GIS	October 29, 2010

JOB NO.	REVISION NO.	
09-1365-1004	2	
OFFICE	DRAWN	CHECK
GOLD-SAS	MK	JV

Figure 11.10.II-23



LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Proposed Tellsun Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES

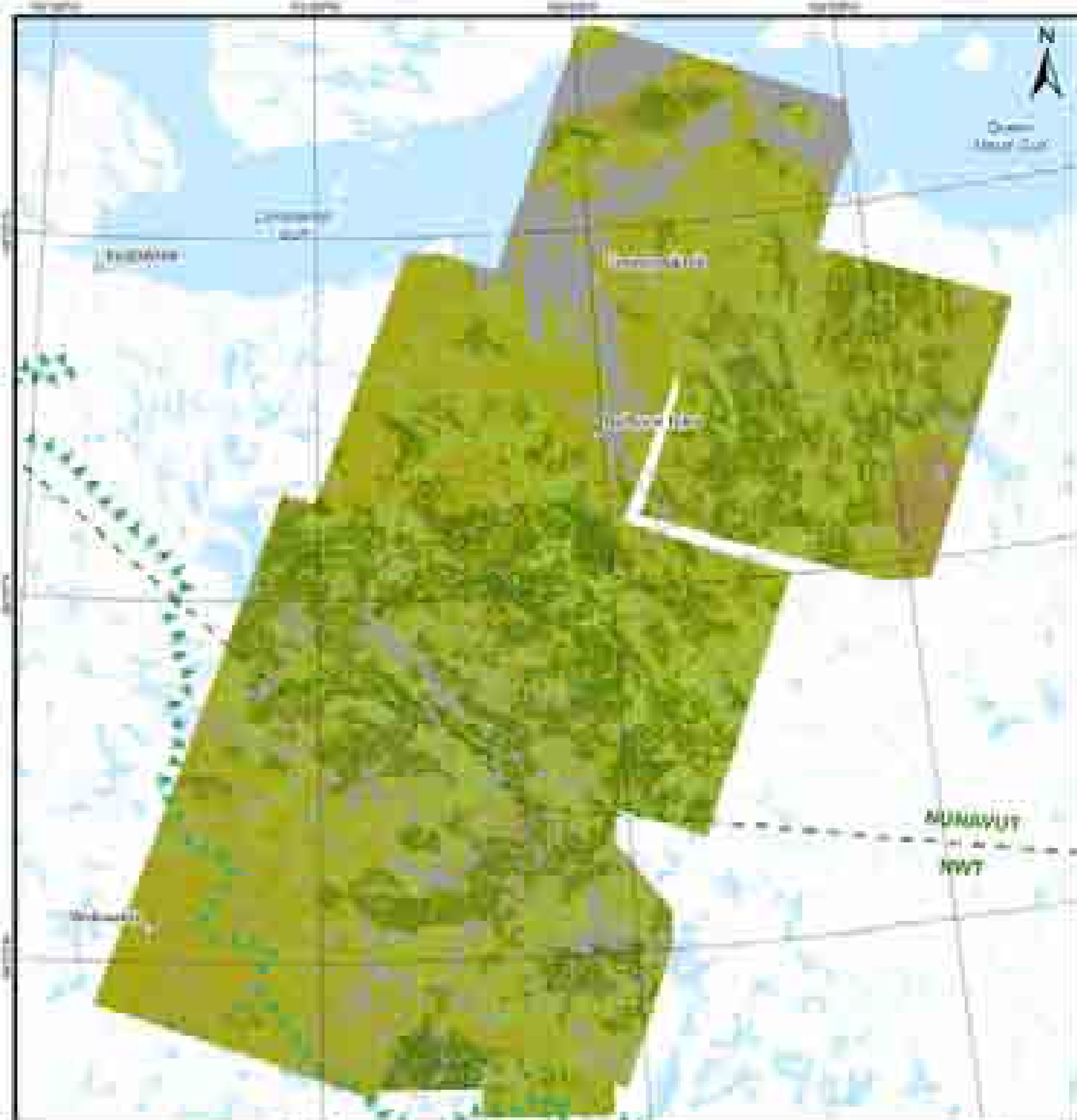
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Grizzly Bear in Autumn: Future Case

