12 CUMULATIVE EFFECTS ASSESSMENT

12.1 SCOPE OF ASSESSMENT

12.1.1 Introduction

Cumulative effects are natural- and human-related

Cumulative effects represent the sum of all natural and human-induced influences on the cultural, physical, biological, and economic components of the environment within a period of space and time. A number of components of the environment can be subject to various effects brought about by changes to current conditions. Some changes may be human-related, such as implementing new policy or industrial development, and some changes may be associated with natural phenomena, such as periodic harsh or mild winters. It is the goal of the cumulative effects assessment (CEA) to determine the contribution of these types of effects to the amount of change in the cultural, physical, biological, and economic components.

There are a number of projects that may contribute to cumulative effects on environmental components in the Slave Geological Province

The Snap Lake Diamond Project is located in the Slave Geological Province (SGP) and represents the fourth diamond mining development in the region (Figure 12.1-1). Other developments are present in the region, including the Tibbitt-Contwoyto winter road which is used as a transportation route into the SGP for 10 to 12 weeks each year. During their operation, each development and their associated activities has the potential to bring changes to the conditions within the immediate or local environment. Depending on the spatial extent of each project, or the movement or location of a component over the SGP and adjacent area, the effects of some or all projects may accumulate and have a stronger influence on some environmental and socio-economic components.

Goal of Section 12

It is the goal of this section of the environmental assessment (EA) to assess the potential cumulative effects from the Snap Lake Diamond Project on the cultural, physical, biological, and economic components identified as receiving residual impacts from the project in the previous sections.

Figure 12.1-1 Location of Snap Lake Diamond Project Northwest Territories

12.1.2 Terms of Reference

This section meets the Terms of Reference

The CEA section of the EA for the De Beers Canada Mining Inc. (De Beers) Snap Lake Diamond Project has been prepared to meet the Terms of Reference established by the Mackenzie Valley Environmental Impact Review Board (MVEIRB). This section specifically addresses the Terms of Reference shown in Table 12.1-1.

Table 12.1-1 Terms of Reference for Cumulative Effects Assessment

TOR Section	Environmental Assessment or Topic
2.3.2.4	**Existing Snap Lake Diamonds Project Advanced Exploration** Changes to existing advanced exploration facilities, infrastructure and undertakings needed to accommodate the proposed development. Only include changes not permitted in previous licences or permits[1] . Where De Beers demonstrates that existing Land User Permit(s), Water Licence(s), or other authorizations adequately address environmental impacts of the proposed changes in existing infrastructure or undertakings, De Beers is not be required to specifically address those impacts in the scope of development but in the cumulative effects section (4.9 Cumulative Impacts) of the environmental assessment.
2.5	**Environmental Assessment Methodology** De Beers shall provide information on the environment and how it could be affected by the proposed development. De Beers should also provide a sufficient base for the prediction of positive and negative impacts. De Beers shall demonstrate the extent to which negative impacts may be mitigated and positive impacts augmented by planning, development design, construction techniques, operational practices and reclamation techniques. De Beers will refrain from providing significance conclusions in the EAR report. De Beers shall provide quantitative information to the extent possible regarding the nature of predicted environmental impacts. Where professional or traditional knowledge expertise is applied, an explanation of the soundness of those views shall be provided[2]. The Review Board has the final say on significance. Explicit documentation of the assumptions, models, information sources used, as well as information limitations and associated levels of uncertainty should support all steps of the environmental assessment report. The analysis should be quantitative where data are available, but where data or models are lacking, best professional and, or, traditional knowledge judgment may be used. The approach and methodologies used to identify and assess cumulative effects should be explained.
2.9	**Cumulative Impact** For the purposes of this development, the environmental assessment should include an evaluation of cumulative effects that are likely to result from the proposed development in combination with other developments; and developments within the regulatory process on the day these Terms of Reference are issued. De Beers shall consider existing forecasting models of cumulative infrastructure development, where such models are available, and can be calibrated to the regional ecosystem encompassing the proposed development. Report the models considered.

[1] Please submit information verifying that existing authorizations permit the proposed changes to the authorized advanced exploration camp.

[2] De Beers shall provide the credentials of the expert whose opinion is provided. This could be a curriculum vita for scientific experts, and a life history for Elders.

Table 12.1-1 Terms of Reference for Cumulative Effects Assessment (continued)

TOR Section	Environmental Assessment or Topic
2.9 (cont)	De Beers should include, as a minimum, the existing Snap Lake Advanced Exploration Program and other identified developments including but not limited to existing tourism operations in the region, the BHP EKATI™ Diamond Mine (including the expansion), Diavik Diamond project, TM and the Echo Bay Mines™ Ltd. Winter Road, Lupin mine and the proposed Tahara diamond mine. De Beers should also report and describe developments considered but not included in the cumulative effects assessment, and rationale for the decision. De Beers shall explain the likelihood of the proposed development expanding, and any areas of medium to high development potential within the claims block. De Beers should provide confirmation that all existing facilities, infrastructure, *etc*., De Beers plans to use can adequately handle the demands generated by the proposed development. Include cumulative impacts in relation to: I. The bio-physical environment; II. social environment; III. economic environment; IV. cultural environment; V. heritage resources; and VI. visual and aesthetic resources. Explicit documentation of the assumptions, models, information sources used as well as information limitations and associated levels of uncertainty should support all steps of the cumulative environmental assessment, in the environmental assessment report. The analysis should present data and analyses that are verifiable in nature, and quantitative where data are available. In the absence of verifiable knowledge, best professional judgment or expert opinion (unverifiable) should be used, whether that is from traditional or scientific sources. The approach and methodologies used to identify and assess cumulative effects should be explained.

Expansion potential is discussed in the Project Description

The potential for expansion is discussed in the Project Description (Section 3.0). However, for the CEA, it is assumed that the spatial and temporal extent of activities and facilities described in the Project Description represent the only sources of impacts for the Snap Lake Diamond Project.

Definition of cumulative effects and projects considered for assessment

Cumulative effects imply those residual impacts of the Snap Lake Diamond Project on a particular component in addition to the residual impacts (or effects) from other projects or activities that have been or will be carried out in the reasonably foreseeable future. The Mackenzie Valley Resource Management Act (MVRMA) uses the term ‘impacts’, instead of ‘effects’, and defines cumulative impacts as “… any effect on land, water, air or any other component of the environment, as well as on wildlife harvesting, and includes any effect on the social and cultural environment or on heritage resources”. For this EA, assessment of the potential cumulative effects of the Snap Lake Diamond Project on the various components included:

- primary and employment catchment communities;
- existing tourism camps in the region;
- projects in construction and operation (Diavik Diamond Mine, EKATI™ Diamond Mine, Lupin Gold Mine);
- projects in permitting/review phase; and,
- Tibbitt-Contwoyto winter road from Yellowknife to Snap Lake winter access road junction.

Specific details of projects considered in cumulative effects assessment are provided in Table 12.1-2

Specific details for the projects considered in the CEA are contained within the local EA for each project (except the Tibbitt-Contwoyto winter road which has not undergone an EA). For each project, a brief overview of the phase and type of development, total footprint, duration from construction to post-closure, peak production, and distance from the Snap Lake Diamond Project is provided in Table 12.1-2.

Table 12.1-2 Projects Considered as Potential Linkages in the Cumulative Effects Assessment

Project	Project Phase	Type of Development	Total Footprint (km^2)	Predicted Duration (Years)	Through Put at Peak Production (tonnes/day)	Distance from Snap Lake (km)
De Beers Snap Lake Diamond Project	permitting	underground	6.4	26	3,000	--
EKATI™ Diamond Mine (including expansion)	operational/ permitting	open pit	24.5	17	10,000-18,000	119
Diavik Diamond Mine	construction	open pit	11.6	20	5,000	102
Tahera Jericho Diamond Mine	permitting	open pit	3.1	8	900	268
Lupin Gold Mine	operational	underground	11.5	27	1,830	242
Tibbitt-Contwoyto winter road	operational	seasonal winter ice road	2.6	indefinite	--	22.5

Note: km^2 = square kilometres; t/d = tonnes per day; km = kilometres.

12.1.3 Component Description and Organization

The cumulative effects assessment section is composed of seven subsections

To address the EA Terms of Reference, the CEA section has been subdivided into the following subsections:

- socio-economics;
- resource uses;

- air quality;
- noise;
- aquatic resources;
- terrestrial resources; and,
- environmental health.

Some of the subsections have a number of components

The aquatic resources section contains information on hydrogeology, hydrology, water quality, and fish and fish habitat. The terrestrial resources section assesses the potential cumulative impacts on geology and terrain, ecological land classification (ELC) and biodiversity, and wildlife and wildlife habitat.

12.1.4 Assessment Approach

12.1.4.1 Key Issues and Key Questions

Issues derived from a variety of sources initiate the assessment

The CEA process begins with the identification of issues associated with the Snap Lake Diamond Project that are important to the communities that may be affected. Issues were identified by a variety of means, including the following:

- EA Terms of Reference;
- traditional knowledge;
- community consultation;
- discussions with territorial and federal regulators;
- scientific literature; and,
- experience of De Beers staff and their consultants.

Related issues are combined to form a question

In most cases, similar issues are identified from a number of sources. Related issues are combined in the form of a question. Key questions are developed for each component of the CEA (Table 12.1-3). The purpose of the assessment is to answer the key questions.

Table 12.1-3 Key Questions Addressed in the Cumulative Effects Assessment Section

Question Number	Key Question
SE-1	What socio-economic cumulative impacts will the Snap Lake Diamond Project have on employment opportunity and income levels?
SE-2	What will the Snap Lake Diamond Project contribute to the socio-economic cumulative impacts of increased demand for skilled labour?
SE-3	What cumulative impacts will the Snap Lake Diamond Project have on regional economic development?
SE-4	What socio-economic cumulative impacts will the Snap Lake Diamond Project have on the social capacity of the region?
SE-5	What cumulative impacts will the Snap Lake Diamond Project have on changes in the cultural practices and traditions of the Aboriginal people?
CHR-1	What cumulative impacts will the Snap Lake Diamond Project have on heritage resources?
CTLU-1	What cumulative impacts will the Snap Lake Diamond Project have on the availability of land for traditional land use purposes?
CRU-1	What cumulative impacts will the Snap Lake Diamond Project have on the potential to establish protected areas?
CRU-2	What cumulative impacts will the Snap Lake Diamond Project have on natural resource use?
CVQ-1	What cumulative impacts will the Snap Lake Diamond Project have on visual quality?
CAQ-1	What cumulative impacts will air emissions from the Snap Lake Diamond Project have on regional air quality and deposition when combined with existing, approved and planned regional projects?
CN-1	What cumulative impacts will operation of the Snap Lake Diamond Project have on environmental noise?
CHG-1	What cumulative impacts will the underground mine for the Snap Lake Diamond Project have on groundwater quantity and groundwater levels?
CHG-2	What cumulative impacts will the underground mine for the Snap Lake Diamond Project have on groundwater quality?
CHG-3	What cumulative impacts will the surface facilities for the Snap Lake Diamond Project have on groundwater quantity and groundwater levels?
CHG-4	What cumulative impacts will the surface facilities for the Snap Lake Diamond Project have on groundwater quality?
CH-1	What cumulative impacts will the Snap Lake Diamond Project have on near-surface water tables and flows, and water levels in receiving streams, lakes, and wetlands?
CH-2	What cumulative impacts will the Snap Lake Diamond Project have on sediment yields, and sediment concentrations in receiving streams, lakes and wetlands?
CA-1	What cumulative impacts will the Snap Lake Diamond Project have on water quality?

Table 12.1-3 Key Questions Addressed in the Cumulative Effects Assessment Section (continued)

Question Number	Key Question
CAO-1	What cumulative impacts will the Snap Lake Diamond Project have on fish and fish habitat?
CG-1	What cumulative impacts will the Snap Lake Diamond Project have on permafrost and ground thermal regime?
CELCTB-1	What cumulative impacts will the Snap Lake Diamond Project have on ELC, terrain and biodiversity?
CW-1	What cumulative impacts will the Snap Lake Diamond Project have on wildlife and wildlife habitat?
CEH-1	What cumulative impacts will the Snap Lake Diamond Project and other regional developments have on wildlife health?
CEH-2	What cumulative impacts will the Snap Lake Diamond Project and other regional developments have on human health?

12.1.4.2 Cumulative Effects Analysis

Linkages between residual impacts on components due to the Snap Lake Diamond Project and one or more other projects were used to validate potential cumulative effects

Once the key questions have been established, the CEA process identified those components that may be impacted or changed by the cumulative effects of the Snap Lake Diamond Project and other projects. For a cumulative change to occur there has to be a pathway, or linkage, between a component and one or more additional projects or activities. For several components, the local EA for the Snap Lake Diamond Project and other projects, and the distance between projects were used to determine linkages (Table 12.1-2). If the linkage is valid, the assessment proceeds.

Not all components will require a complete cumulative effects assessment

Although each project may generate residual impacts (impacts after mitigation) on a component, as determined from independent EAs, not all of the components will require an analysis of cumulative effects. For example, impacts of the Snap Lake Diamond Project on ELC types and biodiversity within the Taiga Shield ecozone will have no cumulative effects on the terrain or biodiversity in other ecozones. Similarly, impacts on the Lockhart River watershed from the De Beers project should not interact with non-connected drainages such as the Lac de Gras-Coppermine watershed. Cumulative effects will also not likely occur for a wildlife population that has individuals with small home ranges and limited dispersal ability, relative to the distance between the Snap Lake Diamond Project and other projects.

Several types of data were used to analyze potential cumulative effects

For those components identified as having a valid linkage with cumulative effects, the analysis of cumulative impacts is completed on the residual impacts from each project. The detailed analysis is as quantitative as possible using databases, statistical analysis, geographic information system (GIS) methods, and modelling, as appropriate. To answer some questions, a more qualitative approach has to be used; then, a review of published literature, field observations, traditional knowledge, and professional judgement are used. Traditional knowledge is incorporated wherever it is available. The predicted residual impacts are presented as tables of estimated quantities (*e.g.*, hectares (ha) of each habitat type predicted to be lost due to disturbance) if possible.

Cumulative effects analysis is limited by the availability and sensitivity of data

It must be emphasized that the amount of quantitative data available for many of the components is marginal. In addition, the sensitivity of data to detect and assess effects from project-related disturbances on changes to several environmental components is largely unknown. Even if the number of projects influencing a component is accurately assessed, the analysis of cumulative impacts is strongly limited by the availability and sensitivity of data. Consequently, the evaluation of the cumulative effects on a component will likely be coupled with a moderate to high degree of uncertainty.

A forecasting model referred to in the Terms of Reference was considered in the CEA

One model developed by the United Nations Environmental Program (UNEP; http://www.grida.no/prog/polar/globio) has been used to forecast the probability of an impact from multiple projects, and was required for consideration by the MVEIRB (EA Terms of Reference). Similar to the linkage analysis used in this document to identify projects and components for CEA, the UNEP model relates the probability of disturbance on a component to the distance from a project. The UNEP model also uses estimates of project growth rate to forecast the potential number of projects that may disturb elements of the biophysical, cultural or economic environment. However, unlike the approach used by De Beers to estimate the cumulative effect on a component (Section 12.1.6), the UNEP model provides only a classification system for assigning the likelihood of an impact. Predicting the growth of projects from the number of historic and current exploration sites or claim blocks can be useful for estimating the probability of an additional disturbance, but provides no mechanism for assessing the actual effect of a project. With no knowledge of the future size, type, and location of an operation, the magnitude, duration, or geographic extent of effects from an additional project can not be evaluated. Due to these limitations, the UNEP model was not used to assess the potential cumulative effects of the Snap Lake project and other projects on socio-economic or environmental components.

Cumulative effects are evaluated using criteria such as magnitude, duration and geographic extent

Cumulative impacts are described using criteria such as the magnitude, duration, and geographic extent of the impact. The definitions associated with the criteria (*e.g.*, high, moderate, low, or negligible magnitude) are provided in Section 12.1.6.2. To answer the cumulative effect question as succinctly as possible, the overall environmental consequence of cumulative impacts is estimated. Environmental consequence is determined by considering criteria representing the key characteristics (*e.g.*, magnitude, geographic extent, duration, and reversibility) together. The probability of occurrence of the cumulative impact and the level of confidence in the prediction are provided. The CEA does not determine the significance of the cumulative effects.

12.1.4.3 Temporal Considerations

Cumulative effects are assessed from construction until post-closure of the Snap Lake Diamond Project

Assuming that permits for construction and operation of the Snap Lake Diamond Project have been received during the first quarter of 2003, a limited pre-construction work program will begin in 2003. Full construction will begin in early 2004 and be completed by the end of 2005. The production phase will be approximately 21 years from 2006 to 2026, although pre-production mining from underground development will occur from 2003 to 2005. The site closure activities will be carried out primarily in 2027, with limited final clean-up and the continuation of effectiveness monitoring in 2028. Reclamation and monitoring of the effectiveness of reclamation techniques will occur during the operation phase. The total elapsed duration of the project is 26 years. Therefore, any potential cumulative impacts of the Snap Lake Diamond Project on a component will be assessed during this period of time.

12.1.4.4 Mitigation

Mitigation is found in the primary sections of this EA

The influence from each project on a component represents the effect following mitigation (*i.e.*, residual effect). Mitigation was identified in the local EA for each project, except the Tibbitt-Contwoyto winter road, which has not undergone an EA. Specific mitigation for the components of Snap Lake Diamond Project can be found in the primary sections of this EA. Examples of mitigation strategies include changing engineering systems, redesigning mining and operational plans, constructing deterrent structures near containment areas, waste management practices, and altering work rotation schedules to minimize the effect on families in communities.

12.1.5 Study Areas

Spatial boundaries were unique to several components

Due to the unique nature of cultural, physical, biological, and economic components, several spatial boundaries were delineated to assess potential cumulative effects on the components described in Section 12.1.3. For example, socio-economic components may be influenced by several projects over a large geographic area, but noise levels from the Snap Lake Diamond Project were not expected to exceed background levels outside the regional study area (RSA). Similarly, prevailing wind direction and particulate concentration may be the primary factor determining the spatial extent of air emissions, while variation in home range size determines the distribution of wildlife populations. Consequently, the specific details used to define the spatial boundary for each discipline are provided in each component section.

The Tibbitt-Contwoyto winter road

For the purpose of this CEA, De Beers assessed the potential cumulative effects from the Tibbitt-Contwoyto winter road on applicable environmental components related to Snap Lake Diamond Project. This implies that any components that may be influenced by the effects of the Tibbitt-Contwoyto winter road to the junction of the Snap Lake winter access road will be included in the CEA.

12.1.6 Assessment Methods

A classification system is used to assess cumulative impacts

The resulting residual cumulative impacts (*i.e.,* after mitigation) are determined based on a classification system that incorporates direction, magnitude, geographic extent, duration, reversibility, and frequency (Section 12.1.6.1). Definitions of the residual cumulative effect classification terms that are specific to applicable environmental components are provided in Section 12.1.6.2. Determination of the overall environmental consequence or cumulative effect is described in Section 12.1.6.3.

12.1.6.1 Residual Impact Criteria

The residual impacts are assessed by using specific criteria

The following criteria are listed in Section 2.5.4 of the final Terms of Reference (MVEIRB 2001):

- direction;
- magnitude;
- geographic extent;
- duration;
- frequency;
- irreversibility of impacts;
- ecological resilience; and,
- probability of occurrence and confidence level.

Some modifications to the classification system were made

The classification used to assess potential cumulative effects generally follows the above list; however, there are some changes and additions that are described below.

Direction describes an impact or effect as being neutral, positive or negative

Direction describes an impact or effect as being neutral, positive or negative. The direction usually reflects the change from baseline as illustrated for the ELC and terrain sections. Direction for ELC and terrain units is determined based on the net change in the area of each ELC or terrain unit in the far future (> 100 years). For example, a positive direction would be assigned to an ELC unit if the area (*i.e.*, aerial extent) of that ELC unit is predicted to be greater in the far future than at baseline (*i.e.*, pre-development). Conversely, a negative direction would be assigned if the area of an ELC unit is predicted to be less than baseline. For biodiversity, a direction of negative will be assigned if a change, either increase or decrease, is determined. If there is no measurable effect between far future and baseline, the direction is considered neutral for both ELC and biodiversity residual effects. For wildlife, a change which reduces habitat, restricts wildlife movement, changes behaviour, or lowers abundance is classified as negative.

Magnitude is a measure of the intensity or severity of the impact and is component-specific

Magnitude is a measure of the intensity or severity of an impact. It is a measure of the degree of change in a measurement or analysis endpoint. For example, the complete removal of a unit of habitat is a greater magnitude of impact on that unit than a change in the percent cover within the unit. Magnitude is classified into four levels as negligible, low, moderate, and high; the definitions of these terms are specific to each component (*e.g.*, noise, air quality, terrain, wildlife). They are based on scientific and traditional knowledge and the characteristics of the component. Because there is an element of professional judgement needed to assign the levels, the definitions of each level are provided in each component section. This makes the classification process transparent since reviewers can see exactly what is meant by words such as low or high.