FILE NO	SON-11-10-054-GIS
DATE	October 29, 2010
JOB NO	09-1365-1004
REVISION NO	2
OFFICE	GOLD-SAS
DRAWN	MK
CHECK	JV

Figure 11.10.II-24



LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine in Summer: Reference Conditions

PROJECTION	DATUM	
	NAD83	
		DATE
SON-11-10-019-GIS		November 10, 2010
JOB NO.	REVISION NO.	
09-1365-1004	4	
OFFICE	DRAWN	CHECK
GOLD-SAS	ANK	JV

Figure 11.10.II-25

LEGEND

- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

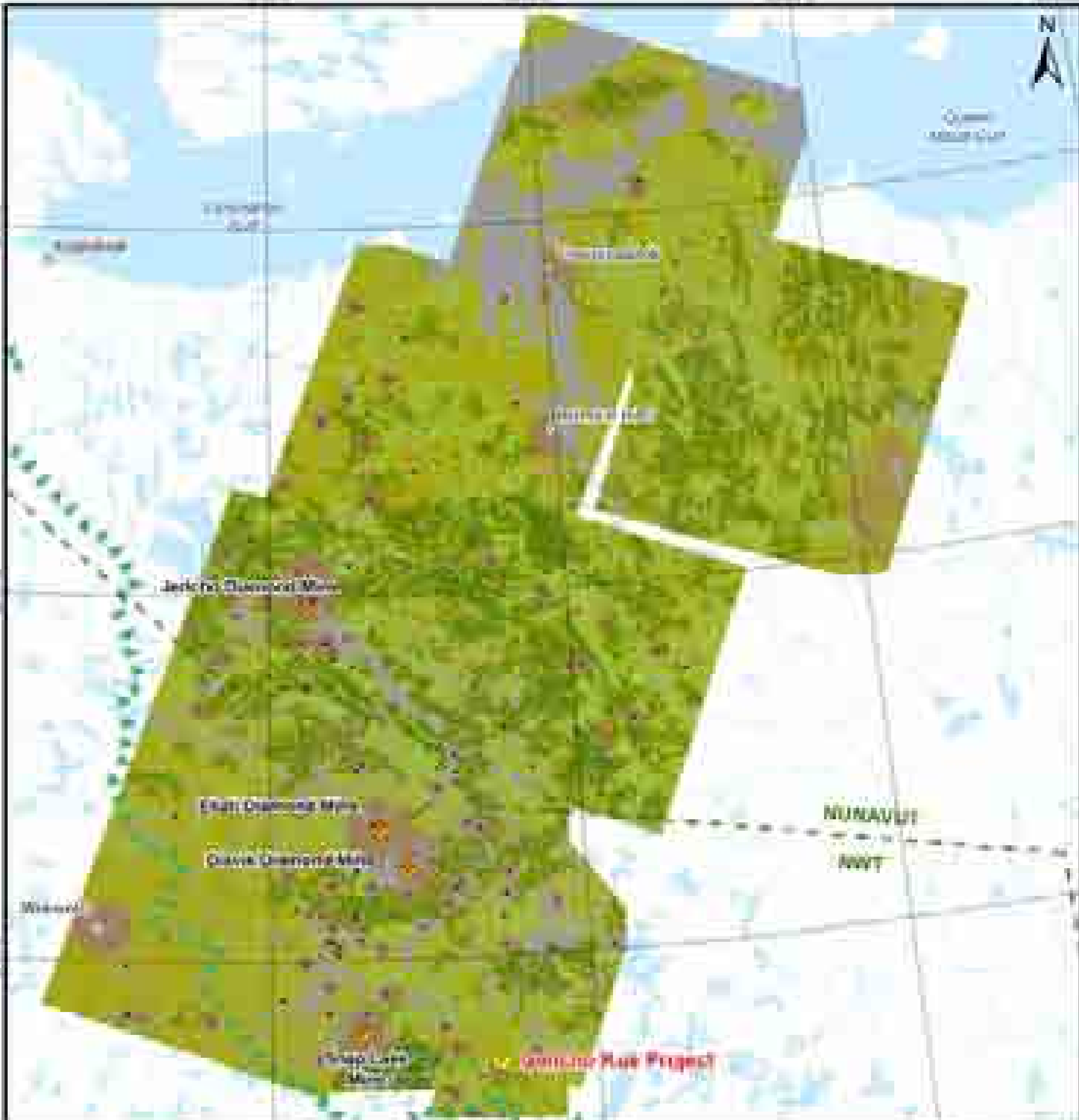
NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine in Summer: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
SON-11-10-020-GIS		DATE: November 10, 2010	
JOB NO: 09-1365-1004	REVISION NO: 4		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	