Geographic extent was selected to capture the maximum zone of influence by a project or activity on a component

Geographic extent refers to the geographic location where the impact is predicted to occur. A local geographic extent is assigned if the effect is restricted to the local study area (LSA) of a project. A regional geographical extent is assigned if the project-effect extends beyond the LSA into the RSA. Similar to magnitude, the spatial extent (*i.e.*, zone of influence) of a project or activity will be specific to a number of components. The idea was to obtain a maximum zone of influence on a component without diluting the effect by defining too large of an area.

Frequency refers to how often an effect will occur and is expressed as low, medium, or high

Frequency refers to how often an effect will occur within a period of time (*i.e.*, duration), and is expressed as low, medium, or high. Direct losses or alteration of ELC units and biodiversity, for example, are considered to have a low frequency since site disturbance and clearing will only occur once. The frequency of noise on some components will be high as noise is likely to be continuous throughout the life of a project.

Duration is defined as the length of time that an impact will occur

Duration is defined as the length of time that a project-related impact will occur. Duration and timing have been combined within the definition of duration used in this CEA. Duration is defined by the timing of the phases of a project. A short-term duration is assigned if effects are limited to the pre-construction and construction phases, which is expected to occur within the first three years. Medium-term is related to the overall duration of the active project, which is dominated by the operations phase, but also includes a blending of construction, operations, and closure since these activities overlap in time. Long-term duration is assigned if the effects are predicted to extend beyond the operations and closure phases of a project.

Irreversibility is classified as reversible (short term), reversible (long term), or irreversible

Irreversibility is an indicator of the potential for recovery from the impact. The irreversibility category is classified as reversible in the short term, reversible in the long-term, or irreversible. Since confusion can arise between the terms long-term duration and reversible in the long-term, these two terms are differentiated by the endpoint of the impact. The endpoint of duration is the cessation of the activity causing the disturbance. From this point forward the environment may be recovering from the impact; this aspect is classified as reversible in the short term, reversible in the long term, or irreversible.

Impacts are reversible when the ecological land classification unit returns to an equivalent capability

Reversible in the long-term is assigned if the effect can be reversed in >100 years following closure of a project. For example, it is predicted that some ELC units will re-establish within 100 years, defined as the far future, and other ELC units are not currently predicted to re-establish due to limited information on technology and reclamation research. Equivalent capability is defined as the capability for an area to support similar ELC units elsewhere in the region but not necessarily in the same proportion or numbers as baseline. Similarly, changes to hydrology, water quality, or increased noise levels are considered reversible if cessation of the disturbance results in a return to baseline conditions. If the effects are not predicted to re-establish to a baseline equivalent capability than these effects are considered irreversible.

Some theoretical work has been conducted on reversibility in ecosystems

Although reversibility can be used to discuss the return of components for all systems, including socio-economic and heritage resources, there are some elements of reversibility that have been developed specifically for ecosystems. The following paragraphs discuss the current theories and ideas surrounding the concept of reversibility in ecosystems.

Ecosystems are not truly reversible because they continually respond to change

Recently the whole concept of reversibility has been challenged, at least with respect to the idea that ecosystems can return to a pre-stressed equilibrium state. Some authors (Matthews *et al*. 1996; Landis *et al*. 2000a; Sandberg and Landis 2001) contend that ecological communities tend to preserve information about every event in their history and they are not at equilibrium, but rather are in the process of responding to their own unique history of interactions. "All systems change, all the time, and our actions are an inevitable part of that change" (Matthews *et al.* 1996). The post-development state of an ecosystem will be different; it may be equally functional with the desired structure, but it will not be the same as before development (Landis and McLaughlin 2000).

Ecological resilience is the rate of ecosystem recovery

Ecological resilience is usually defined as the rate of ecosystem recovery following a disturbance (DeAngelis 1980; Cottingham and Carpenter 1994). Resilience is assessed as the rate at which the ecosystem returns to a stable state. Each of these concepts is also embodied in the classification of reversible in the short- or long-term, described above. The concept of recovery is central to the understanding of the resilience of an ecosystem; therefore, there is overlap with the concept of reversibility. A broader definition of ecological resilience is the capacity of a system to absorb disturbances (Raufflet 2000).

Sub-arctic and Arctic ecosystems are resilient to extreme conditions

Sub-arctic and Arctic systems generally have low taxonomic diversity, low functional redundancy, and low productivity with highly cyclic populations of plants and animals that interact with disturbances in poorly understood ways (Pastor *et al.* 1998). They are highly resilient to natural perturbations, which can be extreme. The literature emphasizing resiliency of ecosystem structure stresses the importance of conserving biodiversity (Folke *et al.* 1996; Schindler 1998).

Mining impacts must not exceed the ecosystem's ability to withstand severe conditions

The response and resilience of the ecosystem to stresses from the Snap Lake Diamond Project and other projects can be inferred from experience at existing sub-arctic and Arctic mine sites and from the known potential changes in ecosystem function and structure caused by mining activities. The underlying principle is that the impact cannot exceed the ability of the ecosystem to sustain itself in the face of natural oscillations of the populations of plants and animals. Resource extraction must not cause local extinctions of a species, reduce the productivity irreparably, nor affect the properties and processes that underlie the resiliency of these ecosystems towards disturbance (Pastor *et al*. 1998).

Since ecological resilience is currently being debated by scientists, it will be discussed, but not rated

Because of the lack of consensus in the literature on ecological resilience and the lack of scientific knowledge on the resilience of Arctic and sub-arctic ecosystems, resilience could not be used as a criterion for the assessment of impacts in the same manner as magnitude, geographic extent, duration, or frequency. To do so would imply that there is sufficient scientific consensus on this topic to make it possible to classify ecological resilience. Therefore, the CEA will consider ecological resilience as discussed in the paragraph above, but not assign a particular rating.

The probability of occurrence will usually be low because most predictions overestimate the impact

Probability of occurrence is the likelihood that the environmental consequence associated with the cumulative impact prediction will occur if the identified projects go ahead. Because of the uncertainty inherent in most predictions of future conditions, conservative assumptions were used in these predictions. As a result, there is usually a high probability that the environmental consequence from cumulative impacts will be less than predicted.

Level of confidence is directly linked to the degree of certainty in the prediction

Level of confidence is directly related to the degree of certainty in the cumulative impact prediction. There are a number of sources of uncertainty. These include lack of data, natural variability in the data, errors in obtaining and handling data, capability of the model (which is always based on a simplification of the environment), and limited understanding of Arctic ecosystem processes. In addition, there is a lack of knowledge concerning the current cumulative impacts of natural and project-related effects on the biological components of the ecosystem. Therefore, estimating the magnitude of the incremental impact from the Snap Lake Diamond Project on a population will likely be associated with a high degree of uncertainty.

12.1.6.2 Definitions of Criteria

Terms are defined in Table 12.1-4

The criteria described above are ranked for each project effect and component. Definitions for the ranking of some criteria such as duration, reversibility, and frequency have been standardized so that they are common to all cultural, physical, biological and economic components (Table 12.1-4). However, the ranking of magnitude is often specific to the component and changes from one component to another. Therefore, each component section will define magnitude during the cumulative impact analysis.

Table 12.1-4 Definitions of Impact Criteria for Environmental Components

Direction	Geographic Extent	Duration	Reversibility	Frequency
Neutral: no change in component; **Negative**: adverse change in component. **Positive**: non-adverse change in component.	**Local**: effect is restricted to the local study area (LSA) (mine footprint plus 500 m buffer); **Regional**: effect extends beyond the LSA into the regional study area; **Beyond Regional**: effect extends beyond the RSA.	**Short-term**: 3 years; includes pre-construction and construction phases; **Medium-term**: includes operations phase; **Long-term**: following closure.	**Reversible (short-term)**: effect can be reversed during closure of the project; **Reversible (long-term)**: effects can be reversed in 100 years of closure of the project; **Irreversible**: effects cannot be reversed.	**Low**: occurs once; **Medium**: occurs intermittently; **High**: occurs continuously.

12.1.6.3 Environmental Consequence

The primary choices made in developing this method were to keep the process simple and transparent

Environmental consequence provides an overall assessment of the cumulative effects based on a ranking system that incorporates the key criteria. Combining the criteria described in the residual impact classification into a single answer to the key question involves choices. The choices that have been made in this CEA include the following:

- the method is transparent;
- the results will be shown as a bar graph (Figure 12.1-2) and as words in the residual impact classification table;
- the criteria will be added to form the bars of the graph;
- the criteria will be given equal weight except for the following:
  - only one criterion related to time will be used to prevent time from being over-weighted;
  - irreversibility and magnitude will be slightly over-weighted due to the greater severity of the consequence of an irreversible impact of high magnitude.

Figure 12.1-2 Generic Environmental Consequence

Numbers have been used only to determine relative strength of cumulative effects

The words (*e.g.*, negligible, low, moderate, high) used to rank the criteria (*e.g.*, magnitude) have been assigned numbers. The numbers have little meaning other than to ensure that ranks are shown in the correct relative position to each other. The assumption is that the rank scores for criteria correctly captures the relative strength of the effect from each project or activity on a component. The numbers used are shown in Table 12.1-5. Environmental consequence is only determined for residual impacts from projects or activities that are negative in direction.

Table 12.1-5 Generic Residual Impact Classification

Magnitude	Geographic Extent	Duration	Reversibility
Negligible (0)	local (0)	short-term (0)	reversible (short-term) (0)
Low (5)	regional (5)	medium-term (5)	reversible (long-term) (5)
Moderate (10)	beyond regional (10)	long-term (10)	irreversible (15)
High (15)			

Environmental consequence is ranked as negligible, low, moderate, or high

The environmental consequence has been determined by adding the numbers and comparing the sum to the scale determined on the following basis:

- negligible = ≤ 5;
- low = > 5 to ≤ 20;
- moderate = > 20 to ≤ 30; and,
- high = > 30.

The ranking of environmental consequence was based on professional judgement

The relative positions of negligible, low, moderate, and high, are shown on the graph. The position of the lines determining the consequence scale is based on professional judgement. For example, an impact that was of moderate magnitude, regional extent, medium-term duration, and irreversible was deemed to be a high environmental consequence. If the same impact was reversible in the long-term, it was deemed to be a moderate environmental consequence. If it was reversible in the short-term, it was deemed to be a low environmental consequence. Professional judgement was used *a priori* to determine the ranking. In general, each component was evaluated with respect to the amount of change expected from the addition of the Snap Lake Diamond Project.

The true environmental consequence would occur over a continuum rather than four categories

Because other professionals may have other opinions on the method or scale, the method used here to bring all the information together has been kept as simple and transparent as possible, while still providing a standardized comparison of the consequence of the project across all parts of the EA. This method of determining environmental consequence will be used to summarize all residual impacts in the CEA.

12.1.7 Monitoring

There is no current mandate for a proponent to monitor or manage cumulative effects

Currently, there is no requirement in law or regulation obliging a proponent to monitor or manage the potential cumulative effects of a number of projects on cultural, physical, biological, or economic components. The responsibility for monitoring and management of cumulative effects within the SGP by various organizations and proponents will have to be determined. In view of these issues, De Beers provides an outline in Section 14 of the concept for monitoring that the company would consider ideal for the Snap Lake Diamond Project.

12.2 SOCIO-ECONOMICS

12.2.1 Scope of Socio-economic Cumulative Effects

Five categories were used to assess socio-economic impacts

The effects on people and communities are the result of complex interrelationships. These effects are further complicated by the uncertainties surrounding other influences and decision processes. Given these circumstances, the discussions of the socio-economic cumulative effects are organized differently from the format used by other disciplines. The socio-economic CEA is organized around the five categories of impacts previously identified in the Socio-economic Impact Assessment (SEIA; Section 5.1):

- employment opportunities and income levels;
- increased demand for skilled labour;
- regional economic development;
- changes in social capacity; and,
- changes in Aboriginal cultural practices and traditions.

Residual impact criteria are not directly applicable to evaluating socio-economic impacts

Section 2.5.4 of the Terms of Reference directs De Beers to evaluate residual impacts according to the set of criteria that has been identified in Section 12.1.6.1 (Residual Impact Criteria). However, as discussed in Section 5.3.5, not all the criteria are appropriate for evaluating residual socio-economic impacts because the applicability of these criteria to the predicted residual socio-economic impact of the Snap Lake Diamond Project is limited. Consequently, cumulative impacts on socio-economic issues from the Snap Lake project are assessed and discussed qualitatively using a range of scenarios.

Projects considered in the cumulative effects assessment

The socio-economic CEA addresses the effects of the Snap Lake Diamond Project in combination with other existing projects and projects that have been approved or are in the regulatory review stage. These projects are largely within the SGP and included:

- other currently ongoing mining projects, *i.e.*, the EKATI™ Diamond Mine, the Diavik Diamond Project, and the Lupin Gold Mine;
- other proposed mining projects in and near the region, specifically the Tahera Jericho diamond mine; and,
- the existence of the Tibbitt-Contwoyto winter road.

Spatial boundary for cumulative effects assessment

The socio-economic CEA for the Snap Lake Diamond Project considers the primary communities and employment catchment area identified in the local SEIA (Figure 12.2-1). Fiscal impacts on Canada as a whole are also considered.

Other developments/ activities could contribute to cumulative effects

In addition to these current and proposed projects, there are other developments in the Northwest Territories (NWT) that could influence the nature of the cumulative effects. These include:

- other activities such as the oil and gas exploration in the NWT;
- ongoing land claim and resource use negotiations; and,
- hunting and research camps, and tourism activities.

Figure 12.2-1 Communities Considered for Assessing Cumulative Effects on Socio-economic Components

Assessment of other developments/ activities is not possible

While the timing and impact of these additional developments are not predictable and therefore are not assessed in this analysis, it is important to recognize that socio-economic effects may be affected by the intensity of any such developments that may occur during the life of the Snap Lake Diamond Project. This is because most developments in the NWT have activities in Yellowknife or service projects through Yellowknife, resulting in overlapping project impact areas, at least for some components. Thus any new development in the NWT may contribute in some degree to socio-economic cumulative effects.

Temporal boundary for cumulative effects assessment

Socio-economic cumulative impacts are considered for the time period until 2038, (*i.e.*, ten years after the proposed closure date of the Snap Lake Diamond Project). Definition of the temporal boundaries is based on the need to consider socio-economic impacts associated with the project's closure.

12.2.2 Analysis of Impacts

12.2.2.1 Introduction

Impacts are related to direct and indirect effects

Some of the major impacts identified in the Snap Lake SEIA are similar, in terms of effect on the primary communities and the residents of the study region, as the impacts experienced from the existing two diamond mines. This is because the communities in the study region are the same as those affected by the existing two mining projects. These are potential direct, indirect, and induced socio-economic impacts on individuals, families, and communities (as defined in Section 5.1.5.4) relative to:

- direct impacts of involvement with wage economy employment;
- cultural and lifestyle adjustments to the rotational work schedule; and,
- community members' participation in job training programs (as discussed in Section 5.3.3.4).

Cumulative effects increase the rate of socio-economic impacts

Some of the socio-economic impacts of the Snap Lake Diamond Project, in combination with the other identified mining development projects, will magnify the rate at which impacts will occur and the impacts will be greater than if each of the mining projects were to operate in isolation. For example, the rate of introduction of the wage economy jobs is accelerated and so the need to adapt to such changes is intensified.

There are a number of uncertainties associated with predicting socio-economic impacts

Given the complexity of assessing socio-economic impacts of any large-scale development project, and the level of uncertainty of the linkages between direct, indirect, and induced socio-economic impacts, assessing the cumulative socio-economic impacts of such development projects is characterized by an even higher degree of uncertainty. The prediction and analysis of socio-economic impacts must be done in the context of a number of uncertainties. These have been identified as:

- environmental uncertainty;
- uncertainty about government policy and regulatory decisions;
- uncertainty about values;
- uncertainty regarding impact magnitude and distribution; and,
- uncertainty regarding mitigation effectiveness.

Mitigation will be important for decreasing the magnitude of sudden and unexpected changes in commodity prices and global events

From an economic perspective, the profitability of the Snap Lake Diamond Project over the life of the mine can be affected by commodity prices and broad global events. These events cannot be predicted but their potential to affect the project must be acknowledged. Given this potential, the ability of the project to adjust to unexpected or accelerated change is important, and reinforces the ongoing effectiveness of mitigation measures and the broader socio-political and economic developments in the region.

Multiple scenarios were used to help assess cumulative effects on socio-economic components

The socio-economic CEA assumes the full adoption and implementation of the SEIA measures (as described in Section 5.3.4). However, this assessment must take into consideration the aforementioned uncertainties, and that social systems (at individual, family, and community or regional levels) are not predictable. Therefore, the assessment employs the use of multiple scenarios to identify the variety of potential impacts that might develop from the current starting point. To fully anticipate potential impacts and the required mitigation measures, this assessment includes consideration of the potential downside, should the multiple uncertainties combine to produce such impacts.

Five key questions were used to consolidate issues related to cumulative impacts on socio-economic components

Five key questions were developed to address the areas of predicted cumulative effects as derived from the SEIA. The likelihood of cumulative effects from mining or other developments is established and the nature of the cumulative effects and mitigation measures discussed, where appropriate. Note that these areas of impacts are in turn closely interrelated, and that the impacts and the mitigation measures must be examined in consideration of each other. The key questions are the following:

Key Question SE-1: What socio-economic cumulative impacts will the Snap Lake Diamond Project have on employment opportunity and income levels?

Key Question SE-2: What will the Snap Lake Diamond Project contribute to the socio-economic cumulative impacts of increased demand for skilled labour?

Key Question SE-3: What cumulative impacts will the Snap Lake Diamond Project have on regional economic development?

Key Question SE-4: What socio-economic cumulative impacts will the Snap Lake Diamond Project have on the social capacity of the region?

Key Question SE-5: What cumulative impacts will the Snap Lake Diamond Project have on changes in the cultural practices and traditions of the Aboriginal people?

12.2.3 Employment Opportunities and Income Levels

12.2.3.1 Key Question SE-1: What Socio-economic Cumulative Impacts Will the Snap Lake Diamond Project Have on Employment Opportunity and Income Levels?

Potential employment opportunities and income levels will increase

Given the Aboriginal and northern preferential hiring policies of all recent mining projects in the region, potential employment opportunities will increase considerably for the Snap Lake primary communities and in the region as a whole, due to the cumulative effects of all the regional mining projects (Table 12.2-1). Employment opportunities will also open up for people within and outside the NWT. It is estimated that mining projects in the SGP and the NWT alone could provide between 1,250 and 2,300 jobs annually from the present time until mine closure.

Other economic developments would further enhance employment opportunity in the region

At the community level, effects are localized to where the development is taking place, although Yellowknife is likely to experience some growth and economic activity from all developments in the region.

12.2.3.1.1 Discussion of Impacts

The cumulative effect of the combined employment generated by the current and proposed projects would make a substantial impact on the availability of wage labour jobs.

Table 12.2-1 Mine Employment Levels During Construction and Operation Phases

Number of Employees During:	EKATI™	Diavik	Snap Lake	Tahera[a]	Lupin Gold Mine[a]
Construction	-	550	450	130	-
Operations	640	400	525	90	285

[a] Located in the SGP but not within the NWT.

Approximate 60% of available jobs will be filled by northern or Aboriginal people

This estimate assumes full operation of the mines and the fact that the numbers of jobs will vary during the mine projects' construction and operations phases. Of these employment opportunities, potentially some 60% (between 750 and 1,400 jobs) will be filled by northern or Aboriginal people, as presented below:

- The proposed Snap Lake Diamond Project will create 450 jobs during the construction phase and 525 jobs during the operations phase. De Beers has committed to hiring as many northern and Aboriginal employees as possible[1].
- Currently, the Diavik mine employs approximately 550 workers for construction of the mine[2]. During the operations phase, this mine project will employ 400 (+/- 50) people. Diavik's intention is that 66% of these employees will be comprised of northerners or Aboriginal people[3].
- The EKATI™ diamond project is currently in operation and provides employment for some 640 workers. The target for northern resident employment is 62% of total employment[4].
- It is estimated that the Tahera Jericho Diamond mine project will employ some 130 people during the construction phase and some 90 people during the operations phase. The mine company aims to ensure that approximately 60% of these workers are northern or

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[1] De Beers Canada Mining Inc.
[2] www.diavik.ca.
[3] Comprehensive Study Report: Diavik Diamonds Project. CEAA June, 1999.
[4] www.bhp.com - Policies on Local Benefits.

Aboriginal[5]. Given its location in Nunavut, it is anticipated that most Aboriginal and northern employees will come from Nunavut.

- The Echo Bay Lupin Gold Mine now employs 285 people, of whom 12 to 15% are Aboriginal[6].

Employment rate should increase along with average disposable income for families within smaller communities

Employment rates are likely to increase proportionally more in the primary communities than in Yellowknife and other large centres or in the region as a whole. The average of disposable incomes will similarly increase considerably in the smaller communities. It is important to note, however, that the increase in employment opportunities in the primary communities is conditional upon the continued availability of a labour pool. Opportunities for income employment will be available for those who can take advantage of them. However, as each new mining project draws employees from the primary and other northern communities, the remaining available pool will diminish; therefore, ongoing skills development and training programs must be implemented in the northern communities. The increased availability of employment opportunities to the local population will therefore only result if mining labour demands are filled and appropriate measures are taken to ensure employability of the local population.

Combined effects from other developments in the region

The increase in employment levels and the associated increases in personal disposable income will combine with effects from other developments in the region. A number of effects may be triggered by the overall increase in employment levels and disposable incomes from a number of projects, including:

- increased opportunities for developing a local economic base, as local spending capacity will increase;
- improvements in the material quality of life of employees and employees' families;
- increased spending on addictive substances and an associated deterioration on employees' and their family members' lives;
- increased need for financial management skills training and services; and,
- community divisions between "have" and "have-nots".

Movement of people out of smaller communities and into the Northwest Territories may change

It is possible that, as more employment opportunities become available to people living in the smaller communities, out-migration from these

[5] Telephone conversation with Tahera representative Oct. 2nd, 2001.
[6] Telephone communication with Echo Bay representative Oct. 5th, 2001.

communities (to Yellowknife and elsewhere) may slow down. At the same time, the greater availability of employment opportunities in the NWT may attract labour from other provinces. Yellowknife and the larger centres may, as such, experience an increased level of in-migration, while the smaller communities may experience reduced rates of out-migration.

Employment opportunities will not be equal across age and gender classes

Initially, it is likely that the employment opportunities associated with the growing non-renewable resource industry will be primarily available to men at a working age and with the skills and capacity to qualify for job training programs. Women, youth, the elderly, and individuals with lower levels of education and skills will likely not benefit directly from the employment opportunities to the same extent. In order that a more even distribution of employment opportunities and incomes be achieved in the northern (and particularly the smaller) communities, adequate resources need to be allocated to the development and support of local economic activities, schools and education, training programs, child care facilities, and social services.

12.2.4 Increased Demand for Skilled Labour

12.2.4.1 Key Question SE-2: What Will the Snap Lake Diamond Project Contribute to the Socio-economic Cumulative Effects of Increased Demand for Skilled Labour?

Skilled labour may need to be trained and brought in from outside the NWT to meet cumulative demand

The collective demand for skilled and/or trained Aboriginal and northern employees by the mining projects may be higher than what can feasibly be supplied from the current labour pool in the defined study area, or even by the region as a whole, particularly in the short term. Therefore, there will be a need to recruit labour from outside the NWT to meet requirements. Currently, the existing mines have a target of about 66% of all employees being Aboriginals and northerners. To meet those employment targets under the cumulative skilled labour demands for all of the projects, there will be an increased need to provide immediate and substantial training of the local and regional labour pool.

Other non-mining developments will compete for skilled labour

Other economic developments in the area, such as oil and gas, if they occur, will compete for some skilled labour from the same labour pool. To the extent that these developments take place, the need for further skills training and in particular in-migration (mostly to Yellowknife and other main centres) will be further accelerated.

12.2.4.1.1 Discussion of Impacts

Operations

Training programs are required

On the one hand, to maximize the proportion of the mining industry employees drawn from the local/primary communities, immediate and ongoing training programs will need to be implemented in the communities. Implementation of training programs will largely depend on the success of agreements reached among companies, communities, and the Government of the Northwest Territories (GNWT)/Canada on provision of financial and technical support needed to develop and provide effective training. Development of training programs will be a crucial aspect in maximizing the community and regional benefits of the proposed project, and in terms of building social capacity at the local level.

Skilled people will likely be needed from outside the Northwest Territories

On the other hand, mining companies (and other future employers in the non-renewable resource development industry) will need to draw employees from the region, and from outside the NWT to meet their labour demands.

Social infrastructure and services will also be required

The increased availability of job opportunities, and the mining companies' requirements for adhering to their preferential hiring policies, will generate a need to develop the social infrastructure to respond to these changes. In other words, both community residents (potential mine employees) and the mining companies will need job training programs and other forms of social services (*e.g.*, transportation arrangements, life skills and substance abuse programs) to be carried out in the communities. Government agencies must carry the broad responsibility of providing such services. To sustain the availability of employment opportunities to the northern communities in the region, industry, government, and communities will have to work in partnership to ensure that the adequate support services and social infrastructure is implemented.

Mine Closure

Training in mine-related jobs will result in very specific skill sets

Where training is mainly provided for industry-specific jobs, employment levels will be highly dependent upon the continued existence of the mining industry. Where this is the case, closure of the mines may cause dramatic fluctuations in the employment levels and increased levels of out-migration from the smaller communities. Mine-specific training and employment will certainly contribute to creating a more skilled and experienced workforce in the northern communities. However, while former mine employees may be able to assume other kinds of employment in the communities upon the closure of the mines, their skills sets and experiences may not be sufficiently broad to ensure continued long-term local economic sustainability.

There is a need for both training and broader education

On the other hand, where training and education is provided with a broader purpose, namely to ensure the development of transferable skills, other economic activities may be stimulated, resulting in a lower degree of reliance on the mining industry in the long term. In the medium and longer run, this will stimulate the development of local economic activities and may prevent out-migration upon the closure of the mines. In addition, the provision of such training may ensure that a wider segment of the population will be able to participate in wage economy activities, primarily women, whom otherwise are offered few employment opportunities in the mining industry.

12.2.5 Regional Economic Development

12.2.5.1 Key Question SE-3: What Cumulative Impacts Will the Snap Lake Diamond Project Have on Regional Economic Development?

The Snap Lake project will increase employment from construction until closure

The Snap Lake Diamond Project will generate substantial levels of employment during the construction, operations and closure phases. During the construction phase a 450 person workforce will be required. It is estimated that there will be a need for 525 person workforce during the operations phase.

Economic forecasts for the construction phase of the Snap Lake project

The economic analysis forecasts that the total employment impacts during the construction phase for the NWT are estimated at 1,000 jobs expressed as full time equivalencies (FTEs). Direct project employment is estimated at 220 FTEs. An additional 560 indirect FTEs and 220 induced FTEs are also expected to result from the project.

Economic forecasts for the operations phase of the Snap Lake project

During the operations phase annual employment impacts for the NWT are estimated at 930 FTEs. Direct project employment is estimated at 500 FTEs. An additional 260 indirect FTEs and 170 induced FTEs are expected to result from the project. As a result of the Snap Lake Diamond Project, nearly 19,610 person years of employment will be created from mine related activities in the NWT that are attributable to the 22 year operations phase of the project. It is estimated that all existing and proposed mines in the SGP will close within a time period of some 20 years, between 2007 and 2028[3].

Mine-related cumulative effects

The existing mining projects will produce, with the addition of the Snap Lake Diamond Project, a considerable increase in fiscal revenues generated within the territory, and in the overall level of economic activity and resources available for investment by the GNWT. The pace and magnitude of the development of new industries will largely shape the economic development patterns in the region. The nature of the impacts related to employment opportunities and labour demands will also influence the way by which the region and territory as a whole develops economically. Thus, the economic impacts on the region may be considered in terms of the revenue and profits generated as a whole, to the GNWT[4], to the mining support industry and related economic ventures, and to individual employees. However, the geographic and demographic distribution of the revenues generated by the industry will greatly determine how the positive and negative cumulative impacts are distributed within the region.

Non-mine related cumulative effects

Given the strong emphasis in the GNWT's strategic plans on promoting non-renewable resource development[5], the recent national interest in developing the petroleum industry in the NWT, and the already intensive mining exploration in the region, there are strong indications that fiscal revenues generated within the territory will considerably increase over the next two or three decades.

12.2.5.1.1 Discussion of Impacts

There are several economic spin-offs associated with mining development in the region

The influx of industry to the region may have an impact on both the small and the large communities. Furthermore, taking into account that larger centres such as Yellowknife will likely see an increased demand for business services, spin-off economic activities may result, for example hotel and catering services, tourism, and other business support services. In the

[3] The Snap Lake mine is estimated to close in year 2028 (De Beers Mining Co.).
The BHP/EKATI™ mine is estimated to close in year 2021 (Communication with a BHP representative).
The Diavik mine is estimated to close in year 2023 (www.diavik.ca /social practices July 2001).
The Lupin mine is estimated to close in year 2007 (Telephone communication with Echo Bay representative, October 5, 2001).
The Tahera Jericho mine is estimated to close in year 2012 (Telephone conversation with Tahera Representative October 2, 2001).
Note that these closure dates assume continued economic profitability and availability of mineral reserves.

[4] Any revenues generated at the territorial level from the Jericho and, since division, the Lupin mine will accrue to Nunavut, not the GNWT.

[5] See, for example, the following documents: GNWT, *Towards a Better Tomorrow*, March 2000; GNWT, *2000-2003 Business Plans*; GNWT, *Common Ground*, June 2000. These are discussed in Section 1.5 of the EA Report.

longer run, the development of such business service capacity may attract other forms of economic activity. It is possible that the attractiveness of Yellowknife as a location to seek employment will grow, with an associated effect of increased out-migration of skilled and qualified labour from the smaller communities in the region (including the primary communities of the Snap Lake Diamond Project). It is likely that out-migration from the smaller communities to the larger centres will take place upon the closure of the mines, if local sustainable economic systems have not been achieved in these communities by that time, as described above. It is then possible that the need for housing and other kinds of development (schools, health care facilities, *etc*.) will increase in Yellowknife.

Economic spin-offs will also be felt within the smaller communities

However, if adequate training programs and support for local business and economic development is provided in the smaller communities in the region, it is possible that these communities will also become more attractive to skilled and trained people, in terms of providing employment opportunities. In the longer run, if the smaller communities have been provided with the resources needed to establish local sustainable economies, it is possible that the smaller communities will indeed retain their current population, and eventually grow. Such growth may in itself have a range of both positive and negative implications, in terms of the need for infrastructure development, services provided, environmental and social capacity, cultural changes, and community cohesiveness. The federal and territorial governments play a major role in the distribution of benefits from the mining industry.

The nature and magnitude of socio-economic impacts will vary between age class and gender

It is reasonable to assume that the nature and magnitude of the socio-economic impacts of the mining industry will differ between small communities and Yellowknife, as well as between gender groups, Aboriginal and non-Aboriginal residents, and among age groups of the population. Based on the development and implementation of decisions at the individual, community, territorial, and federal level, as well as implementation of the measures proposed by De Beers, there is a range of outcomes that could occur. These outcomes can be viewed as occurring along a spectrum with positive results at one end and negative results at the other end of the spectrum. The following discussions illustrate possible outcomes.

High employment should be associated with increased business and service development

High level of employment and the consistent level of substantial income will encourage increased business and service development. Likewise, the growth in the number of jobs and demand for increased skill levels may encourage residents to maximize education opportunities. Together these influences can lead to a broader range of economic activity as well as enhanced social capacity and contribute to economic and social sustainability.

The closure of all mining projects within the next 20-30 years may be associated with an economic downturn in the region

In the event that all of the mine projects in the region were to close at approximately the same time, and in the absence of any other large scale resource development activity coming on stream, the closure of the mines may result in a severe economic downturn in both the smaller communities and the larger centres of the NWT. The primary communities are particularly prone to develop a high degree of dependency on this one industry sector, in terms of providing employment opportunities, financing social services and training programs, and providing subsidiary contract/business opportunities. By the time of the closure of the mine projects, one or two whole generations of the community members will have experienced integration into the wage economy, both as it relates directly to the mine projects and to the various economic activities that may emerge in support of the mining industry (such as, trucking/transportation activities or catering businesses). As the major drivers of the wage economy in the primary communities cease operation, and if efforts to diversify the local economic base are not successful, the impacts on the local economy and the people relying on it for their subsistence will be considerable. Within a relatively short time period, as the mining industry phases out of operation, communities may then experience major social disruption, in the form of sharply increasing unemployment levels, reliance on welfare support, and a lack of financial resources to support social services, training and education programs, or programs for promoting traditional practices and activities. This kind of "boom-bust" cycle would particularly affect the people and sustainability of the smaller communities in the NWT.

Economic development during the next 20-30 years should create new opportunities that would alleviate the economic downturn

However, it is foreseeable that over the next 20 to 30 years, mining exploration and development will continue. This will maintain a certain amount of activity and may result in new opportunities for employment within the mining industry for people who may have been previously employed by a mine that has closed.

12.2.6 Social Capacity of the Region

12.2.6.1 Key Question SE-4: What Socio-economic Cumulative Effects Will the Snap Lake Diamond Project Have on the Social Capacity of the Region?

Mine related cumulative effects

As more mining industry companies begin to operate in the region, the increased demand for local skilled labour, and the need for social services to support individuals' and communities' transition to the wage economy becomes increasingly challenging. The increased revenues flowing to the

GNWT, and the need for companies to support the development of a healthy, skilled labour force, may result in increased expenditures (private, public, or in partnership) to build social capacity.

Non-mine related cumulative effects

The contribution of other developments to stressing social capacity in Yellowknife is likely and would extend to the remainder of the region for those services which are administered centrally out of Yellowknife. Relative to other aspects of social capacity, and for small communities, the existence of cumulative effects would depend on the actual geographic impact area of the multiple projects.

12.2.6.1.1 Discussion of Impacts

Opportunity for social capacity building

The cumulative effects, both in terms of pressures and increased fiscal resources, open up opportunities for investing in social capacity building within the territory. Such opportunities will be determined by a number of factors, including:

- GNWT's identified priorities and plans for education, health care, or social service provision, and the ability of the GNWT to implement such plans;
- the amount of financial revenues ear-marked by governments for reinvestment into the region; and,
- the nature of partnerships struck between industry, the GNWT and Canada, and communities.

Importance of social capacity for community cohesiveness and sustainability

Training/education and social services might improve, particularly in the smaller communities. As a result, literacy rates may improve, the level of education attained may be raised, and individuals and families may enjoy better health care and social support services. In the longer run, such improvements may contribute to the diversification of the local economy (as people are more employable) and less financial strain on the social support services (*e.g.*, reduced substance abuse issues leading to healthier and more intact families). These improvements, taken together, are essential in creating overall social cohesiveness and sustainability of communities. If investment into social capacity building of communities is not made, then a negative social scenario may result.

Potential for negative social impacts

It cannot be assumed that fiscal revenues generated by the mining industry will readily "trickle down" to the benefit of all segments of the NWT population. As discussed in Section 5.1, people from the primary communities have already indicated some disappointment with the training programs and some other services that were to be provided by the existing mining projects. While the overall NWT economy may improve, failure to adequately provide social services, health services, and education and training programs for the people of the NWT, and in particular the residents of the smaller communities, may result in negative social circumstances. Such negative social circumstances will occur if:

- partnerships between industry, government, and communities are not developed and nurtured, thereby limiting the financial resources available for social support services;
- education, literacy, life skills, and employment training programs are not adequately provided in the local communities, thereby stifling possibilities to create local economic activities and diversify the local economic base;
- individuals and groups of individuals are unable or unwilling to participate in service and/or education programs provided, and when reasons for low levels of participation are not properly explored as a means to improve service delivery;
- commitment on behalf of the government to its strategic plans concerning education and social services is not demonstrated; and,
- financial resources are not used efficiently and effectively to provide adequate and appropriate social services.

12.2.7 Changes on Cultural Practices and Traditions of Aboriginal People

12.2.7.1 Key Question SE-5: What Cumulative Effects Will the Snap Lake Diamond Project Have on Changes in the Cultural Practices and Traditions of the Aboriginal People?

Mine related cumulative effects

The rapid rate at which participation in the wage economy is occurring, through the existing and proposed mining projects, will affect the lifestyles and opportunities of Aboriginal peoples in the primary communities and their practice of traditional activities. The extent to which it will enable or limit participation in traditional activities, however, is very difficult to predict. To some extent, this will depend on individuals' and communities' own choices to maintain strong cultural traditions. It will also, however, depend on employment arrangements that recognizes traditional activity cycles (*i.e.*, hunting time, best fishing times) and permits Aboriginal people to continue participation.

Increased employment may provide more opportunity for traditional practices

The introduction of the wage economy to the Snap Lake primary communities may improve mine employees' (and, possibly, employees' families) opportunities to engage in traditional practices. Earning a disposable income may facilitate the purchase of equipment for traditional activities, *e.g.*, fishing and hunting. In communities where resources and efforts are made to create a diversified local economic base, new business may emerge based on the local culture (such as arts and crafts, tourism, or traditional foods catering). These business activities can contribute to social and economic sustainability.

Work schedules may interfere with traditional activities

However, it is also important to keep in mind that the stresses associated with the mine employment rotational work schedules and the rate at which individuals and communities as a whole will need to adapt to the wage economy may cause changes in traditional practices at the cost of decreased quality of life and wellness. The strong presence of the mining companies and their involvement in community affairs (through, for example, spin-off economic opportunities and engaging in consultation meetings during the project's phases) is likely to increase the influence of non-aboriginal ("western") culture in the Aboriginal communities.

There must be opportunity for Aboriginal employees to preserve their traditional practices

The presence of the mining industry will combine with, and possibly magnify, the effects upon Aboriginal culture by other factors, such as media and opportunities to travel. For Aboriginal peoples to be in a position to make choices about preservation of their traditional practices, they will require adequate support and opportunity for doing so. Further, cumulative effects on family and communities may occur if community members worked for different companies and were on different rotational schedules.

Non mine-related cumulative effects

Importantly, it should also be noted that changes to the natural environment, over time, may impact Aboriginal traditional practice and cultural well-being.

12.2.7.1.1 Discussion of Impacts

Uncertainty associated with environmental effects

EA work conducted to date for the Snap Lake Diamond Project has indicated that there will be no major long-term consequences on the natural environment in the study area. However, given the complexity of predicting environmental cumulative effects in the region, it is important to note that changes in the state of the natural environment may have cumulative effects on Aboriginal traditional practices.

Changes in culture and tradition will likely occur

It is reasonable to assume that the cultural identities of Aboriginal peoples in the NWT will continue to experience change during the next few decades, as they have in the relatively recent past. Given that no culture is ever static, the issue of concern is not change *per se* but, rather, the rate at which cultural practices and traditions will change in a given time period, the factors influencing change, and the effects of such changes upon the quality of life and well-being of individuals, communities, and cultures. It will also depend on the extent to which cultural promotion and education programs are offered to youth, the resources available to communities for arranging cultural events, and the provision of education in native languages.

12.3 RESOURCE USES

12.3.1 Introduction

12.3.1.1 Component Description and Organization

There are four components of resource uses

The Resource Uses section has been subdivided into the following subsections:

- heritage resources;
- traditional land uses;
- non-traditional land uses; and,
- aesthetic quality.

Each component in resource use is described

The heritage resources section includes information on archaeological resources. Non-traditional land uses includes information on: ecologically representative areas; granular resources and other subsurface resources; other natural resources such as domestic, sport, and commercial hunting, trapping, and fishing; recreation and tourism; and access (with the exception of the Tibbitt-Contwoyto winter road). Aesthetic quality includes effects to the environment that may change the colour, texture, and landforms from those existing on the landscape. Analysis of potential cumulative effects from noise is found in Section 12.5.

The study area for resource uses is the regional study area

The spatial boundary used to assess and analyze potential cumulative impacts of the Snap Lake Diamond Project for heritage resources, traditional land use, non-traditional land use, and aesthetic quality is the RSA (Figure 12.3-1). It was selected because it provides an adequate overview of resource uses within the area.

The cumulative effects assessment for the Tibbitt-Contwoyto winter road is found in Section 6.6

The Tibbitt-Contwoyto winter road has been in operation since the early 1980s. During the EA for this component of the environment (Section 6.6), De Beers took into consideration the existing traffic loads on this winter road related to EKATI™, Diavik, Echo Bay, Snap Lake, and miscellaneous users. As well, the projected peak traffic loads associated with existing and potential future developments' use of the winter road until the year 2020 were also considered during the EA. As a result, the CEA has been completed for the Tibbitt-Contwoyto winter road and is found in Section 6.6.

12.3.1.1.1 Key Issues and Key Questions

Five key questions were developed to address the issues

Issues related to the cumulative effects of the Snap Lake Diamond Project on resource uses are placed in the context of the following key questions:

Key Question CHR-1: What cumulative impacts will the Snap Lake Diamond Project have on heritage resources?