Figure 11.10.II-26



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

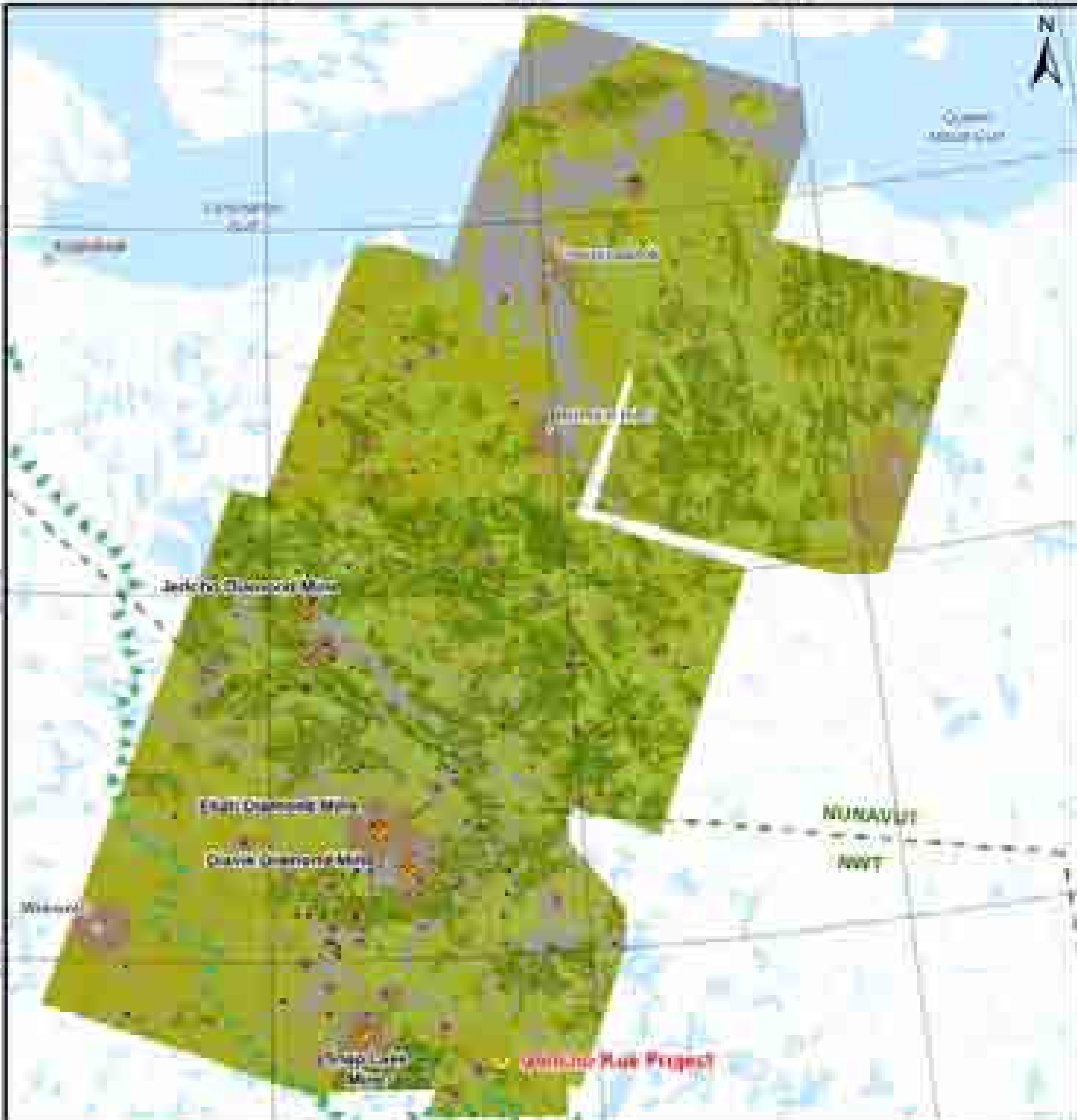
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine in Summer: 2006 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
Scale 1:3,500,000			
SON-11-10-021-GIS		DATE: November 10, 2010	
JOB NO: 09-1365-1004	REVISION NO: 4	**Figure 11.10.II-27**	
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine in Summer: 2010 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83	
SON-11-10-055-GIS		November 10, 2010
JOB NO: 09-1365-1004	REVISION NO: 1	**Figure 11.10.II-28**
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV

LEGEND

- Gahcho Kue Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine in Summer: Application Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
FILE No: SON-11-10-056-GIS		DATE: November 10, 2010	
JOB No: 09-1365-1004	REVISION No: 1	**Figure 11.10.II-29**	
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	

LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Proposed Taltson Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT	
Habitat Suitability for Wolverine in Summer: Future Case	
PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale 1:3,000,000	
FILE No.: SON-11-10-057-GIS	DATE: November 10, 2010
JOB NO.: 09-1365-1004	REVISION NO.: 1
OFFICE: GOLD-SAS	DRAWN: ANK; CHECK: JV
Figure 11.10.II-30	

LEGEND

- Populated Place
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine in Winter: Reference Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83	
FILE NAME: SON-11-10-016-GIS		DATE: November 10, 2010
JOB NO: 09-1365-1004	REVISION NO: 4	
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV

Figure 11.10.II-31

LEGEND

- Existing Mine
- Populated Place
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

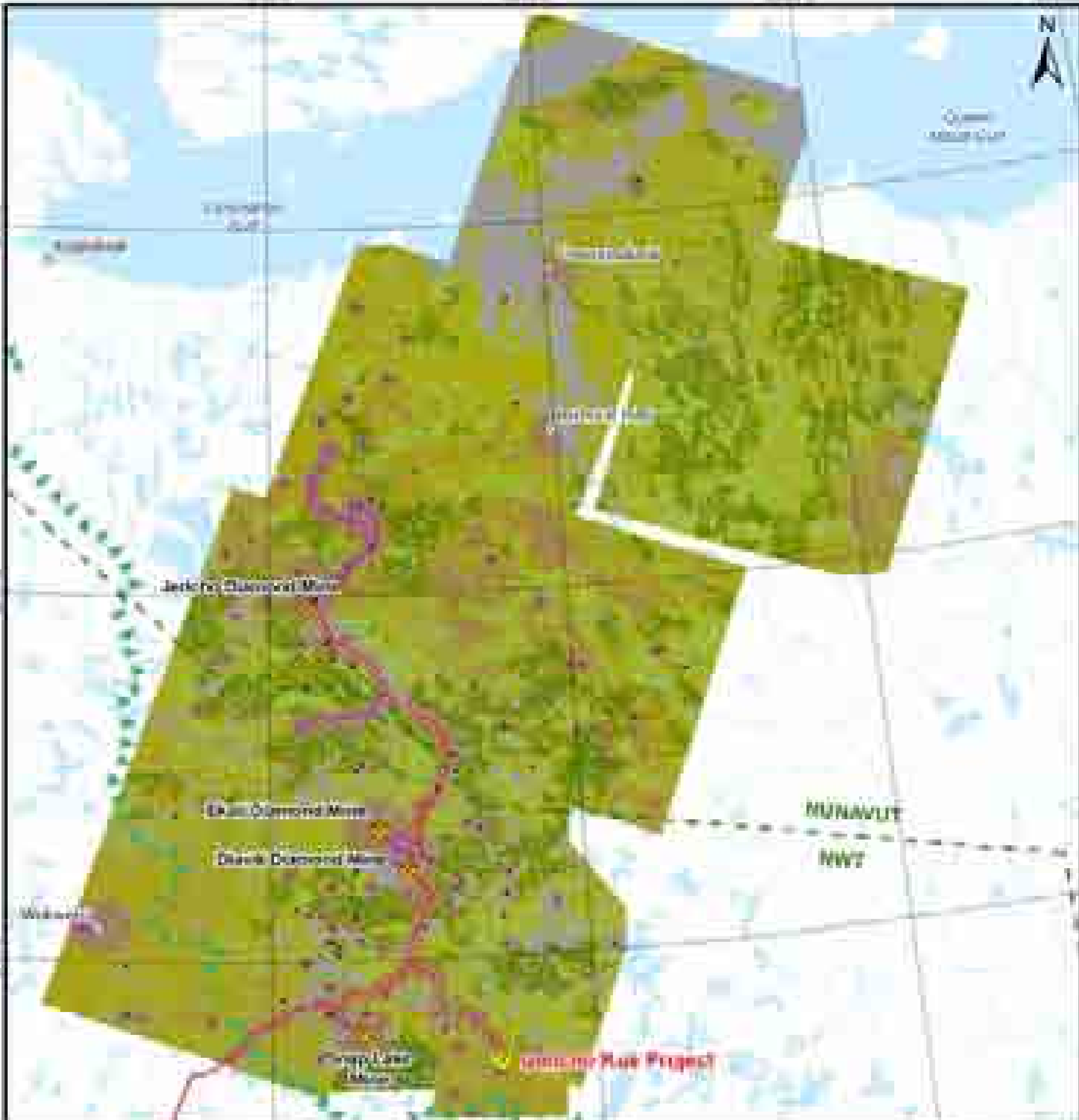
- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine in Winter: 2000 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83	
FILE No: SON-11-10-017-GIS		DATE: November 10, 2010
JOB NO: 09-1365-1004	REVISION NO: 3	**Figure 11.10.II-32**
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES:
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

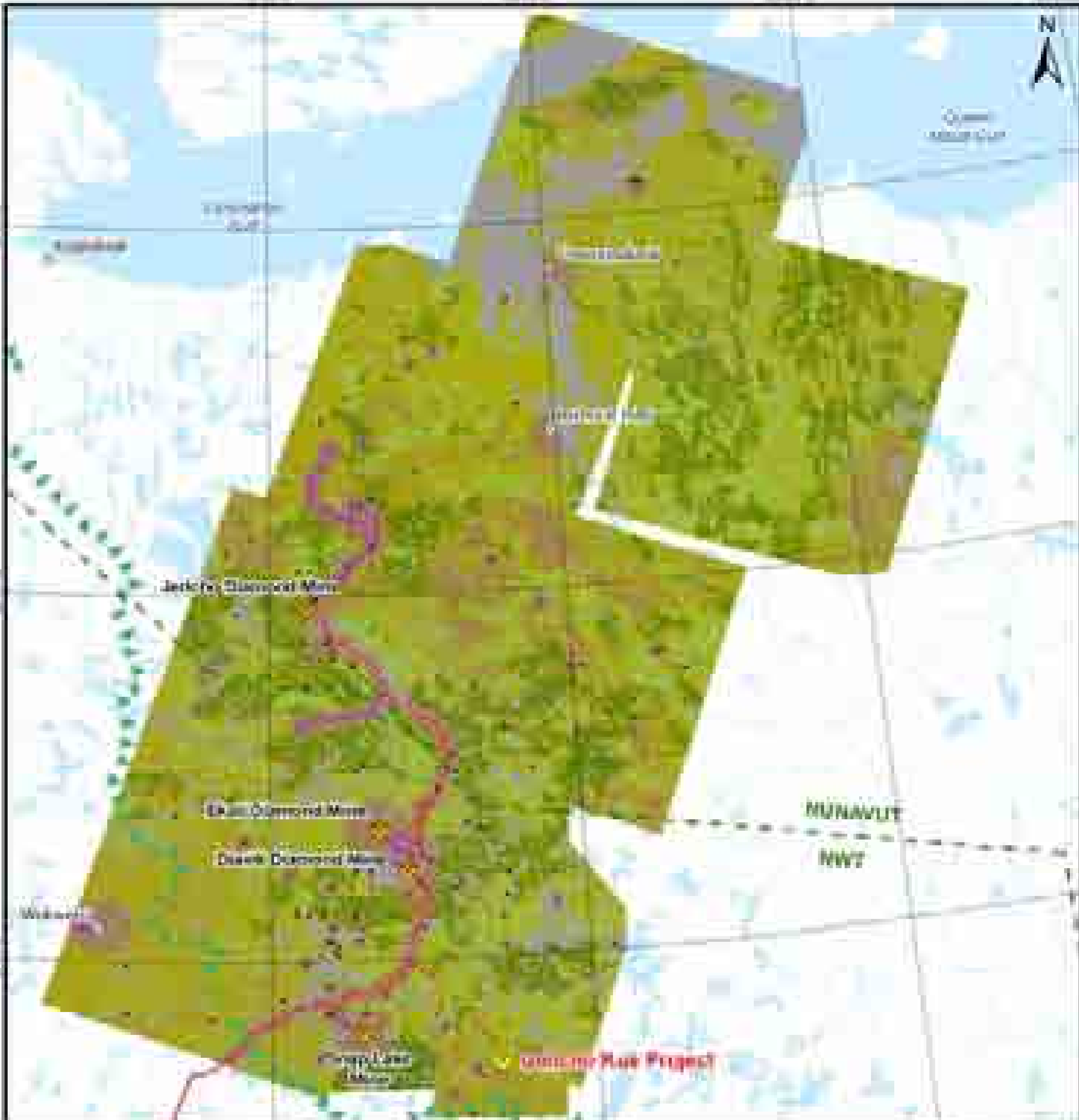
Habitat Suitability for Wolverine In Winter: 2006 Baseline Conditions