Key Question CTLU-1: What cumulative impacts will the Snap Lake Diamond Project have on the availability of land for traditional land use purposes?

Key Question CRU-1: What cumulative impacts will the Snap Lake Diamond Project have on the potential to establish protected areas?

Key Question CRU-2: What cumulative impacts will the Snap Lake Diamond Project have on natural resource use?

Key Question CVQ-1: What cumulative impacts will the Snap Lake Diamond Project have on visual quality?

12.3.1.1.2 Residual Impact Criteria

Impact criteria are defined in Tables 12.1-4 and 12.3-1

Criteria for assessing the residual impacts from projects or activities are described in detail in Section 12.1.6.1. Direction, geographic extent, duration, reversibility, and frequency are defined for all components of the CEA in Table 12.1-4. Since the method for determining magnitude changes from one component to another, the magnitude for each resource uses component is defined in Table 12.3-1.

Figure 12.3-1 Spatial Boundary for Assessing Cumulative Effects on Resource Use

Table 12.3-1 Definitions of Magnitude for Resource Uses

	Heritage Resources	Traditional Land Uses	Ecologically Representative Areas	Non-traditional Resource Uses	Aesthetic Quality
Negligible	no physical impact occurs or no archaeological sites are expected to be present	no change in availability of land for traditional land use purposes	no change in ecologically representative areas	no appreciable change in resource uses, resource availability, or access	no appreciable change in aesthetics in the vicinity of the project
Low	minimal impact to valuable resources, or resources are few and of low value	minimal (<10%) loss of land for traditional land use purposes	minimal (<10%) loss of potential ecologically representative areas	possible small change (increase or decrease) in resource uses, resource availability, or access	changes to the environment will not change the general impression in the vicinity of the project. The colour, texture, landforms, and objects introduced will not vary much from those existing on the landscape
Moderate	partial impact to resources of high or moderate archaeological value	some (10-25%) loss of land for traditional land use purposes	moderate (10-25%) loss of potential ecologically representative areas	some (increase or decrease) change in resource uses, resource availability, or access	changes to the environment may be noted by an observer, but would be considered minor. The colour, texture, landforms, and objects introduced will differ from those existing on the landscape
High	severe physical impact to resources of high archaeological value	substantial (>25%) loss of land for traditional land use purposes	substantial (>25%) loss of potential ecologically representative areas	possible substantial change (increase or decrease) in resource uses, resource availability, or access	changes to the environment occur which an observer may consider as substantial change to the landscape. The colour, texture, landforms, and objects introduced will differ substantially from those existing on the landscape

12.3.2 Heritage Resources

12.3.2.1 Baseline

A number of archaeological assessments have been conducted

A number of archaeological assessments have been conducted as a result of diamond exploration and development. Projects considered in the CEA of heritage resources for the Snap Lake Diamond Project are described in Table 12.1-2. While some projects have conducted extensive archaeological studies, others such as the Lupin Gold Mine have had little archaeological study. Archaeological sites can be affected by other activities such as establishment of hunting and fishing camps, tourist lodges, and the casual use of areas by recreational users. No archaeological information is available related to these uses. However, the footprints associated with hunting and fishing camps is limited.

EKATI™ attempts to avoid archaeological sites, but about 10% of the known sites have been mitigated

Between 1994 and the present, archaeological assessments for the EKATI™ mine site north of Lac de Gras have been conducted (Bussey 1994, 1995, 1997, 1998a, 1999, 2000, 2001, in prep a). These assessments are all outside the RSA of the Snap Lake Diamond Project. In total, 170 archaeological sites have been recorded within the BHP Billiton EKATI™ claim block. Of these 170 sites, 17 have been disturbed or were threatened by disturbance and were subject to mitigation through detailed recording and data recovery. This represents 10% of the known sites. BHP Billiton has routinely attempted to avoid known archaeological sites, and when that has not been feasible, has ensured that data recovery is conducted.

Approximately 68% of archaeological sites at Diavik Diamonds Project were threatened and a selected sample was mitigated

A number of archaeological assessments have been conducted in advance of the Diavik Diamond Project (Fedirchuk 1995, 1997, 1999a, 2000; Unfreed 1997). These assessments are all outside the RSA of the Snap Lake Diamond Project. A total of 199 sites have been recorded in conjunction with the Diavik Diamond Project. Sixty-eight of these sites were threatened by development and a selected sample was mitigated through collection and/or excavation, including four near Lac de Gras camp (Fedirchuk 2000). The percentage (approximately 34%) of site loss for this project is high. It is located on an island where heritage resources are concentrated as opposed to the mainland where the sites are more dispersed and where there are more options to relocate development.

A total of 44 new sites have been found at the Jericho Diamond Project with 10 sites mitigated

Two archaeological assessments for the Jericho Diamond Project located near Contwoyto Lake in Nunavut were conducted (Fedirchuk 1996, 1999b). These assessments are outside the RSA of the Snap Lake Diamond Project. A total of 44 new archaeological sites have been recorded as a result of the Jericho Diamond Project. The ten sites found during the 1999 inventory were small sites that were mitigated through recording and surface collection. One of the 34 sites found earlier was mitigated through recording, surface collection and subsurface testing. The status of the other 33 sites is unknown. Mitigation of the 11 sites represents a contribution to a poorly known section of the regional database.

Sixty-nine sites have been identified on the Tibbitt-Contwoyto winter road and approximately 40% of these sites have been disturbed

During the 2001 field season, a detailed post-construction inventory of the existing Tibbitt-Contwoyto winter road was conducted (Bussey in prep a). A portion of this assessment is located within the RSA of the Snap Lake Diamond Project. Fifty-five new archaeological sites were discovered. About half these sites are located between kilometre (km) 1 and km 222 of the winter road. A few were located within the RSA. As well, 14 previously recorded sites located near the Tibbitt-Contwoyto winter road were revisited. Analysis of the data is underway, but it appears that approximately 40% of these sites have been disturbed to some degree as a result of winter road construction and maintenance. The high percentage of sites disturbed is not surprising considering this study was post-construction.

Fifty-three sites have been identified in the vicinity of Snap Lake and two sites were mitigated

As a result of heritage assessments related to the Snap Lake Diamond Project, there have been 12 new sites discovered. One of these sites was sufficiently near enough to a potential development that mitigation was undertaken (Bussey 1998b, 1999, in prep b). During an assessment of a possible road alignment in the vicinity of Snap Lake to connect the Tibbitt-Contwoyto winter road, 41 archaeological sites were discovered (Thomson 2001). In 2001, one site adjacent to a portage was judged to be threatened and was mitigated (Bussey in prep a). The two sites mitigated represent disturbance at less than 4% of the total known Snap Lake sites. De Beers' management strategy is to avoid sites and to ensure that a professional archaeologist conducts monitoring and surveillance of site activities.

12.3.2.2 Cumulative Impact Assessment

12.3.2.2.1 Introduction

Key questions

The cumulative impact assessment process involved the formulation of the following key question related to heritage resources.

Key Question CHR-1: What cumulative impacts will the Snap Lake Diamond Project have on heritage resources?

Linkages were established

Key questions are used to develop cause and effect pathways or linkage diagrams (Figure 6.2-6). Project activities, environmental changes, and effects to heritage resources are shown as ovals, rectangles, and diamonds, respectively.

The following approach was used for the assessment of impacts:

- development of linkage diagrams for each key question;
- determination of the validity of each linkage within each key question;
- proposed mitigation options;
- analysis of residual impacts; and,
- classification of residual impacts.

12.3.2.2.2 Linkage Analysis

Unmitigated land surface disturbances result in a loss of heritage resources

Heritage resources are generally located directly on existing land surfaces and are non-renewable resources that are especially sensitive to land surface disturbance. The linkages between the effects of these disturbances and heritage resource cumulative impacts are permanent, and generally entail complete destruction of any resource within these zones of development. However specific types of disturbances, such as winter road segments that occur on lake ice or low lying terrain, generally pose little or no threat to heritage resources.

Cumulative effects were assessed for mines and the winter road

The activities associated with the CEA of the Snap Lake Diamond Project that are considered for this linkage analysis are the following:

- site clearing, construction, and infrastructure development associated with the Snap Lake Diamond Project, EKATI™ Diamond Mine, Diavik Diamonds Project, and Jericho Diamond Project; and,
- annual construction activities associated with the Tibbitt-Contwoyto winter road.

No data are available for tourist camps or the Lupin mine

No heritage resource data exists for the Lupin Gold Mine. Tourist and other camps have not been considered due to the lack of archaeological data associated with these developments and the very limited extent and magnitude of disturbance associated with them.

The linkage is valid

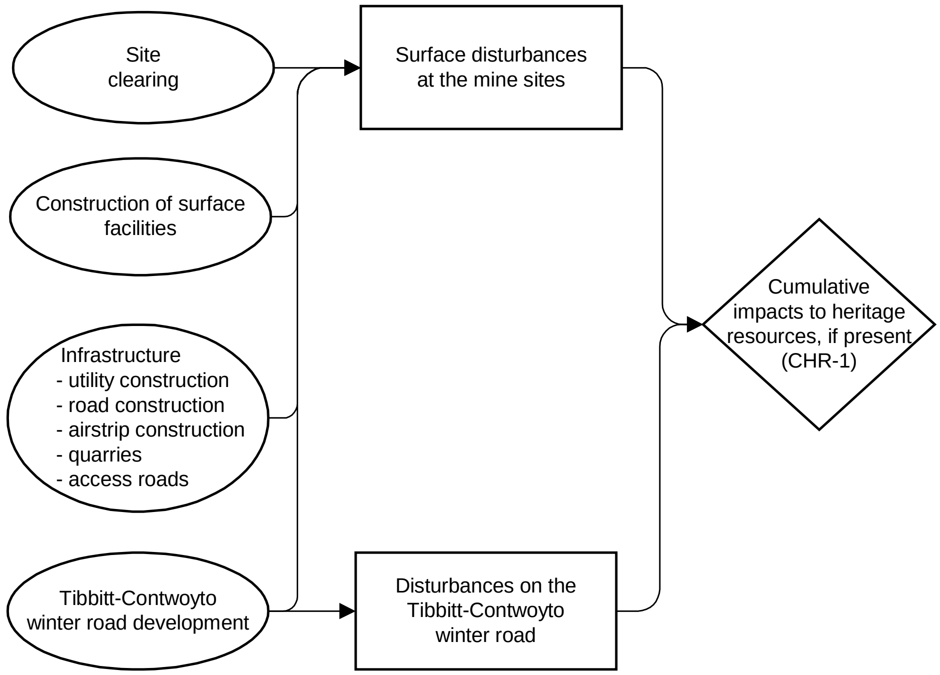
The potential cumulative impacts of the Snap Lake Diamond Project and other mines on heritage resources are identified in a linkage diagram (Figure 12.3-2). Most types of development result in complete removal of heritage resources within direct impact zones. The linkages between these activities and heritage resources are valid.

12.3.2.2.3 Mitigation

BHP Billiton's mitigation measures

BHP Billiton's mitigation measures at the EKATI™ site include inventory in advance of development, avoidance of archaeological sites, systematic data recovery, prohibition of vehicles on eskers, and education about the value of archaeological resources (BHP 2000).

Figure 12.3-2 Heritage Resources Linkage Diagram



Diavik's mitigation measures

Diavik's mitigation measures at the Diavik Diamond Mine site include systematic data recovery, ensuring the archaeological integrity of new and existing sites, and strict enforcement of a no disturbance policy for protected sites (Diavik Diamonds Project 1998a).

De Beers' mitigation measures

De Beers' mitigation measures at the Snap Lake Diamond Project include avoidance, monitoring and surveillance, systematic data recovery when resources cannot be avoided, and education of site staff.

Tahera Corporation's mitigation measures

Tahera Corporation's mitigation measures at the Jericho Diamond Project include systematic data recovery, and completion of archaeological investigations prior to any expansion of the site footprint (Tahera Corporation 2000a).

The Joint Venture's mitigation measures

The Tibbitt-Contwoyto Joint Venture has committed to ensure that any new terrain that could be affected by proposed winter road activities is assessed for archaeological deposits prior to development activity, and to protect or minimize future impacts by methods such as avoidance, staking/fencing, or capping (EBA 2001).

12.3.2.2.4 Cumulative Impact Analysis

Approximately 521 archaeological sites have been observed

As a result of development, approximately 521 archaeological sites, ranging from isolated finds to habitations or camp sites, were discovered in areas that were archaeologically unknown. Snap Lake Diamond Project has contributed 53, or approximately 10%, of these discoveries. These archaeological studies have also contributed to the knowledge of traditional camps, since such sites are often encountered (and recorded) during the archaeological fieldwork. The artifacts contained within some sites have suggested that occupation and use of the region extends to at least 3,500 years before present.

Some impacts have occurred

At a number of the mining developments, impacts to sites have occurred. When the sites have been mitigated through data recovery (recording, subsurface excavation, and/or systematic surface collection), the effect is mitigated. But when no data recovery has been conducted, the impact is considered negative although site discovery was a positive effect. Since archaeological resources are non-renewable, there is no recovery of data possible once impact has occurred. The potential for indirect impacts is affected by the proximity of sites to increased levels of human activity.

The degree of impact has varied from development to development

The degree of impact to archaeological sites that has occurred has varied considerably from development to development. This is partially a result of location. Developments that are not easily relocated (such as open pits), that are situated in areas with high archaeological potential and a high frequency of known sites, have resulted in a higher degree of site impact. Snap Lake is located in an area that has low archaeological potential. Developments that are more flexible (such as road routes) and those located in areas with lower archaeological potential, and a low to nil site yield, have generally resulted in limited site impacts when preceded by archaeological inventories. Developers have avoided archaeological sites when possible.

50 sites have been mitigated and 64 sites have been destroyed

Of the approximate 521 sites that have been identified as a result of the developments under consideration, 64 (or 12%) have been destroyed, and 50 (or 9.6%) have been mitigated. At the Snap Lake Diamond Project, 2 sites, or <1% of the total sites that have been identified, have been mitigated, and no sites have been destroyed.

Further effects can be limited

With careful planning, detailed archaeological assessments in advance of development, and emphasis on site avoidance and mitigation of threatened sites, the effects of further development on archaeological resources can be limited.

12.3.2.2.5 Residual Impact Classification

The overall environmental consequence of the cumulative effect on heritage resources in moderate

Cumulative impact on heritage resources is expected to be negative in direction (Table 12.3-2). Sixty-four (or 12%) of the known 521 archaeological sites have been destroyed, therefore the magnitude of the cumulative impact on heritage resources is considered to be low. However, to date, no sites have been destroyed as a result of the Snap Lake Diamond Project. As well, results to date indicate that, provided the development proceeds as planned, no heritage sites are expected to be encountered during the construction and operations stages of the project. The geographical extent is local, as the impacts are within each development's footprint. The duration is medium-term, as any impact would occur during the construction and operations of the developments. The impacts are irreversible. The overall environmental consequence is moderate.

Table 12.3-2 Classification of Residual Impacts of the Cumulative Impact of Snap Lake Diamond Project on Heritage Resources

Resource	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Environmental Consequence
Heritage resources	negative	low	local	medium-term	irreversible	moderate
Increase in heritage information	positive	moderate	local	long-term	irreversible	n/a[(a)]

Note: Frequency is omitted since it is not applicable to heritage resources.

[(a)] n/a = not applicable since environmental consequence is not determined for positive impacts.

The increase in heritage information provides moderate positive effects

There is an increase in heritage resource as a result of the developments under consideration. For example, as a result of heritage assessments related to the Snap Lake Diamond Project, there have been 12 new sites discovered. Thus, the direction of the cumulative impact is positive with a moderate level of magnitude. The geographical extent is local, long-term in duration and irreversible. Overall environmental consequences are not calculated for positive impacts.

Level of confidence is high

Due to the mitigation initiative planned, there is a high level of confidence that the impacts will not be greater than predicted.

12.3.3 Traditional Land Use

12.1.1.1 Key Question CTLU-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on the Availability of Land for Traditional Land Use Purposes?

12.3.3.1.1 Linkage Analysis

Other mines do not contribute to a loss of land within the regional study area

The EKATI™ Diamond Mine, Diavik Diamond Mine, Jericho Diamond Project, and the Lupin Gold Mine do not contribute to the loss of land within the RSA. Given the distance between the Snap Lake Diamond Project and these other projects (Table 12.1-2), there is no potential for effects from the Snap Lake Diamond Project to overlap with the zone of influence from these other developments.

Cumulative effects with the Tibbitt-Contwoyto winter road are not expected

A portion of the Tibbitt-Contwoyto winter road is located within the Snap Lake RSA. The impact from the Snap Lake Diamond Project on the loss of land for traditional land use purposes is predicted to be low (Section 6.3). In addition, the area of land that the Tibbitt-Contwoyto winter road covers within the RSA is negligible (1.64 ha or less than 0.001% of the RSA), and it is anticipated that it will not impact the loss of land within the Snap Lake RSA (Section 6.6).

MacKay Lake Lodge

The MacKay Lake Lodge is found within the RSA. Other lodges are found in the area, but not within the RSA. There are likely some permanent and seasonal camps in the RSA, but information on these were not available. However, the potential loss of land associated with these activities is expected to be negligible.

No further assessment is required

Overall, the information collected indicates that that the RSA is not intensely used for traditional land use purposes or other activities (Section 6.3). In addition, the distance between the Snap Lake Diamond Project and other major projects precludes the overlap of potential effects among relatively large developments. Thus, the linkage between Snap Lake and cumulative impacts on the availability of land for traditional land use purposes is not valid. No further assessment is required.

12.3.4 Non Traditional Land Use

12.1.1.1 Key Question CRU-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on the Potential to Establish Protected Areas?

12.3.4.1.1 Linkage Analysis

No other mines are located in the Coppermine River Uplands Ecoregion

Snap Lake is located within the Coppermine River Uplands Ecoregion. The EKATI™ Diamond Mine, Diavik Diamonds Project, Lupin Mine and Jericho Diamond Project are all located in the Takijuq Lake Upland Ecoregion. These projects would not impact the ability to establish protected areas in the Coppermine River Uplands Ecoregion.

Other activities are negligible

Other activities such as the Tibbitt-Contwoyto winter road, tourist lodges, and permanent and seasonal camps are located within the Coppermine River Uplands Ecoregion, but are limited in geographic extent (Section 6.4). In addition, the exact location of the Tibbitt-Contwoyto winter road is not fixed and could be modified to accommodate the boundary of protected areas. Thus, the degree of potential overlap between these activities and the Snap Lake Diamond Project is negligible.

No further assessment is required

Linkage analysis indicates that the Snap Lake Diamond Project is located in a different ecoregion than the other projects considered for the CEA. Although there is potential overlap between the RSA of the Snap Lake Diamond Project and other activities (*e.g.*, Tibbitt-Contwoyto winter road, tourist lodges, and camps), it is expected to be negligible. Therefore, the link between the Snap Lake Diamond Project and the cumulative impacts on the potential to establish protected areas within the Coppermine River Uplands Ecoregion is not valid. No further assessment is required.

12.3.4.2 Key Question CRU-2: What Cumulative Impacts Will the Snap Lake Diamond Project Have on Natural Resource Use?

12.3.4.2.1 Linkage Analysis

Other mining development does not contribute to resource use in the regional study area

Snap Lake does not contribute to renewable resource use (sport and domestic hunting, commercial and recreational fishing, trapping; Section 6.4). The EKATI™ Diamond Mine, Diavik Diamonds Project, Lupin Mine, the Jericho Diamond Project, and the Tibbitt-Contwoyto winter road do not change renewable and non-renewable (gravel extraction) resource uses within the RSA.

Other activities are negligible

Other activities such as tourist lodges, and permanent and seasonal camps do not have an impact on non-renewable resource use. Due to their limited size, wide distribution, and the limited timeframe for their activities (July – September), their effects on renewable resource use is likely negligible.

No further assessment is necessary

The link between Snap Lake and the cumulative impacts on natural resource use is not valid. No further assessment is required.

12.3.5 Aesthetic Quality

12.1.1.1 Key Question CVQ-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on Visual Quality?

12.3.5.1.1 Linkage Analysis

There are no cumulative effects of visual quality

Due to the large distances separating the Snap Lake Diamond Project and the EKATI™ Diamond Mine, Diavik Diamonds Project, Lupin Mine, and the Jericho Diamond Project, there will be no overlap of visual impacts. Therefore, the link between Snap Lake and the cumulative impact on visual quality is not valid. No further assessment is required.

12.4 AIR QUALITY

12.4.1 Introduction

12.4.1.1 Component Description and Organization

The air quality section describes and quantifies the cumulative impacts from the Snap Lake project on air emissions, ground level concentrations and deposition patterns

This section of the air quality assessment describes and quantifies the expected changes in air emissions, ground level concentrations, and deposition patterns encompassed by the CEA case. The assessment of CEA case for air quality impacts is presented at the end of this section as an answer to the key question introduced in Section 12.4.1.1.1.

The study area for air quality is the regional study area

The spatial boundary for assessing the cumulative effects of the Snap Lake Diamond Project on air quality is defined by the RSA for the local impact assessment (Section 7.1). Although there are no physical barriers to the movement of atmospheric pollutants, there are numerous practical limitations that require us to delineate an RSA that can be evaluated as part of the EA process.

Size and shape of the regional study area was determined from wind direction and speed

For the Snap Lake Diamond Project, an RSA was selected that incorporated some of the complex processes involved in the transport or dispersion of air compounds in the atmosphere. The size and shape of the RSA was defined on the basis of the distance that air compounds could travel from the Snap Lake Diamond Project in a single hour. Specifically, the dimensions of the RSA in each of the 16 cardinal downwind directions (these are the same 22½° sectors of a windrose described in Section 7.2.2.1 and shown in Figure 7.2-2) was based on the 99^{th} percentile of the observed wind speeds. This method covers virtually all of the conditions observed at the site while avoiding the effect of unusual and extreme events.

Specific details of the study area are provided in Section 7.1

The resulting area extends between 29 and 49 km from the site, depending on the direction (Figure 12.4-1). The RSA, which is described more fully in Section 7.1, encompasses the area where the effects of emissions from the Snap Lake Diamond Project would be quantifiable. The same RSA will be used for the CEA. However, there are no additional sources of emissions within the RSA. Therefore, the CEA case assesses the predicted ground levels and concentrations within the RSA resulting from air compounds emitted from all current and reasonably foreseeable projects (Section 12.4.1.2).

12.4.1.1.1 Key Issues and Key Questions

Identification of key air quality parameters

Several key air quality parameters have been assessed as part of the EA. An important air quality parameter associated with the Snap Lake Diamond Project is the total suspended particulate (TSP) matter and two subsets of TSP, the fine particles, commonly referred to as PM_{10} and $PM_{2.5}$. The term TSP refers to small airborne particles that are smaller than 30 micrometres (microns) in diameter. Fine particulate matter PM_{10} refers to particles that are 10 microns or smaller in diameter (about one-eighth the width of a human hair). PM_{10} particles can reach lungs and are considered as inhalable particles. The smaller the particle, as a rule, the deeper into the lungs it can be inhaled. Fine particles less than 2.5 micron ($PM_{2.5}$), known as respirable particles, are able to reach deeper into the respiratory tract and may have greater deleterious health impacts than the coarser PM_{10} particles. The NWT currently has a standard for TSP.

Sulphur dioxide, oxides of nitrogen, and potential acid input are also assessed

Other parameters that have been assessed in the air quality assessment include sulphur dioxide (SO_2), oxides of nitrogen (NO_x), and the deposition of acid-forming compounds, expressed as potential acid input (PAI). The deposition of acid-forming compounds on soils or lakes can have a direct effect on their chemistry (assessed in Sections 9.4, 9.5, and 10.3).

Figure 12.4-1 Spatial Boundary for Assessing Cumulative Effects on Air Quality

Air quality issues were assessed by formulating a key question

The cumulative air quality issues associated with the Snap Lake Diamond Project, in combination with other regional developments, has been summarized into the following key question:

Key Question CAQ-1: What cumulative impacts will air emissions from the Snap Lake Diamond Project have on regional air quality and deposition when combined with existing, approved and planned regional projects?

12.4.1.1.2 Residual Impact Criteria

Impact criteria are defined in Table 12.1-3 and 12.4-1

Criteria for assessing the residual impacts from projects or activities are described in detail in Section 12.1.6.1. Direction, geographic extent, duration, reversibility and frequency are defined in Table 12.1-3. Magnitude is defined separately in Table 12.4-1 for potential air quality cumulative effects issues.

Table 12.4-1 Magnitude Characterization of CEA Case Air Compounds for the Snap Lake Diamond Project

Parameter	Magnitude if Maximum is:			
	Negligible	Low	Moderate	High
24-Hour TSP[a] concentration [µg/m³][b]	no increase	< 100	< 120	> 120
Annual TSP concentration [µg/m³]	no increase	< 60	< 70	> 70
24-Hour PM_{10}[c] concentration [µg/m³]	no increase	< 50	< 150	> 150
Annual PM_{10} concentration [µg/m³]	no increase	< 60	—	> 60
24-hour $PM_{2.5}$[d] concentration [µg/m³]	no increase	< 30	< 65	> 65
Annual $PM_{2.5}$ concentration [µg/m³]	no increase	< 15	—	> 15
1-hour sulphur dioxide concentration [µg/m³]	no increase	< 450	< 900	> 900
24-hour sulphur dioxide concentration [µg/m³]	no increase	< 150	< 300	> 300
Annual sulphur dioxide concentration [µg/m³]	no increase	< 30	< 60	> 60
1-hour nitrogen dioxide concentration [µg/m³]	no increase	< 400	—	> 400
24-hour nitrogen dioxide concentration [µg/m³]	no increase	< 200	—	> 200
Annual nitrogen dioxide concentration [µg/m³]	no increase	< 60	< 100	> 100
Potential Acid Input [keq/ha/yr][e]	no increase	<0.17	<0.25	>0.25

(a) TSP = total suspended particulates.
(b) µg/m³ = micrograms per cubic metre.
(c) PM_{10} = inhalable particles.
(d) $PM_{2.5}$ = respirable particles.
(e) keq/ha/yr = kiloequivalents per hectare per year.

12.4.1.2 Description of the Cumulative Assessment Case

Assessment of cumulative effects was based on the three case scenarios

In order to evaluate the potential air quality impacts associated with the Snap Lake Diamond Project, the following emission cases have been identified:

- The **baseline** case describes the current environmental setting, against which changes in the environment from the Snap Lake Diamond Project could be assessed. As there are no approved developments within the RSA, the baseline case focuses on summarizing the available monitoring data gathered at the Snap Lake Diamond Project.
- The **application** case represents the air quality impact predicted to occur from the emissions associated with the Snap Lake Diamond Project. This case is based on the level of emissions when the project is fully developed and the activities at the mine site will be at a maximum.
- The **cumulative effect assessment** (CEA) case presents the predicted ambient air quality in the region at some future date. It includes an assessment of the cumulative air quality impacts from the Snap Lake Diamond Project in combination with other existing, approved, or reasonably foreseeable developments in the region. The CEA case includes the regional projects listed in Table 12.4-2.

Table 12.4-2 Projects Included in the Cumulative Effects Assessment Case

Project	Project Status	Direction Relative to Snap Lake	Distance from Snap Lake [km]
De Beers Snap Lake Diamond Project [(a)]	permitting	—	—
EKATI™ Diamond Mine	operational	N	119
EKATI™ Diamond Mine Expansion	permitting	N	119
Diavik Diamond Mine	construction	NNE	102
Tahera Jericho Diamond Mine	permitting	N	268
Lupin Gold Mine	operational	N	242

(a) At the present time, no approved or reasonably foreseeable projects were identified in the regional study area other than the Snap Lake Diamond Project.

12.4.1.3 Air Modelling Approach

Analysis was based on the CALPUFF model

As detailed in Section 7.1.5.3, the CALPUFF dispersion model was selected for assessing the air quality effects associated with the Snap Lake Diamond Project. The CALPUFF model was selected since it included the following capabilities:

- can simulate the chemical transformation of sulphur and nitrogen compounds required for predicting acid deposition;
- capable of predicting both wet and dry deposition of acid forming compounds;
- able to predict ambient concentrations and deposition patterns close to the facility as well as at distances in excess of 50 km from the site; and,

- capable of modelling the emissions from sources located several hundred km away.

12.4.1.3.1 Model Limitations

Limitations of the CALPUFF model

Numerical dispersion models simplify small-scale atmospheric motions and turbulence, which limits their capability to replicate individual events. Therefore, these models must predict concentration and deposition patterns for a given set of meteorological parameters. Furthermore, the modelling cannot deal with hour-to-hour variations in the emission rates that may occur during the life of the project.

12.4.1.3.2 NO_X to NO_2 Conversion Methods

The Northwest Territories has no current protocol for determining the conversion of nitric oxide to nitrogen dioxide

The NO_X that are emitted from industrial facilities, automobiles, and other combustion sources are a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is an unstable component which rapidly reacts with oxygen to form NO_2. Currently the NWT does not have an established protocol for determining the fraction of the NO that is converted to NO_2.

Conversion of nitric oxide to nitrogen dioxide was based on Alberta Environment guidelines

Based on discussions with Environment Canada personnel (Dave Fox, Environment Canada, pers. comm.), it was decided to follow the guidance provided by Alberta Environment (AENV 2000). The ozone limiting method (OLM) assumes that approximately 10% of the NO_x emissions are in the form of NO_2, with the balance being in the form of NO. The NO is assumed to rapidly react with ambient levels of ozone (O_3) to form additional NO_2. The OLM formulation is based on the work of Cole and Summerhays (1979). Since no site-specific O_3 data are available for the Snap Lake Diamond Project site, Environment Canada have indicated that the following O_3 values should be used:

- for converting hourly NO_x concentrations 50 parts per billion (ppb);
- for converting daily NO_x concentrations 40 ppb; and,
- for converting annual NO_x concentrations 35 ppb.

12.4.1.3.3 Background Levels of Acid-Forming Compounds

Acidification by nitrogen and sulphur can result in changing water and soil chemistry

Deposition, including both wet and dry processes, can result in the long-term accumulation of compounds in aquatic and terrestrial ecosystems. Wet processes involve the removal of emissions by precipitation. Dry processes are emission removal by direct contact with surface features (*e.g.*, vegetation). Both wet and dry deposition values, expressed as a flux, are in units of “kg/ha/yr.” Because estimates of deposition include several chemical forms of nitrogen, sulphur, and base cations (*i.e.*, positively charged alkaline earth metals), the flux is expressed as "keq/ha/yr", where "keq" refers to the number of equivalent hydrogen ions (1 keq = 1 kmol H^+). For sulphur compounds, each molecule is equivalent to two hydrogen ions. Each molecule of a nitrogen compound is equivalent to one hydrogen ion. The deposition of sulphur and nitrogen compounds has been associated with changes in water and soil chemistry, and with the acidification of water and soil.

Potential acid input was used to measure acidic input from nitrogen and sulphur

PAI has become the preferred measure of acidic input for Alberta Environment since it incorporates the following:

- the effects of both nitrogen and sulphur compounds;
- the impacts of both dry and wet deposition mechanisms; and,
- the effect of base cations in mitigating acidity.

Estimation of potential acid input background levels

In areas with numerous sources of SO_2 and NO_x emissions, the wet and dry deposition will contribute equally to PAI. In remote areas like Snap Lake, however, the acid deposition will be dominated by wet deposition. The wet background PAI value obtained from the precipitation monitoring completed at Snare Rapids indicates that the background wet PAI values are 0.04 keq/ha/yr. Since the Snap Lake Diamond Project is well removed from other sources of emissions, the background wet PAI from Snare Rapids was considered to be representative for assessing acid deposition from the Snap Lake Diamond Project. This value will be added to the PAI values predicted across the study area.

12.4.2 Modelled CEA Emissions

12.4.2.1 Summary of Snap Lake Diamond Project Emissions

There are a number of emissions from the Snap Lake project

There will be a release of gaseous and particulate atmospheric emissions from operations of the Snap Lake Diamond Project. Emissions will emanate from fuel combustion, vehicle exhausts, and other sources associated with the operation of the project. The primary emissions addressed in this section are SO_2; NO_X; TSP; PM_{10} (particles with a nominal diameter less than 10 µm); and $PM_{2.5}$ (particles with a nominal diameter less than 2.5 µm). The emissions associated with the Snap Lake Diamond Project have been detailed in Section 7.3.2. Table 12.4-3 provides a summary of the emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ from all sources at the Snap Lake Diamond Project.

Table 12.4-3 Summary of Project Emissions

Source	Emission Rates [tonnes per day]				
	Sulphur Dioxide	Oxides of Nitrogen	Total Suspended Particulates	Inhalable Particles (PM_{10})	Respirable Particles ($PM_{2.5}$)
Power plant	0.059	3.715	0.115	0.065	0.054
Mine heaters	0.068	0.195	0.030	0.017	0.015
Underground activities	0.037	1.560	0.129	0.040	0.012
Quarry activities	0.011	0.213	0.212	0.070	0.021
Process plant	0.000	0.000	0.045	0.010	0.007
Incinerators	0.000	0.001	0.012	0.006	0.004
North pile	0.000	0.000	0.011	0.005	0.002
Total	**0.175**	**5.684**	**0.554**	**0.213**	**0.115**

12.4.2.2 EKATI™ Diamond Mine

Emissions from EKATI™ mine

The emissions from the EKATI™ Diamond Mine, shown in Table 12.4-4, were derived from the EKATI™ Diamond application (BHP 1995). The total emissions of SO_2, NO_X, TSP and PM_{10} from this project are 0.469, 5.923, 21.388 and 0.049 tonnes per day (t/d), respectively. No emission estimates for $PM_{2.5}$ were available.

Table 12.4-4 EKATI™ Diamond Mine Emissions

Source	Emission Rates [tonnes per day]				
	Sulphur Dioxide	Oxides of Nitrogen	Total Suspended Particulates	Inhalable Particles (PM_{10})	Respirable Particles ($PM_{2.5}$)
Power generation	0.092	2.117	0.160	0.014	—
Mining activities	—[a]	—	0.301	0.000	—
Mine fleet	0.342	3.803	—	—	—
Ore processing	0.000	0.000	0.240	0.021	—
Support facilities	0.035	0.003	0.240	0.007	—
Wind erosion	0.000	0.000	20.447	0.007	—
Total	**0.469**	**5.923**	**21.388**	**0.049**	**—**

[a] "—" indicates that no data were available.

12.4.2.3 EKATI™ Diamond Mine Expansion

Emissions from EKATI™ expansion

Table 12.4-5 summarizes the emissions from the proposed BHP Billiton EKATI™ Diamond Mine Expansion. These data were derived from the 2006-operating year emissions listed in the original EA for the EKATI™

Diamond Mine (BHP 1995). The total emissions of SO_2, NO_X, TSP and PM_{10} from this project were calculated to be 0.361, 4.138, 20.988 and 0.028 t/d, respectively. No emission estimates for $PM_{2.5}$ were available.

Table 12.4-5 EKATI™ Diamond Mine Expansion Emissions

Source	Emission Rates[(a)] [tonnes per day]				
	Sulphur Dioxide	Oxides of Nitrogen	Total Suspended Particulates	Inhalable Particles (PM_{10})	Respirable Particles ($PM_{2.5}$)
Power generation	0.020	0.334	0.080	0.007	—
Mining activities	—	—	20.668	0.000	—
Mine fleet	0.341	3.804	—	—	—
Ore processing	0.000	0.000	0.240	0.021	—
Total	**0.361**	**4.138**	**20.988**	**0.028**	—

[(a)] The emissions are based on the 2006 development stage of the EKATI™ Project.
[(b)] "—" indicates that no data were available.

12.4.2.4 Diavik Diamond Mine

Emissions from Diavik mine

Table 12.4-6 summarizes the emissions from the Diavik Diamond Mine. The emissions values were taken from the EA for the Diavik Diamonds Project (Diavik Diamonds Project 1998a). The total emissions of SO_2, NO_X, TSP and PM_{10} from the Diavik Diamond Mine are 0.200, 16.500, 8.900 and 2.800 t/d, respectively. No emission estimates for $PM_{2.5}$ were available.

Table 12.4-6 Diavik Diamond Mine Emissions

Source	Emission Rates[(a)] [tonnes per day]				
	Sulphur Dioxide	Oxides of Nitrogen	Total Suspended Particulates	Inhalable Particles (PM_{10})	Respirable Particles ($PM_{2.5}$)
Power generation	0.108	11.534	0.186	0.186	—[(b)]
Mining activities	0.000	0.000	6.205	1.752	—
Mine fleet	0.087	4.958	1.190	0.378	—
Ore processing	—[(b)]	—	—	—	—
Support facilities	0.005	0.008	0.011	0.006	—
Wind erosion	0.000	0.000	1.308	0.478	—
Total	**0.200**	**16.500**	**8.900**	**2.800**	—

[(a)] The emissions are based on the Diavik EIA (Diavik Diamonds Project 1998a).
[(b)] "—" indicates that no data were available.

12.4.2.5 Tahera Jericho Diamond Mine

Emissions from Tahera mine

Table 12.4-7 summarizes the emissions from the proposed Tahera Jericho Diamond Mine. The total emissions of SO_2, NO_X, TSP and PM_{10} from this project are 0.898, 2.345, 1.161, and 0.427 t/d, respectively. No emission estimates for $PM_{2.5}$ were available. The emissions values were taken from the recent project description report (Tahera Corporation 2000b).

Table 12.4-7 Tahera Jericho Diamond Mine Emissions

Source	Emission Rates [tonnes per day]				
	Sulphur Dioxide	Oxides of Nitrogen	Total Suspended Particulates	Inhalable Particles (PM_{10})	Respirable Particles ($PM_{2.5}$)
Power generation	0.307	0.874	0.020	0.013	— [(a)]
Mining activities	—	—	0.011	0.003	—
Mine fleet	0.101	0.756	—	—	—
Ore processing	0.490	0.715	0.000	0.000	—
Support facilities	—	—	—	—	—
Wind erosion	0.000	0.000	1.130	0.411	—
Total	**0.898**	**2.345**	**1.161**	**0.427**	**—**

(a) "—" indicates that no data were available.

12.4.2.6 Lupin Gold Mine

Emissions from Lupin gold mine

Table 12.4-8 summarizes the likely emissions from the Lupin Gold Mine. The total emissions of SO_2, NO_X, TSP, PM_{10} and $PM_{2.5}$ from this project were calculated to be 0.080, 2.625, 0.256, 0.097, and 0.052 t/d, respectively. Although no specific emissions information were available for this project, the data presented in the table were scaled from the Snap Lake Diamond Project emissions on the basis of ore volumes extracted on a daily basis.

Table 12.4-8 Lupin Gold Mine Emissions

Source	Emission Rates [tonnes per day]				
	Sulphur Dioxide	Oxides of Nitrogen	Total Suspended Particulates	Inhalable Particles (PM_{10})	Respirable Particles ($PM_{2.5}$)
Total	**0.080**	**2.625**	**0.256**	**0.097**	**0.052**

12.4.2.7 Summary of CEA Case Emissions

Emissions for cumulative effects assessment scenario

Table 12.4-9 summarizes the regional emissions used in the assessing the CEA case concentrations and deposition values for the Snap Lake Diamond Project. The total emissions of SO_2, NO_X, TSP, PM_{10}, and $PM_{2.5}$ were estimated to be are 2.181, 37.215, 53.248, 3.610, and 0.165 t/d, respectively. The $PM_{2.5}$ emissions were only determined for the Snap Lake Diamond Project and the Lupin Gold Mine. The Snap Lake Diamond Project emissions account for less than 8% of the regional SO_2, 15% of the regional NO_X, and only 1% of the total regional particulate emissions.

Table 12.4-9 Summary of Regional Emissions

Source	Emission Rates [tonnes per day]				
	Sulphur Dioxide	Oxides of Nitrogen	Total Suspended Particulates	Inhalable Particles (PM_{10})	Respirable Particles ($PM_{2.5}$)
Snap Lake Diamond Project	0.173	5.684	0.555	0.209	0.113
EKATI™ Diamond Mine	0.469	5.923	21.388	0.049	—[a]
EKATI™ Diamond Mine Expansion	0.361	4.138	20.988	0.028	—
Diavik Diamond Mine	0.200	16.500	8.900	2.800	—
Tahera Jericho Diamond Mine	0.898	2.345	1.161	0.427	—
Lupin Gold Mine	0.080	2.625	0.256	0.097	0.052
Total	**2.181**	**37.215**	**53.248**	**3.610**	**0.165**

(a) "—" indicates that no data were available.

12.4.3 Air Quality Predictions

Model outputs are in the form of figures and tables

The CALPUFF dispersion model, described in Section 7.1.5.3, was used to predict concentrations and deposition patterns for the CEA case. The modelling results are presented in a combination of tables and figures.

Results are presented with and without the Snap Lake project to determine the added effect of the project

The series of tables used in this section include two separate sets of results. The first results represent the predictions over the entire RSA including the active mine area. The second results represent the predictions excluding the active mine area. This allows the reviewers to separate regional air quality impacts from those that occur in the active mine area.