PROJECTION	Canadian Lambert Conf. Conic
DATUM	NAD83
FILE NO	SON-11-10-018-GIS
DATE	November 10, 2010
JOB NO	09-1365-1004
REVISION NO	4
OFFICE	GOLD-SAS
DRAWN	ANK
CHECK	JV

Kilometres

De Beers

Figure 11.10.II-33



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

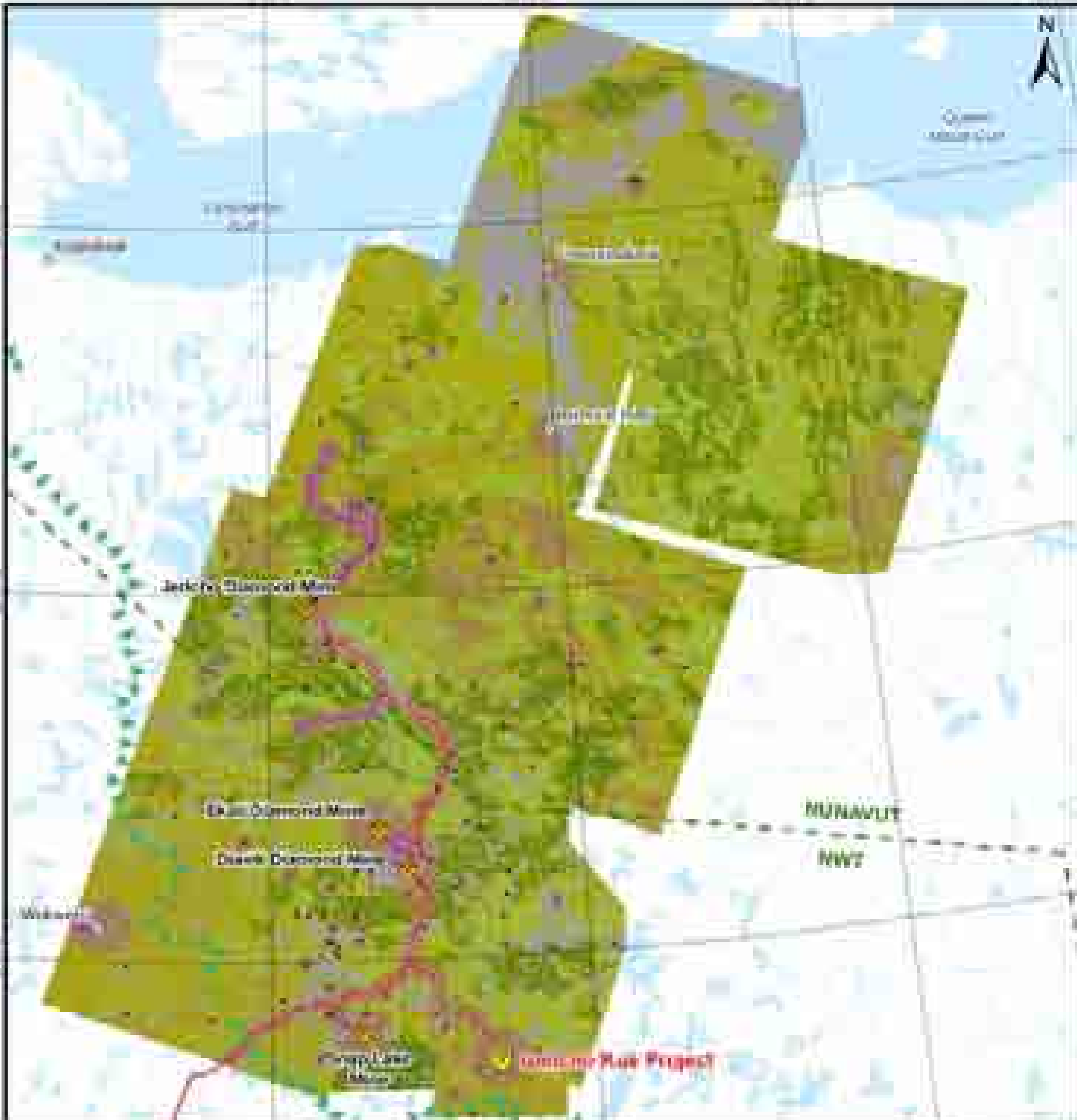
- High
- Good
- Low
- Poor
- Nil

NOTES:
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine In Winter: 2010 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83	
Scale 1:3,100,000		
FILE No: SON-11-10-058-GIS		DATE: November 10, 2010
JOB NO: 09-1365-1004	REVISION NO: 4	**Figure 11.10.II-34**
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

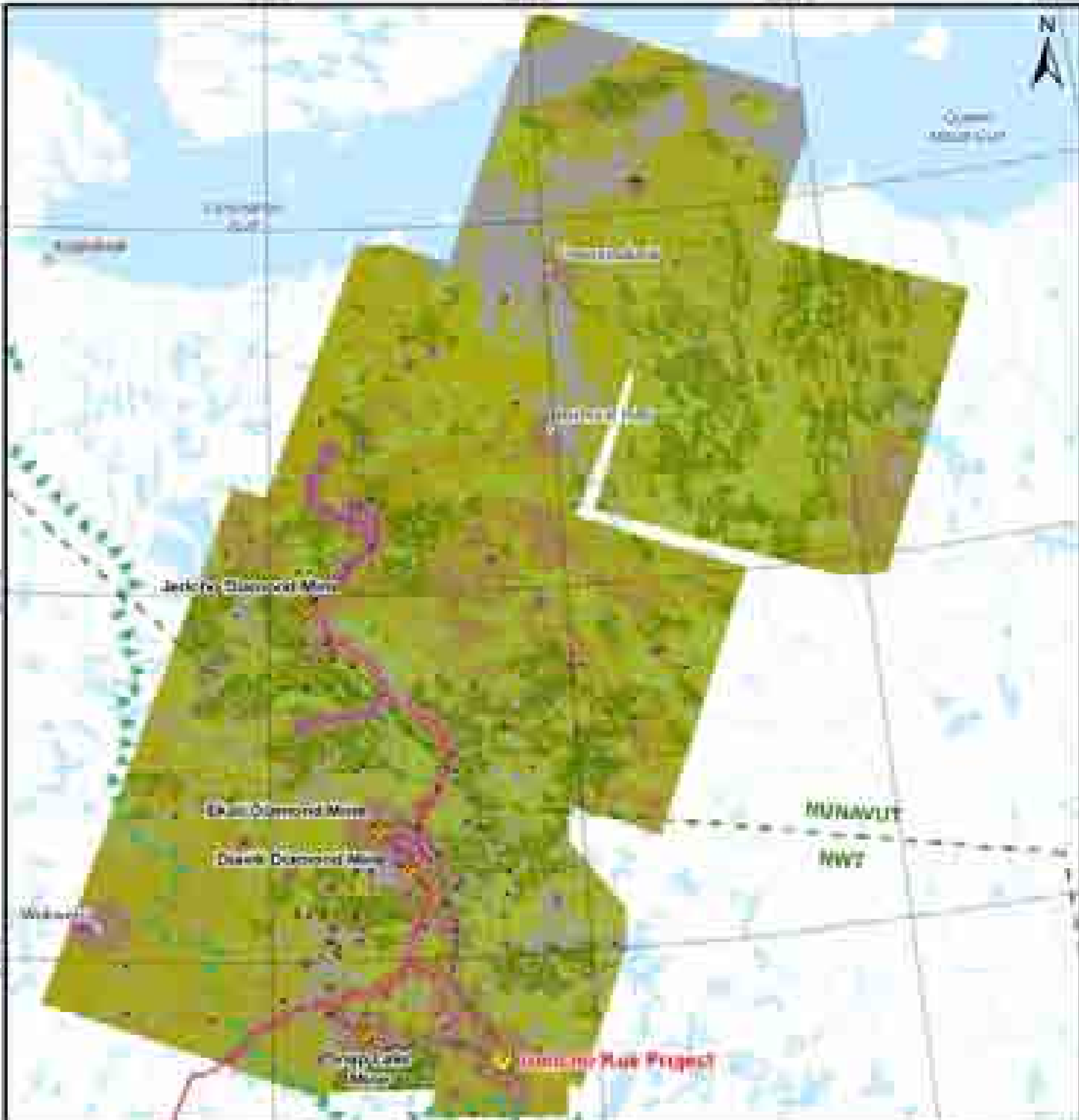
GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine In Winter: Application Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
FILE NO: SON-11-10-059-GIS	DATE: November 10, 2010
JOB NO: 09-1365-1004	REVISION NO: 4
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV

De Beers

Figure 11.10.II-35



LEGEND

- Gahcho Kué Project
- Existing Mine
- Populated Place
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Proposed Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Proposed Taltson Transmission Line
- Proposed Taltson Winter Road

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES:
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolverine In Winter: Future Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
Scale 1:3,100,000	Kilometres		
FILE No: SON-11-10-060-GIS		DATE: November 10, 2010	
JOB NO: 09-1365-1004	REVISION NO: 1	Figure 11.10.II-36	
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LEGEND

- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function:

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolf in Spring to Autumn: Reference Conditions

PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

Scale 1:5,000,000
Kilometres

SON-11-10-022-GIS | November 10, 2010

JOB NO	REVISION NO
09-1365-1004	4

OFFICE	DRAWN	CHECK
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Figure 11.10.II-37

LEGEND

- Existing Mine
- Development Location
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolf in Spring to Autumn: 2000 Baseline Conditions

SON-11-10-023-GIS		November 10, 2010
JOB NO. 09-1365-1004	REVISION NO. 4	Figure 11.10.II-38
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LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolf in Spring to Autumn: 2006 Baseline Conditions

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83		
Scale 1:5,000,000			
FILE No: SON-11-10-024-GIS		DATE: November 10, 2010	
JOB NO: 09-1365-1004	REVISION NO: 4		
OFFICE: GOLD-SAS	DRAWN: ANK	CHECK: JV	Figure 11.10.II-39

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LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolf in Spring to Autumn: 2010 Baseline Conditions

PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

Scale 1:5,000,000

Kilometres

FILE No.			DATE
SON-11-10-061-GIS			November 10, 2010
JOB NO.	REVISION NO.		
09-1365-1004	1		**Figure 11.10.II-40**
OFFICE	DRAWN	CHECK	
GOLD-SAS	ANK	JV	

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

NOTES
Base data source: The Atlas of Canada

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolf in Spring to Autumn: Application Case

PROJECTION	DATUM
Canadian Lambert Conf. Conic	NAD83

Scale 1:5,000,000
Kilometres

De Beers

FILE No		DATE
SON-11-10-062-GIS		November 10, 2010
JOB NO	REVISION NO	
09-1365-1004	1	
OFFICE	DRAWN	CHECK
GOLD-SAS	ANK	JV

Figure 11.10.II-41

LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Watercourse
- Waterbody
- Territorial/Provincial Boundary
- Treeline
- Development Location
- Existing Transmission Line
- Proposed Taltson Transmission Line

Resource Selection Function

- High
- Good
- Low
- Poor
- Nil

GAHCHO KUÉ PROJECT

Habitat Suitability for Wolf in Spring to Autumn: Future Case

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale 1:8,000,000	
FILE NO: SON-11-10-063-GIS	DATE: November 10, 2010
JOB NO: 09-1365-1004	REVISION NO: 1
OFFICE: GOLD-SAS	DRAWN: ANK / CHECK: JV

Figure 11.10.II-42