Figures are used to show the how air quality changes over the RSA

The figures show the distribution of maximum concentration or deposition, as represented by isopleths (*i.e.*, curves joining points of equal concentration or deposition values). To illustrate concentration or deposition isopleths, consider any point (or receptor) in the RSA. For every hour modelled, the dispersion model will calculate a concentration or deposition value at this point. This value changes from hour to hour eventually reaching an absolute maximum concentration or deposition value for the particular point. Each such point modelled in the RSA reaches its maximum value at different times. An isopleth is then simply a curve joining points in the RSA of equal maximum concentrations or deposition values.

Figures show the pattern of air quality at the regional and local scale

The concentration isopleths, in units of micrograms per cubic metre ($\mu g/m^3$), represent 100%, 50%, and 25% of the relevant criteria. The deposition isopleths represent PAI values of 1.00, 0.50, 0.25, and 0.17 keq/ha/yr. The isopleths overlay the local topography. In each figure, the larger plot to the left encompasses the entire RSA (dashed line). The smaller plot in the upper right presents the same results as the larger plot, but focuses on the immediate vicinity of the Snap Lake Diamond Project.

12.4.3.1 Particulate Matter

Three sizes of particulate matter were assessed

For this assessment, three ranges of particulate matter are evaluated. The TSP matter represents the fraction of emitted particles that are small enough to remain airborne for more than a few metres. The PM_{10} fraction of the airborne particles represents the fraction of the TSP that is nominally smaller than 10 µm in diameter. The $PM_{2.5}$ fraction of the airborne particles represents the fraction of the TSP that is nominally smaller than 2.5 µm in diameter. Both PM_{10} and $PM_{2.5}$ are subsets of TSP, therefore the emissions and predictions of TSP include the PM_{10} and $PM_{2.5}$ fractions. As particulate matter emissions were estimated to be at a maximum during operations, only predictions during the operations phase of the development have been presented.

12.4.3.1.1 Total Suspended Particulates

Distribution of total suspended particulates

Table 12.4-10 presents the TSP predictions resulting from the cumulative emissions released from the approved and planned projects in the region as well as the Snap Lake Diamond Project. Over the entire RSA, the maximum 24-hour and annual TSP concentrations exceed the NWT standards of 100 and 60 $\mu g/m^3$, respectively. However, the ground-level TSP concentrations decrease rapidly outside the confines of the active mine area. Beyond the active mine area, the 24-hour TSP predictions exceeded the NWT standard of 100 $\mu g/m^3$ only once, in a small area adjacent to the quarry. None of the annual TSP predictions outside of the active mine area plus a 500 metre (m) buffer exceeded the NWT standard of 60 $\mu g/m^3$.

Table 12.4-10 Maximum CEA Case TSP Predictions

Parameter	Averaging Period	
	24-Hour	Annual
RSA Including Active Mine Area		
Maximum TSP[(a)] concentration [µg/m³][(b)]	274.0	102.3
Occurrences above NWT standard	190	1
Areal extent above NWT standard [ha]	59	9
RSA Excluding Active Mine Area		
Maximum TSP concentration [µg/m³]	116.5 [(c)]	18.5
Occurrences above NWT standard	1	0
Areal extent above NWT standard [ha]	1	0
NWT TSP Standard[(d)] [µg/m³]	**100**	**60**

(a) TSP = total suspended particulates.

(b) µg/m³ = microgram per cubic metres.

(c) This concentration, which exceeds the NWT TSP Standard, occurred adjacent to the active mine area within the 500 m buffer identified in Table 12.4-2.

(d) Guideline respecting ambient air quality standards for sulphur dioxide and total suspended particulate in the Northwest Territories (GNWT 1994).

24 hour and annual total suspended particulates predictions

Plots of the maximum 24-hour and annual TSP predictions for the application case emissions are provided in Figures 12.4-2 and 12.4-3, respectively. The concentration isopleths represent 100%, 50%, and 25% of the NWT standards for TSP. The figures indicate the following:

- The maximum 24-hour predictions (Figure 12.4-2) are generally less than the NWT standard outside the active mine area. The exception is an isolated area near the quarry.
- The plot of annual TSP prediction (Figure 12.4-3) illustrates that the only areas where the concentrations exceed the NWT standards of 60 µg/m³ are contained within the active mine area. Annual TSP concentration outside the active mine area are less than 25% of the NWT standard.

12.4.3.1.2 PM_{10}

PM_{10} predictions

Table 12.4-11 presents the PM_{10} predictions resulting from the cumulative emissions released from the approved and planned projects in the region as well as the Snap Lake Diamond Project. As the NWT has yet to establish criteria for PM_{10}, the interim 24-hour guidelines adopted in British Columbia, Ontario, and Newfoundland were used. The maximum 24-hour PM_{10} concentrations for the RSA are predicted to exceed the 50 µg/m³ criteria adjacent to the active mine area. The maximum 24-hour PM_{10} concentrations also exceed the criteria at two locations within the active mining area. None of the annual PM_{10} predictions exceed the U.S. EPA primary of 50 µg/m³. This is the only annual PM_{10} criterion available in North America.

Figure 12.4-2 Maximum 24-Hour CEA Case TSP Predictions

Figure 12.4-3 Annual CEA Case TSP Predictions

Table 12.4-11 Maximum CEA Case PM_{10} Predictions

Parameter	Averaging Period	
	24-Hour	**Annual**
RSA Including Active Mine Area		
Maximum PM_{10}[a] concentration [µg/m³][b]	120.8	27.5
Occurrences above the criteria	40	0
Areal extent above the criteria [ha]	18	0
RSA Excluding Active Mining Area		
Maximum PM_{10} concentration [µg/m³]	45.2	5.1
Occurrences above the criteria	0	0
Areal extent above the criteria [ha]	0	0
PM_{10} Criteria [µg/m³]	**50[c]**	**50[d]**

(a) PM_{10} = inhalable particles.
(b) µg/m³ = micrograms per cubic metre.
(c) Newfoundland, Ontario and BC have established a 24-hour PM_{10} guideline of 50 µg/m³.
(d) The annual U.S. EPA primary PM_{10} standard is 50 µg/m³.

24 hour and annual inhalable particles predictions

Plots of the maximum 24-hour and annual PM_{10} predictions for the application case emissions are provided in Figures 12.4-4 and 12.4-5, respectively. The concentration isopleths of 50, 25, and 12.5 µg/m³ represent 100%, 50%, and 25% of the available PM_{10} criteria for both the 24-hour and annual averaging periods. The figures indicate the following:

- The maximum 24-hour PM_{10} predictions (Figure 12.4-4) are generally below the 50 µg/m³ interim criteria established in British Columbia, Ontario, and Newfoundland outside the active mine area. The exception is a small area in the vicinity of the quarry.
- Figure 12.4-5 illustrates the annual PM_{10} predictions. None of the annual PM_{10} exceed the U.S. EPA primary standard.

12.4.3.1.3 $PM_{2.5}$

Respirable particles predictions

Table 12.4-12 presents the $PM_{2.5}$ predictions resulting from the cumulative emissions released from the approved and planned projects in the region as well as the Snap Lake Diamond Project. The maximum 24-hour $PM_{2.5}$ concentrations are predicted to exceed the 30 µg/m³ Canada-Wide Standard (CWS) within the active mine area. However, the 98th percentile of the observed/predicted values is to be used when determining compliance with the CWS for $PM_{2.5}$. The $PM_{2.5}$ CWS would be satisfied on this basis, even in the active mining area. None of the annual $PM_{2.5}$ predictions exceed the U.S. EPA primary standard of 15 µg/m³. There are no annual $PM_{2.5}$ criteria available in Canada.

Figure 12.4-4 Maximum 24-Hour CEA Case PM_{10} Predictions

Figure 12.4-5 Annual CEA Case PM_{10} Predictions

Table 12.4-12 Maximum CEA Case $PM_{2.5}$ Predictions

Parameter	Averaging Period	
	24-Hour	**Annual**
RSA Including Active Mine Area		
Maximum $PM_{2.5}$[a] concentration [µg/m³][b]	42.1	8.1
Occurrences above criteria	2	0
Areal extent above criteria [ha]	<1	0
RSA Excluding Active Mine Area		
Maximum $PM_{2.5}$ concentration [µg/m³]	16.1	1.6
Occurrences above criteria	0	0
Areal extent above criteria [ha]	0	0
Areal extent above criteria [ha]	0	0
$PM_{2.5}$ Criteria [µg/m³]	**30[c]**	**15[d]**

(a) $PM_{2.5}$ = respirable particles.
(b) µg/m³ = micrograms per cubic metre.
(c) The 24-hour Canada-Wide Standard (CCME 2000) for $PM_{2.5}$ is 30 µg/m³.
(d) The annual U.S. EPA primary $PM_{2.5}$ standard is 15 µg/m³.

24 hour and annual respirable particles predictions

Figures 12.4-6 and 12.4-7 present the maximum 24-hour and annual $PM_{2.5}$ predictions, respectively. The concentration isopleths represent 100%, 50%, and 25% of the available $PM_{2.5}$ criteria. The figures indicate the following:

- The maximum 24-hour $PM_{2.5}$ predictions in the RSA exceed the 30 µg/m³ level adopted as the Canada-Wide Standard over a small area within the active mine area. The area is so small (<1 ha) that it is not visible in Figure 12.4-6. All of the 24-hour $PM_{2.5}$ outside the active mine area are below 30 µg/m³.
- Figure 12.4-7 presents a plot of the annual $PM_{2.5}$ predictions. None of the annual $PM_{2.5}$ predictions in the RSA exceed the U.S. EPA primary standard.

12.4.3.2 Sulphur Dioxide

Sulphur dioxide predictions

Table 12.4-13 presents the maximum predictions resulting from the cumulative emissions released from the approved and planned projects in the region as well as the Snap Lake Diamond Project. The maximum 1-hour, 24-hour, and annual concentrations for the RSA (including the active mine area) are predicted to be below the respective NWT standards of 450, 150, and 30 µg/m³.

Figure 12.4-6 Maximum 24-Hour CEA Case $PM_{2.5}$ Predictions

Figure 12.4-7 Annual CEA Case $PM_{2.5}$ Predictions

Table 12.4-13 Maximum CEA Case SO_2 Predictions

Parameter	Averaging Period		
	1-Hour	**24-Hour**	**Annual**
RSA Including Active Mine Area			
Maximum SO_2[(a)] concentration [µg/m³][(b)]	245.0	129.5	11.6
Occurrences above the NWT standard	0	0	0
Areal extent above the NWT standard [ha]	0	0	0
RSA Excluding Active Mine Area			
Maximum SO_2 concentration [µg/m³]	35.9	12.2	1.6
Occurrences above the NWT standard	0	0	0
Areal extent above the NWT standard [ha]	0	0	0
NWT SO_2 Standard[(c)] [µg/m³]	**450**	**150**	**30**

(a) SO_2 = sulphur dioxide.

(b) µ/gm³ = micrograms per cubic metre.

(c) Guideline respecting ambient air quality standards for sulphur dioxide and total suspended particulate in the Northwest Territories (GNWT 1994).

Daily and annual sulphur dioxide predictions

Figures 12.4-8, 12.4-9, and 12.4-10 present the maximum 1-hour, 24-hour, and annual SO_2 predictions, respectively. The concentration isopleths represent 100%, 50%, and 10% of the NWT SO_2 standards. The lowest isopleth line has been set at 10% of the NWT standards in an effort to show some of the predictions on the figures. The figures indicate the following:

- The maximum 1-hour SO_2 predictions (Figure 12.4-8) are below the NWT standard of 450 µg/m³. In fact, there is only a small area near the power plant where the maximum 1-hour SO_2 concentrations were predicted to exceed 10% of the NWT standards.
- The maximum 24-hour SO_2 predictions (Figure 12.4-9) are all well below NWT standard of 150 µg/m³.
- The plot of annual SO_2 predictions (Figure 12.4-10) illustrates patterns similar to the 1-hour and 24-hour predictions. None of the annual SO_2 predictions in the RSA exceed the NWT standard of 30 µg/m³.

12.4.3.3 Oxides of Nitrogen

Nitrogen oxide predictions

Table 12.4-14 summarizes the maximum NO_2 and NO_X predictions resulting from the Snap Lake Diamond Project. As indicated in the table, the maximum 1-hour, 24-hour, and annual NO_2 concentrations over the entire RSA are below the respective federal ambient air quality objectives (FAAQO) of 400, 200, and 100 µg/m³.

Figure 12.4-8 Maximum 1-Hour CEA Case SO_2 Predictions

Figure 12.4-9 Maximum 24-Hour CEA Case SO_2 Predictions

Figure 12.4-10 Annual CEA Case SO_2 Predictions

Table 12.4-14 Maximum CEA Case NO_X and NO_2 Predictions

Parameter	Averaging Period		
	1-Hour	24-Hour	Annual
RSA Including Active Mine Area			
Maximum NO_X[(a)] concentration [µg/m³][(b)]	1,408.5	632.0	219.1
Maximum NO_2[(c)] concentration[(d)] [µg/m³]	236.5	139.7	88.8
Areal extent above the criteria [ha]	0	0	0
RSA Excluding Active Mine Area			
Maximum NO_X concentration [µg/m³]	1,080.3	216.0	27.3
Maximum NO_2 concentration[(a)] [µg/m³]	203.6	98.1	27.3
Areal extent above the criteria [ha]	0	0	0
NO_2 Criteria[(e)] [µg/m³]	**400**	**200**	**100**

(a) NO_x = oxides of nitrogen.
(b) µg/m^3 = micrograms per cubic metre.
(c) NO_2 = nitrogen dioxide.
(d) NO_2 concentrations calculated by the ozone limiting method (AENV 2000).
(e) Acceptable federal ambient air quality objective.

Daily and annual nitrogen oxide predictions

Figures 12.4-11, 12.4-12 and 12.4-13 present the maximum 1-hour, 24-hour and annual NO_2 predictions, respectively. The concentration isopleths represent 100%, 50%, and 25% of the acceptable FAAQOs. The figures indicate the following:

- The maximum 1-hour NO_2 predictions in the RSA (Figure 12.4-11) are all below FAAQO of 400 µg/m³. The 1-hour NO_2 concentrations were calculated using the ozone limiting method and a background O_3 concentration of 50 ppb.
- The maximum 24-hour NO_2 predictions (Figure 12.4-12) are all below the acceptable FAAQO of 200 µg/m³. The 24-hour NO_2 concentrations were calculated using the OLM and a background O_3 concentration of 40 ppb.
- The plot of annual NO_2 prediction (Figure 12.4-13) illustrates that none of the annual predictions exceed the acceptable FAAQO of 100 µg/m³. Annual NO_2 concentrations were calculated using the ozone limiting method and a background O_3 concentration of 35 ppb.

12.4.3.4 Potential Acid Input

Potential acid input was also considered

The air quality assessment of the Snap Lake Diamond Project includes an evaluation of the deposition of acid forming compounds. The air quality assessment will focus on determining the PAI resulting from the project

Figure 12.4-11 Maximum 1-Hour CEA Case NO_2 Predictions

Figure 12.4-12 Maximum 24-Hour CEA Case NO_2 Predictions

Figure 12.4-13 Annual CEA Case NO_2 Predictions

emissions of SO_2 and NO_X. The PAI is a widely accepted method of assessing acidification, since it incorporates the effect of sulphur and nitrogen compounds as well as the neutralizing effect of available base cations. As discussed in Section 7.1.5.4, PAI was determined using the CALPUFF dispersion model. The PAI predictions include a uniform background PAI value of 0.040 keq/ha/yr.

Potential acid inputs decrease rapidly within the limits of the active mine area

Table 12.4-15 summarizes the maximum PAI, nitrogen, and sulphur deposition levels predicted for the cumulative emissions from the Snap Lake Diamond Project in combination with other approved and planned developments in the region. The table shows that the maximum predictions fall off rapidly within the limits of the active mine area.

Table 12.4-15 Maximum CEA Case PAI Predictions

Parameter	Annual Deposition [keq/ha/yr][(a)]
RSA Including Active Mine Area	
Overall PAI[(b)]	1.106
Background PAI	0.040
Nitrogen deposition	0.984
Sulphur deposition	0.083
RSA Excluding Active Mine Area	
Overall PAI[(a)]	0.175
Background PAI	0.040
Nitrogen deposition	0.123
Sulphur deposition	0.013

(a) keq/ha/yr = kiloequivalents per hectare per year.

(b) The overall potential acid input (PAI) predictions include a uniform background value of 0.040 keq/ha/yr.

Potential acid inputs are low

In addition to the maximum PAI predictions, CALPUFF was used to determine the areas with predicted PAI above 1.00, 0.50, 0.25, and 0.17 keq/ha/yr. These results are presented in Table 12.4-16. The table demonstrates that none of the predicted PAI values beyond the active mine area exceed 0.25 keq/ha/yr, which has been identified as providing long-term protection to the most sensitive ecosystems (CASA 1999). In fact, less than 1 ha outside the active mining area was predicted to receive PAI levels in excess of 0.17 keq/ha/yr.

The distribution of potential acid input is confined almost entirely within the active mine area

Figure 12.4-14 presents a plot of the CEA Case PAI predictions resulting from the Snap Lake Diamond Project. The figure indicates that the deposition of acid forming compounds is contained almost entirely within the active mine area.

Figure 12.4-14 CEA Case Potential Acid Input (PAI) Predictions

Table 12.4-16 Spatial Extent for Predicted CEA Case PAI Values

Parameter	Spatial Extent[(a)]	
	Area [ha]	Fraction of RSA [%]
RSA Including Active Mine Area		
Area with PAI greater than 0.17 keq/ha/yr	47	0.004
Area with PAI greater than 0.25 keq/ha/yr	35	0.003
Area with PAI greater than 0.50 keq/ha/yr	12	0.001
Area with PAI greater than 1.00 keq/ha/yr	0	0.000
RSA Excluding Active Mine Area		
Area with PAI greater than 0.17 keq/ha/yr	< 1	0.000
Area with PAI greater than 0.25 keq/ha/yr	0	0.000
Area with PAI greater than 0.50 keq/ha/yr	0	0.000
Area with PAI greater than 1.00 keq/ha/yr	0	0.000

(a) Calculations of the spatial extent incorporated a uniform background potential acid input (PAI) of 0.040 kiloequivalents per hectare year (keq/ha/yr).

12.4.4 Cumulative Impact Assessment

12.4.4.1 Introduction

Key question

The cumulative impact assessment process involved the formulation of the following key question related to air quality.

Key Question CAQ-1: What cumulative impacts will air emissions from the Snap Lake Diamond Project have on regional air quality and deposition when combined with existing, approved and planned regional projects?

The following approach was used for the assessment of cumulative impacts:

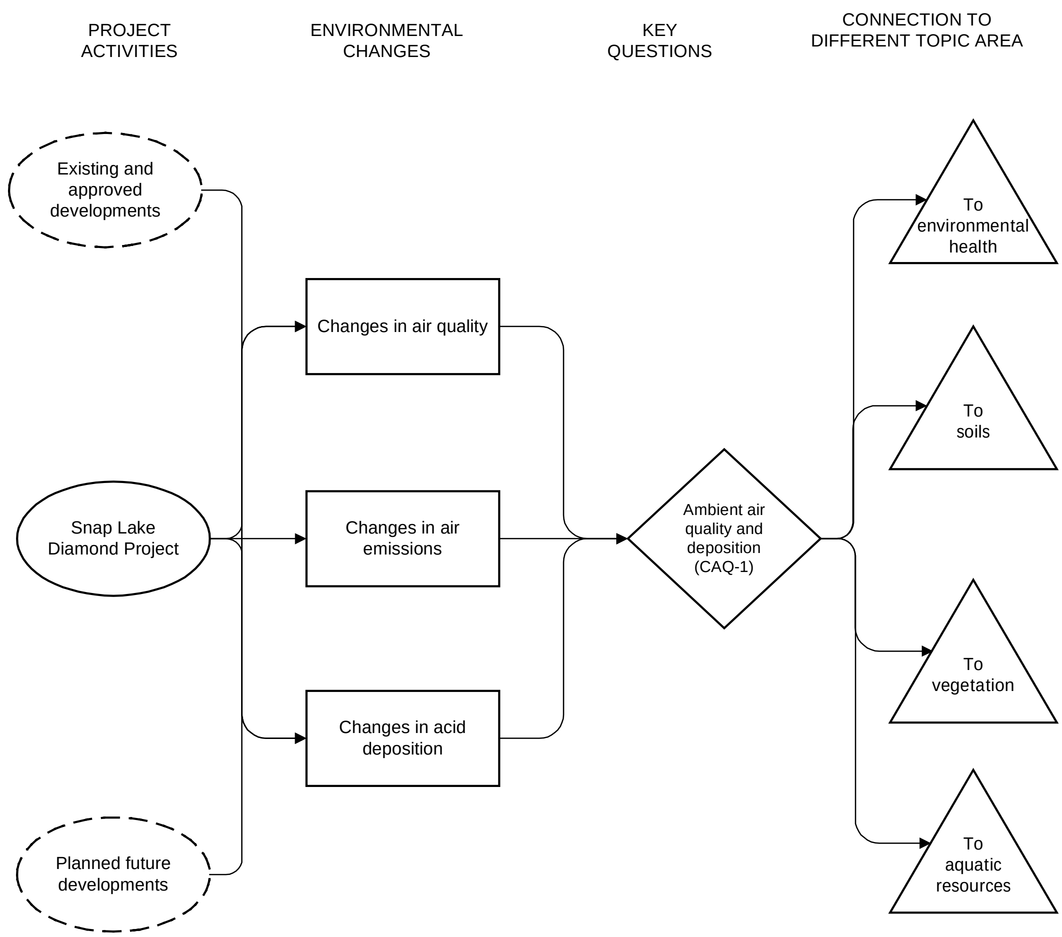
- development of linkages for the key question;
- determination of validity of each linkage for the key question;
- analysis of residual impacts; and,
- classification of residual impacts.

12.4.4.1.1 Linkage Analysis

The linkage for potential cumulative effects is valid

The potential for emissions from the Snap Lake Diamond Project to affect the quality of the air in the region is an essential issue with regulators and regional stakeholders. The linkage pathways for this key question are shown in Figure 12.4-15. The linkage diagram illustrates that various components of the Snap Lake Diamond Project can contribute to increased air emissions in the region, which will result in changes in air quality. These changes can, in turn, affect other components of the environment such as vegetation or human and wildlife health. The linkages in Figure 12.4-15 were considered valid, and an impact assessment has been completed.

Figure 12.4-15 Linkage Diagram for Ambient Air Quality



12.4.4.2 Cumulative Impact Analysis

For most compounds, emissions from the Snap Lake project represents less than 20% of regional emissions from other projects

The first stage of the evaluation of cumulative air effects associated with the Snap Lake Diamond Project is to compare the project emissions to the total regional emissions from approved and planned developments. A comparison of the air emissions from the Snap Lake Diamond Project to the overall regional emissions is given in Table 12.4-17. For most compounds, the Snap Lake Diamond Project represents a minor component (<20%) of the regional emissions. The exception shown in the table is the regional emissions of $PM_{2.5}$, which appear to be dominated by emission from Snap Lake. However, the Snap Lake Diamond Project is the only proposed development that included calculations of $PM_{2.5}$ emissions in their application (the $PM_{2.5}$ emissions for the Lupin project were scaled from the Snap Lake emissions). In reality, the $PM_{2.5}$ particles (particles that are small enough to enter into deeply into the respiratory track) represent a subset of the TSP emissions released from all of the regional developments.

Table 12.4-17 Comparison of Project and Regional Emissions

Description	Snap Lake Diamond Project	CEA Case Emissions	Percentage of Regional CEA Emissions[(a)]
Sulphur dioxide emissions [tonnes per day, t/d]	0.175	2.181	8.0% of CEA emissions
Oxides of nitrogen emissions [t/d]	5.684	37.215	15.3% of CEA emissions
Acid forming compounds [t/d][(b)]	4.154	28.232	14.7% of CEA emissions
Total suspended particulate emissions [t/d]	0.554	53.248	1.0% of CEA emissions
Inhalable particles (PM_{10}) emissions [t/d]	0.213	3.610	5.9% of CEA emissions
Respirable particles ($PM_{2.5}$) emissions [t/d]	0.115	0.165	69.7% of CEA emissions[(c)]

(a) This column calculates the relative contribution of the Snap Lake Diamond Project to the regional CEA emissions.

(b) Acid forming compounds are the sum of the SO_2 and 70% of the NO_X emissions. This accounts for the slightly lower acid forming potential of NO_X emissions.

(c) Only the Snap Lake Diamond Project and the Lupin Project listed PM2.5 emissions. Although PM2.5 emissions represent a subset of the particulate emissions from the other regional projects, no emissions data were available from the relevant project applications.

Modelling was also used to predict ground level concentrations of air emissions

Although the relative magnitude of the emissions from the Snap Lake Diamond Project gives some indication of the cumulative impacts associated with the development and other approved or proposed projects in the region, the effects these emissions will have on ground level concentrations and acid deposition patterns are more direct indicators. To address this issue, regional concentrations of SO_2, NO_2, TSP, PM_{10}, and $PM_{2.5}$ and regional deposition patterns of PAI were predicted using the CALPUFF dispersion model. Where applicable, the modelling results were compared to NWT air quality standards or criteria available from other North American jurisdictions.

Summary of ground level predictions for change in emissions due to the Snap Lake project

Table 12.4-18 compares the ground level predictions associated with the Snap Lake Diamond Project (application case predictions) to the predictions resulting from the cumulative regional emissions (CEA case predictions). The predictions indicated the following:

- Over the entire RSA, the cumulative predictions for SO_2, $PM_{2.5}$, annual PM_{10} and 1-hour NO_2 were unchanged for the predicted concentrations resulting from the Snap Lake Diamond Project on its own. The predicted CEA case concentrations of TSP, 24-hour PM_{10}, 24-hour and annual NO_2 were slightly higher (<1.5%) than the concentrations predicted for the Snap Lake Diamond Project on its own.
- When the active mine area is excluded, only the CEA case predictions of the annual TSP, 1-hour NO_2 and annual NO_2 were higher than the concentrations resulting from the Snap Lake Diamond Project on its own.

Table 12.4-18 Comparison of Predicted Concentrations for the Application and CEA Case Modelling

Parameter	Maximum Predictions [µg/m³]		Comment
	Snap Lake Diamond Project[(a)]	CEA Case	
RSA Including Active Mine Area			
24-hour total suspended particulates (TSP)	270.5	274.0	1.3% increase
Annual TSP	101.8	102.3	0.5% increase
24-hour PM_{10}	120.7	120.8	0.1% increase
Annual PM_{10}	27.5	27.5	no change
24-hour $PM_{2.5}$	42.1	42.1	no change
Annual $PM_{2.5}$	8.1	8.1	no change
1-hour sulphur dioxide (SO_2)	245.0	245.0	no change
24-hour SO_2	129.5	129.5	no change
annual SO_2	11.6	11.6	no change
1-hour nitrogen dioxide (NO_2)	236.5	236.5	no change
24-hour NO_2	139.7	139.8	0.1% increase
Annual NO_2	88.8	88.9	0.1% increase
RSA Excluding Active Mine Area			
24-hour TSP	116.5	116.5	no change
Annual TSP	18.0	18.5	2.8% increase
24-hour inhalable particles (PM_{10})	45.2	45.2	no change
Annual PM_{10}	5.1	5.1	no change
24-hour respirable particles ($PM_{2.5}$)	16.1	16.1	no change
Annual $PM_{2.5}$	1.6	1.6	no change
1-hour SO_2	35.9	35.9	no change
24-hour SO_2	12.2	12.2	no change
annual SO_2	1.6	1.6	no change
1-hour NO_2	203.6	203.7	0.05% increase
24-hour NO_2	98.1	98.1	no change
Annual NO_2	27.3	27.5	0.7% increase

(a) The ground level concentrations associated with the Snap Lake Diamond Project alone have been referred to as the application case predictions.

(c) The ground level concentrations associated with the Snap Lake Diamond Project in combination with emissions from approved and planned developments in the region have been referred to as the CEA case predictions.

Predicted changes in potential acid input

Table 12.4-19 compares the PAI predictions associated with the Snap Lake Diamond Project (application case predictions) to the predictions resulting from the cumulative regional emissions (CEA case predictions). The predictions indicated the following:

- The maximum predicted 1-hour, 24-hour and annual ground-level SO_2 concentrations were well below the applicable NWT standards both outside and within the active mine area.
- There was a slight increase (<1%) in the maximum PAI predicted for the CEA case emissions compared to the emissions from the Snap Lake Diamond Project on its own.
- There were not differences between the areas predicted to be above 0.17, 0.25, 0.50 and 1.00 keq/ha/yr.

Table 12.4-19 Summary of Predictions for Criteria Air Compounds

Parameter	PAI Predictions		Comment
	Snap Lake Diamond Project	CEA Case	
RSA Including Active Mine Area			
Maximum PAI[(a)] [keq/ha/yr]	1.106	1.108	0.2% increase
Area with PAI greater than 0.17 keq/ha/yr [ha]	47	47	no change
Area with PAI greater than 0.25 keq/ha/yr [ha]	35	35	no change
Area with PAI greater than 0.50 keq/ha/yr [ha]	12	12	no change
Area with PAI greater than 1.00 keq/ha/yr [ha]	0	0	no change
RSA Excluding Active Mine Area			
Maximum PAI[(a)] [keq/ha/yr]	0.175	0.176	0.6% increase
Area with PAI greater than 0.17 keq/ha/yr [ha]	< 1	< 1	no change
Area with PAI greater than 0.25 keq/ha/yr [ha]	0	0	no change
Area with PAI greater than 0.50 keq/ha/yr [ha]	0	0	no change
Area with PAI greater than 1.00 keq/ha/yr [ha]	0	0	no change

(a) The potential acid input (PAI) predictions include a uniform background value of 0.040 kiloequivalents per hectare per year (keq/ha/yr).

12.4.4.3 Residual Impact Classification

Environmental consequence of predicted incremental changes to air quality from the Snap Lake project is summarized in Table 12.4-20

Despite measures incorporated into the Snap Lake Diamond Project, the project emissions after mitigation will result in changes to the ambient air quality. Evaluating the residual impacts from these changes incorporated the method described in Section 12.1.6.1. In general, the impacts are classified using the following criteria: direction, magnitude, geographic extent, duration, frequency, and reversibility. The methods outlined in

Table 12.1-3 describe the definitions used to classify direction, geographic extent, duration, frequency, and reversibility. Table 12.4-1 defines the magnitude of air quality impacts from the Snap Lake Diamond Project. The impact assessments of changes in the air quality of criteria compounds is presented in Table 12.4-20. The overall environmental consequences of the residual impacts, calculated according to the method described in 12.1.6.3, are also shown in Table 12.4-20.

Uncertainty in model predictions was minimized by a number of careful steps

The confidence level of the impact prediction is directly related to the measures used to reduce uncertainty. Uncertainty is related to natural variability (both spatial and temporal), model uncertainty, uncertainty of future emissions, measurement errors and data errors. Uncertainty due to natural variability has been reduced by using continuous data for more than one year from the meteorological station at Snap Lake. Uncertainty due to measurement and data errors was controlled by the use of appropriate equipment, calibration procedures, sampling protocols and quality assurance (QA) procedures. The QA of model inputs and outputs was undertaken to minimize errors that could lead to uncertainty in the model predictions.

There is a high level of confidence in the output from the air quality dispersion model

The evaluation of changes in acid deposition patterns depends on the use of air dispersion models to predict the deposition rates and patterns in the region. As with any form of prediction, there are uncertainties regarding the ability of models to predict the deposition values accurately. To minimize these uncertainties, an accepted dispersion model (*i.e.*, CALPUFF) was selected for the analysis. This model has been reviewed extensively in the United States to ensure that it provides realistic, but conservative, predictions. In addition, the CALPUFF model has been used extensively in northeastern Alberta (an area where the evaluation of the deposition of acid forming compounds has been a key issue for several years).

There is some degree of uncertainty associated with background estimates of potential acid input

One of the primary uncertainties with the evaluation of PAI relates to the background values used in the assessment. This assessment used a uniform background PAI of 0.040 keq/ha/yr. This value was determined from long-term precipitation monitoring at Snare Rapids, NWT. The ideal situation would be to calculate the background PAI from long-term monitoring at the Snap Lake site; however, such data are not available.

Low uncertainty implies a high level of confidence in predictions of environmental consequence

The efforts to reduce uncertainty result in a high confidence in the impact assessment. The conservative emission estimates and other assumptions intended to produce conservative predictions result in a high confidence that actual changes in air quality will be less than defined by the dispersion modelling predictions.

Table 12.4-20 Residual Impact Classification for Cumulative Air Quality Effects

Parameter	Direction[(a)]	Magnitude[(b)]	Geographic Extent[(a)]	Duration[(a)]	Frequency	Reversibility[(a)]	Environmental Consequence
1-hour sulphur dioxide (SO_2)	negative	negligible	local	medium-term	moderate	reversible (short-term)	negligible
24-hour SO_2	negative	negligible	local	medium-term	moderate	reversible (short-term)	negligible
Annual SO_2	negative	negligible	local	medium-term	high	reversible (short-term)	negligible
1-hour nitrogen dioxide (NO_2)	negative	low	local	medium-term	moderate	reversible (short-term)	low
24-hour NO_2	negative	low	local	medium-term	moderate	reversible (short-term)	low
Annual NO_2	negative	high	local	medium-term	high	reversible (short-term)	low
24-hour total suspended particulates (TSP)	negative	high	local	medium-term	moderate	reversible (short-term)	low
Annual TSP	negative	high	local	medium-term	high	reversible (short-term)	low
24-hour inhalable particles (PM_{10})	negative	moderate	local	medium-term	moderate	reversible (short-term)	low
Annual PM_{10}	negative	negligible	local	medium-term	high	reversible (short-term)	negligible
24-hour respirable particles ($PM_{2.5}$)	negative	negligible	local	medium-term	moderate	reversible (short-term)	negligible
Annual $PM_{2.5}$	negative	negligible	local	medium-term	high	reversible (short-term)	negligible
Potential Acid Input (PAI)	negative	low	local	medium-term	high	reversible (short-term)	low

(a) The methods used to classify direction, geographic extent, duration, and reversibility are described in Table 7.1-8. The duration definition includes timing.

(b) The methods used to classify magnitude are described in Table 7.1-9.

Note: The ecological resilience was not classified or used in determining the environmental consequence for air quality. Air is a pathway or route of exposure. The ecological resilience will be discussed when assessing the receiving environment.

12.5 NOISE

12.5.1 Introduction

12.5.1.1 Component Description and Organization

Environmental noise produced by the Snap Lake facility could combine with noise from other facilities

The Snap Lake Diamond Project will produce environmental noise during construction, operation, and closure of the facility. Environmental noise will affect the area around the project site, and also a corridor along the winter access road that will be used to supply material to the site (*i.e.*, within the RSA). Traffic from the Snap Lake Diamond Project along the Tibbitt-Contwoyto winter road will also contribute to noise along part of the road. This noise could potentially combine with noise from other industrial and recreational resource activities in the region to produce a cumulative effect on environmental noise.

The study area for noise is the regional study area and the Tibbitt-Contwoyto winter road

The study area for cumulative effects of environmental noise is the RSA of the Snap Lake Diamond Project and the segment of the Tibbitt-Contwoyto winter road extending from Yellowknife to the Snap Lake winter access road turnoff (Figure 12.5-1). The RSA includes the area within a circle with a 31 km radius from the site. The local noise impact assessment showed that noise originating from the site will be negligible at this distance and therefore will have no cumulative effect on environmental noise outside the RSA. The Tibbitt-Contwoyto winter road segment of the CEA study area includes a 30 km wide corridor along the route. The local noise impact assessment indicated that noise from truck traffic would be well below existing ambient noise beyond 15 km from the winter road and will therefore not contribute to any cumulative noise effects beyond this corridor width.

Section 12.5 includes the approach and methods, the impact assessment, and conclusions

The following sections describe the assessment approach, time period and the assessment methods for determining potential cumulative effects of noise on the environment. Section 12.5.2 identifies the major sources that will contribute to the cumulative effects of noise, provides predicted incremental increases in sound levels, and assesses and classifies the impact of the sound level increases from the Snap Lake Diamond Project. The effects on wildlife are addressed in Section 12.7.4.

Figure 12.5-1 Spatial Boundary for Assessing Cumulative Effects on Noise

12.5.1.1.1 Key Issues and Key Questions

There is one key question

The issues related to cumulative noise effects are impacts on wildlife, and on the human uses of natural resources including traditional land use and tourist facilities in the region. These noise issues have been consolidated in the following key question:

CN-1: What cumulative impacts will operation of the Snap Lake Diamond Project have on environmental noise?

12.5.1.1.2 Residual Impact Criteria

Criteria for assessing the residual impacts from projects or activities are described in detail in Section 12.1.6.1. Direction, duration, reversibility and frequency are defined in Table 12.1-4. Geographic extent is equivalent to that defined in Table 12.1-4, except the LSA for noise includes the mine footprint plus a 1.5 km buffer. Magnitude is defined as:

- negligible – no increase in sound levels;
- low – an increase in average sound level up to 5 A-weighted decibel levels (dBA);
- moderate – an increase in average sound level up to 10 dBA; and,
- high – an increase in average sound level greater than 10 dBA.

12.5.2 Cumulative Impact Assessment

12.5.2.1 Introduction

Key question

The cumulative impact assessment process involved the formulation of the following key question related to environmental noise.

Key Question CN-1: What cumulative impacts will operation of the Snap Lake Diamond Project have on environmental noise?

Linkages were assessed

The key question was used to develop cause and effect pathways or linkages. The following approach was used to assess the potential cumulative impacts on environmental noise:

- identifying linkages between noise from the Snap Lake Diamond Project, and noise from other projects and facilities in the region, and potentially affected communities, and tourist sites;

- determining if the linkages are valid;
- identifying noise sources contributing to cumulative effects;
- predicting sound levels for existing facility activities, predicting incremental sound level increases due to Snap Lake Diamond Project activities and identifying the extent of affected areas;
- analysis of residual impacts; and,
- classification of residual impacts.

12.5.2.1.1 Linkage Analysis

Cumulative noise effects are the combination of noise from Snap Lake Diamond Project and other existing and proposed industrial activities

The cumulative effects with respect to environmental noise are the effects of noise from construction and operation of the Snap Lake Diamond Project combined with potential noise from other existing and proposed industrial activities in the region. In Table 12.5-1 the closest existing and proposed projects and activities to the Snap Lake site are identified.

Table 12.5-1 Projects Considered as Linkages in the Cumulative Effects Assessment

Project	Project Phase	Distance from Snap Lake (km)
De Beers Snap Lake Diamond Project	permitting	--
EKATI™ Diamond Mine	operational	119
EKATI™ Diamond Mine Expansion	permitting	119
Diavik Diamond Mine	construction	102
Tahera Jericho Diamond Mine	permitting	268
Lupin Gold Mine	operational	242
Tibbitt-Contwoyto winter road	operational	22.5

There will be no cumulative effect with respect to noise from the Snap Lake site

As indicated in the table, the distances between the Snap Lake site and all other project sites are in excess of 100 km. Because of the large distances separating the sites, there will be no interaction between noise produced by the Snap Lake site and noise produced by the other sites. Therefore, there will be no cumulative effect with respect to noise from the Snap Lake site within the RSA. Thus, the linkage between Snap Lake Diamond Project and other existing and proposed projects (except part of the Tibbitt-Contwoyto winter road), and the change in environmental noise within the RSA is not valid.

Snap Lake truck traffic noise along part of the Tibbitt-Contwoyto winter road will cause a cumulative effect

There will be a cumulative effect with respect to truck traffic noise along part of the Tibbitt-Contwoyto winter road. This road is currently used by BHP and Diavik for their mine operation traffic, and a segment of this road will also be used by truck traffic accessing the Snap Lake site. The increased traffic volume from Yellowknife to the junction of Snap Lake winter access road will result in an increase in traffic noise. Therefore, the linkage between Snap Lake Diamond Project construction and operations, and the change in environmental noise along this section of the Tibbitt-Contwoyto winter road is valid.

Distances between the Snap Lake site and primary communities have been determined

In Table 12.5-2, the primary communities in the same region as the Snap Lake site are identified along with the approximate distances between Snap Lake and the communities.

No communities will be affected by noise from the site or the winter road

All the communities identified in Table 12.5-2 are well in excess of 100 km from the Snap Lake site and will not be affected by noise from the project. These communities are also more than 100 km from the Tibbitt-Contwoyto winter road, with the exception of Yellowknife, N'Dilo and Dettah which are approximately 50 km from the winter road. These distances are all too great for traffic noise from the winter road to have any cumulative effects on environmental noise for Yellowknife, N'Dilo and Dettah. Therefore, the linkage between cumulative noise impacts from the Snap Lake Diamond Project or the Tibbitt-Contwoyto winter road and communities is not valid.

Table 12.5-2 Primary Communities in the Region

Community	Distance from Snap Lake (km)
Lutsel K'e	130
Wekweti	182
Gameti	323
Wha Ti	350
Rae/Edzo	280
Yellowknife	220
N'Dilo	220
Dettah	216

Distances between tourist sites and the Snap Lake site and winter road have been determined

There are three tourist sites within the RSA of the Snap Lake Diamond Project that could potentially be affected by traffic noise from the Tibbitt-Contwoyto winter road. The identity, and distance and orientation of each of these sites relative to Snap Lake and the Tibbitt-Contwoyto winter road is presented in Table 12.5-3.

Table 12.5-3 Tourist Site Locations

Tourist Site	Distance and Orientation from Snap Lake Site	Distance and Orientation from Tibbitt-Contwoyto Winter Road [(a)]
MacKay Lake Lodge	28.5 km northeast	36 km northeast
Warburton Bay Lodge	30 km northwest	2.7 km southeast
Lac du Roche Camp	28.5 km southwest	34 km southeast

[(a)] Junction at Tibbitt-Contwoyto winter road and Snap Lake winter access road

Warburton Bay Lodge could potentially be affected by increases in traffic noise

Both the MacKay Lake Lodge and Warburton Bay Lodge are close enough to the Tibbitt-Contwoyto winter road to be affected by existing truck traffic noise. However, only the Warburton Bay Lodge is close enough to the Tibbitt-Contwoyto winter road segment between Yellowknife and the Snap Lake turnoff to be potentially affected by increases in traffic noise due to the Snap Lake Diamond Project (Table 12.5-3). Therefore the linkage between cumulative noise impact and the Warburton Bay Lodge is valid. The Lac du Roche Camp is also too far from the Tibbitt-Contwoyto/Snap Lake winter access road junction to be affected by truck traffic noise. As a result, the linkage between potential cumulative noise from the Snap Lake Diamond Project, and MacKay Lake Lodge, and Lac du Roche Camp is not valid.

Wildlife could potentially be affected by increases in traffic noise

Much of the area adjacent to the Tibbitt-Contwoyto winter road from Yellowknife to the junction of the Snap Lake winter access road consists of wildlife habitat. Wildlife in these areas may be affected by noise emissions from existing truck traffic on the winter road, and could also be potentially affected by increases in traffic noise from the Snap Lake Diamond Project along the route. Therefore, the linkage between cumulative noise impact and wildlife is valid, but cumulative impacts on wildlife will be assessed in Section 12.7.4.

12.5.2.1.2 Environmental Noise Descriptors

Environmental noise constantly varies over time

Environmental noise is typically not steady and continuous in nature but constantly varies over time. For environmental noise in the vicinity of an industrial facility, there is usually a steady background sound level that exists due to noise from the facility that is slowly varying because of changes in atmospheric and/or ground cover conditions, as well as changes in facility operating conditions. Along with the facility noise, there may also be periodic, short-term, higher level noise, typically associated with transportation sources in the vicinity of the site. Other sources of noise that are associated with the surrounding area may also occur.

The L_{eq} is the average sound level of time varying noise

To account for the time-varying nature of environmental noise, a single number known as the equivalent continuous sound level (L_{eq}) is used. This number quantifies sound that varies over time, such as that commonly occurring in outdoor environments. It is generally accepted and used for environmental noise measurements and criteria by acoustical experts (Beranek 1992) and government agencies (CMHC 1981; Environment Canada 1989; Nova Scotia Department of the Environment 1989; MOE 1978; Manitoba Department of Environment 1988; EUB 1999). L_{eq} is the average sound level (based on acoustical energy) of time-varying noise occurring over a specific time period. Time periods commonly used for L_{eq} measurements and criteria are day time (07:00 to 22:00 hrs), night time (22:00 to 07:00 hrs) and 24 hours. Shorter time periods of one hour or less may also be used.

Different time periods such as 5-minute, 1-hour, and 24-hour periods may be used depending on the type of noise

Day time, night time, and 24-hour time periods are typically used by government agencies (MOE 1978; Manitoba Department of Environment 1988; Environment Saskatchewan 1975; EUB 1999; CMHC 1981) for noise assessments in rural or urban areas that may also be affected by community and/or transportation noise sources. In these areas, ambient sound levels are typically greater during the day as a result of increased community and/or transportation activity. During the night, ambient sound levels are typically lower as a result of reduced activity. For a remote area such as the Snap Lake site, there would likely be little difference between ambient noise during day and night. Consequently, the 1-hour and 24-hour L_{eq} time periods are considered to be more appropriate descriptors for assessing the impact of noise from the Snap Lake Diamond Project. Moreover, the environmental noise effects of intermittent noise sources such as road and air traffic accessing the site, are typically quantified in terms of L_{eq} values for periods of 1 hour or 24 hours.

A-weighted sound levels account for human hearing ability

L_{eq} values for environmental noise are normally based on A-weighted sound levels expressed in units of decibels (dBA). The A-weighting accounts for the frequency content of the sound and assesses it with a frequency response similar to that of the human ear. Thus measurements and criteria for environmental noise are normally quantified in units of dBA L_{eq}.

12.5.2.1.3 Noise Impact Criteria

The Alberta Energy and Utilities Board is the only regulatory body that provides guidelines specifically for developments in remote locations

There are presently no environmental noise regulations or guidelines directly applicable to noise impact from the Snap Lake Diamond Project. Several jurisdictions in Canada, such as Nova Scotia (Nova Scotia Department of Environment 1989), Ontario (MOE 1978), Manitoba (Manitoba Department of the Environment 1988), Saskatchewan (Environment Saskatchewan 1975) and Alberta (EUB 1999), do have environmental noise regulations or guidelines; however, these documents are generally oriented towards the impact of environmental noise on permanent or seasonal dwellings. They are not generally applicable to environmental noise in remote locations, such as the proposed Snap Lake Diamond Project. One exception to this is the Alberta Energy and Utility Board (EUB) Interim Noise Control Directive ID 99-8, which includes a guideline to prevent uncontrolled noise generation in remote locations in the province of Alberta. This guideline recommends that new facilities planned for remote areas should be designed to meet a target sound level of 40 dBA L_{eq} at a distance of 1.5 km from the site.

Noise from facility operation will include both continuous noise from the site and short-term noise from vehicle and air traffic

As indicated in Section 8.1.5.1, the L_{eq} value is an average sound level that takes into account the variation of environmental noise over time. Noise variations are due to different types of noise sources and outdoor sound propagation conditions. Noise produced by sources associated with the Snap Lake site can be subdivided into two main types. These include steady, continuous noise, typically associated with the continuous operation of stationary equipment (*e.g.*, diesel generators, mine fans, and aggregate crushing equipment). This type of noise would be expected to emanate from most sources located on the site. The second type is short-term, intermittent noise, typically associated with the effects of vehicles on the winter access road and air traffic accessing the site. Table 12.5-4 identifies typical sound levels associated with common sources of these two types of noise (Harris 1979).

Table 12.5-4 Typical Sound Levels of Common Noises

Description	Type of Noise	Sound Level (dBA) [(a)]
Rural area – background noise	continuous	30 -35
Small town residential – background noise	continuous	35 - 40
Snowmobile at 15 m	intermittent	75 (peak)
Snowmobile at 1 km	intermittent	50 (peak)
Truck at 15 m	intermittent	85 (peak)
Truck at 1 km	intermittent	60 (peak)

[(a)] dBA = A-weighted decibel level.

Sound levels (dBA) in Table 12.5-1 can be compared to the human perception of sound

The values in Table 12.5-4 may be compared with the predicted sound level values for noise from facility activity, in order to obtain a subjective impression of the cumulative noise impact. When comparing sound level values, the following general rule may be used:

- a difference in sound level of less than 3 dBA is barely perceptible to the human ear;
- a difference of 5 dBA is noticeable;
- a difference of 10 dBA corresponds to a halving or doubling in perceived loudness; and,
- a 20 dBA difference corresponds to a four-fold difference in perceived loudness.

12.5.2.1.4 Sound Attenuation

Various sound attenuation mechanisms affect outdoor sound propagation

Outdoor sound propagation between a noise source and a receptor (*i.e.*, a person listening) is affected by several sound attenuation mechanisms. These include the following:

- distance dissipation: sound naturally decreases with increasing distance from the source;
- ground attenuation: sound is absorbed by the ground that it passes over;
- atmospheric absorption: sound is absorbed by the atmosphere it passes through;
- barrier attenuation: sound can be blocked by physical barriers (*e.g.*, buildings or hills);
- sound is affected by wind conditions (*i.e.*, a distant noise source will be louder under downwind conditions than it will be under calm conditions; conversely, a distant source will be quieter under upwind conditions than it will be under calm conditions); and,
- sound is affected by temperature conditions in the atmosphere (*i.e.*, a distant noise source will be louder under atmospheric inversion conditions than it will be under neutral atmospheric conditions).

Temperature and relative humidity affect sound

Temperature and relative humidity have effects on some of the variables mentioned; however, they do not have specific sound attenuation mechanisms associated with them.

To be conservative, this assessment assumed low ground attenuation values

Ground cover conditions in the study area may include boggy soil (high ground attenuation values) and exposed rock and open water (low ground attenuation values). Winter ground cover conditions may range from soft, fresh snow (high ground attenuation values) to hard or crusty snow (low ground attenuation values). To be conservative, this noise assessment assumed that low ground attenuation values associated with exposed rock, open water, and hard or crusty snow would be most typical for the study area. This corresponds to the ground cover condition associated with the worst case for facility and traffic noise.

Sound levels differ when a location is upwind or downwind from a noise source, but this effect cancels out when winds shift direction over time

The effects of wind gradients on outdoor sound propagation can cause variations in sound levels at a distance from an operating facility. Under upwind conditions, the wind will cause greater than normal outdoor sound attenuation to occur. This would result in lower sound levels upwind of the facility than would normally occur under calm conditions. However, under downwind conditions, the opposite effect will occur, resulting in higher than normal sound levels. Crosswinds do not have these effects and result in sound levels that are essentially the same as those for calm conditions. If the effects of downwind and upwind sound propagation are averaged over the long term, there would typically be as many times that facility noise would get louder due to downwind conditions as it would get quieter due to upwind conditions. Averaged over time, the expectation is that the sound propagation effects for downwind and upwind conditions would cancel each other, resulting in a net sound propagation effect equivalent to calm conditions.

12.5.2.1.5 Sound Levels Predictions

Noise predictions were calculated by computer modelling

Sound level predictions of noise emissions for operation of the facility were calculated using the SoundPLAN Outdoor Noise Prediction computer program. SoundPLAN is one of the most sophisticated computer noise prediction programs currently available in the world. The calculation procedures used by the program are from international research and standards specific to industrial noise and outdoor sound propagation (CONCAWE 1981; Danish Acoustical Laboratory 1982; ISO 1992). The calculation procedure for the Snap Lake facility used the acoustical formula specified in CONCAWE (1981). This procedure was selected for the sound level predictions because it is specifically applicable to the environmental noise effects of industrial facilities like the Snap Lake Diamond Project.

The computer model predicted noise from all primary noise sources

The computer model calculated predicted sound levels of facility related noise throughout the study area. The model included the effects of noise emissions from stationary and mobile equipment at the mine site, as well as the effects of road and air traffic.

Attenuation and dissipation of outdoor sound were included in the predictions

The following outdoor sound propagation effects were included in the computer model calculation of predicted sound levels:

- distance dissipation;
- ground attenuation;

- atmospheric absorption; and,
- barrier attenuation.

Winter weather conditions were used

Weather parameters and ground attenuation values typical of early or late winter weather conditions were used in the computer model, since these would be the most commonly occurring weather conditions in the region.

12.5.2.2 Cumulative Impact Analysis

Snap Lake site traffic will increase the amount of truck traffic noise along the Tibbitt-Contwoyto winter road

The segment of the Tibbitt-Contwoyto winter road extending from Yellowknife to the Snap Lake winter road turnoff is currently affected by noise from trucks accessing the existing mine sites in the region during the winter road season. The Snap Lake site traffic will increase the amount of truck traffic noise along this segment, although the traffic noise sources will be the same.

Predicted incremental increases in noise due to Snap Lake site traffic were calculated

The winter road season occurs annually for about 11 weeks, during which truck traffic continuously uses the route. The estimated peak number of loaded trucks travelling along the route is approximately 10,000 per year (including 2,800 for Snap Lake). This is equivalent to about 10.6 trucks per hour (loaded and unloaded) along the road during the season. This information was used to predict 24 hour L_{eq} sound levels for the existing truck traffic along the route, as well as sound levels for the increased truck traffic resulting from operation of the Snap Lake site. Predicted sound levels for truck traffic noise at various distances from the winter road route are provided in Table 12.5-5, along with the predicted incremental increase in noise due to Snap Lake site traffic.

Table 12.5-5 Predicted Sound Levels for Truck Traffic At Various Distances from the Tibbitt-Contwoyto Winter Road

Distance from Road	Predicted Sound Level (dBA L_{eq})[a]		
	Existing Traffic	Existing and Snap Lake Traffic	Incremental Increase
750 m	31.5	33.2	1.7
1.5 km	22.3	24.0	1.7
3 km	11.5	13.1	1.6

[a] dBA = A-weighted decibel level for equivalent continuous sound level.

Predicted sound level values are for the contributions of truck traffic noise only

The values appearing in Table 12.5-5 are for the contributions of truck traffic noise only. They do not include the effects of the existing ambient sound environment.

Traffic noise is predicted to increase by less than 2 dBA L_{eq} as a result of the additional truck traffic

The results in Table 12.5-5 indicate a predicted increase in traffic noise of less than 2 dBA L_{eq} as a result of the additional Snap Lake truck traffic. This sound level increase, which is effectively the increase in average noise produced by the traffic, is too small to be perceptible to humans, although the increase in the number of vehicles per hour on the route may be noticeable.

Truck traffic noise may be audible up to approximately 10 kilometres from the winter road

The existing truck traffic noise and the incremental noise associated with Snap Lake truck traffic may be audible during calm weather conditions at distances of approximately 10 km from the roadway. However, the cumulative average traffic noise contribution at 3 km from the route will be less than typical ambient noise when the winter road is closed.

The only tourist site affected will be the Warburton Bay Lodge

The predicted increase in truck traffic noise will affect the Warburton Bay Lodge, because the segment of the winter road near this location will be used by Snap Lake truck traffic. There will be no cumulative noise impact effects at the MacKay Lake Lodge. Although the MacKay Lake Lodge is within 3 km of the winter road, it is approximately 35 km from the closest segment that will be used by Snap Lake truck traffic and this distance is too great for any cumulative noise effects with respect to the Snap Lake traffic.

12.5.2.3 Residual Impact Classification

The magnitude of the impact will be low

The direction of the cumulative impact of traffic noise on the Tibbitt-Contwoyto winter road will be negative, although the magnitude of the impact will be low (Table 12.5-6). The extent of the cumulative traffic noise impact will be beyond regional, but confined to a 20 km wide corridor along the winter road route. This corridor corresponds to the zone within which both existing and Snap Lake truck traffic would be audible. The duration of the impact will be medium-term, extending throughout the operational life of the project. The cumulative impact is reversible in the short-term because the incremental traffic noise contributions will cease when the Snap Lake traffic is terminated at the end of each operational season. The frequency of the impact will be moderate, occurring annually during the winter months for several weeks, although during that period the impact will be frequent. The overall environmental consequence of the cumulative effect of noise is anticipated to be low.

Probability of occurrence and confidence level are high

The probability of occurrence is high because the predicted noise effects are based on winter road traffic that would be required as part of the proposed project and on existing winter road traffic which is required for the other project sites. The confidence in the predicted sound level values is high because the predictions are based on published noise data (Harris 1979), and current prediction methods (Barry and Reagan 1978) for road traffic noise.

Table 12.5-6 Residual Impact Classification for Cumulative Effects of Noise from the Snap Lake Diamond Project during the Operation Phase

Source	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Road traffic	negative	low	beyond regional	medium-term	reversible (short-term)	moderate	low

12.6 AQUATIC RESOURCES

12.6.1 Introduction

12.6.1.1 Component Description and Organization

Local impacts were identified for the Snap Lake project

The Snap Lake Diamond Project will have localized effects on surface and subsurface water levels, quality and quantity, water flow regimes, and fish habitat and populations. These effects may combine with effects from other projects in the SGP and potentially alter flow rates, water balance, water quality and fish populations in adjacent lakes, rivers and streams.

Fugitive dust and increased access are factors that may contribute to cumulative effects

In addition, analysis identified two factors that could contribute the cumulative effects on fish and fish habitat related directly to the Snap Lake Diamond Project. Fugitive dust from the Snap Lake Diamond Project and other mines outside the RSA could affect fish health, habitat and abundance within the Lockhart drainage basin. Also, increased access to Snap Lake via the Snap Lake winter access road could lead to increased fishing pressure thereby affecting fish abundance.

The aquatic resource section is divided into four subsections

To assess the potential cumulative effects of the Snap Lake Diamond Project on these water resource issues, the aquatic resources section has been divided into the following four subsections:

- hydrogeology;
- hydrology;
- water quality; and,
- fish and fish habitat.

The study area for water components is the Lockhart River watershed

The spatial boundary for hydrogeology, hydrology, water quality, fish and fish habitat was based on hydrologic and terrain studies. Results indicated that Snap Lake is located in the Lockhart River drainage basin. Water from Snap Lake drains into MacKay Lake which eventually drains into the East Arm of Great Slave Lake (at Reliance) via Aylmer Lake, Clinton-Colden Lake and Artillery Lake (Figure 12.6-1). Based on this information, the spatial boundary for CEA for aquatic resources included the lakes, rivers and streams of the Lockhart River watershed.

12.6.1.1.1 Key Issues and Key Questions

Seven key questions were developed to address the issues

The issues related to the cumulative effect of the Snap Lake Diamond Project on aquatic resource components were placed into the following key questions:

CHG-1: What cumulative impact will the underground mine for the Snap Lake Diamond Project have on groundwater quantity and groundwater levels?

CHG-2: What cumulative impact will the underground mine for the Snap Lake Diamond Project have on groundwater quality?

CHG-3: What cumulative impact will the surface facilities for the Snap Lake Diamond Project have on groundwater quantity and groundwater levels?

CHG-4: What cumulative impact will the surface facilities for the Snap Lake Diamond Project have on groundwater quality?

CH-1: What cumulative impact will the Snap Lake Diamond Project have on near-surface water tables and flows, and water levels in receiving streams, lakes, and wetlands?

CH-2: What cumulative impact will the Snap Lake Diamond Project have on sediment yields, and sediment concentrations in receiving streams, lakes and wetlands?

CA-1: What cumulative impacts will the Snap Lake Diamond Project have on water quality?

CAO-1: What cumulative impacts will the Snap Lake Diamond Project have on fish and fish habitat?

Figure 12.6-1 Spatial Boundary for Assessing Cumulative Effects on Aquatic Resources

12.6.1.1.2 Residual Impact Criteria

Impact criteria are defined in Table 12.1-4, 12.6-1, and 12.6-2

Criteria for assessing the residual impacts from projects or activities are described in detail in Section 12.1.6.1. Direction, geographic extent, duration, reversibility and frequency are defined in Table 12.1-4. Table 12.6-1 defines magnitude for hydrology and water quality, while Table 12.6-2 defines magnitude for fish and fish habitat. Because hydrogeology is a pathway to changes in water flow, water quality, and fish and fish habitat, environmental consequence is not assessed for hydrogeology (Section 9.2). Therefore, magnitude is not classified as negligible to high, but rather as a continuum of proportional change (Section 9.2).

Table 12.6-1 Definitions of Magnitude for Hydrology and Water Quality for Cumulative Effects Assessment

Magnitude	Aquatic Resource Component	
	Hydrology - Stream Flow	Water Quality[(a)]
No effect	percent change is less than 1%	cumulative effects result in no measurable change in predicted water quality over project changes
Negligible	percent change is 1-5%	cumulative effects result in no exceedance of water quality guidelines or HC_5 site-specific benchmarks
Low	percent change is between 5 and 10%	cumulative effects result in no exceedance of water quality guidelines or HC_{10} site-specific benchmarks
Moderate	percent change is between 10 and 20%	cumulative effects result in no exceedance of water quality guidelines or HC_{20} site-specific benchmarks
High	percent change is greater than 20%	cumulative effects exceed water quality guidelines or HC_{20} site-specific benchmarks

(a) Guidelines without water quality guidelines or site-specific guidelines (*e.g.*, total dissolved solids (TDS) and phosphorous) were considered on a parameter-specific basis, were relevant to an impact pathway.

Table 12.6-2 Impact Magnitude Definitions for Aquatic Organisms and Habitat

Element	Negligible	Low	Moderate	High
Sedimentation of habitat	< 1 mm deposition annual on spawning habitat	n/a[(a)]	n/a[(a)]	> 1 mm deposition annually on spawning habitat
Population abundance	no detectable change from baseline conditions	exceeds the average value for baseline conditions, but within the range of natural variation and well below a guideline or threshold value	exceeds the average value for baseline conditions, approaches the limits of natural variation, but below or equal to a guideline or threshold value	predicted to exceed baseline conditions or a guideline or threshold value so that there will be a detectable change beyond the range of natural variation (*i.e.*, change of state from baseline conditions).

(a) Low and moderate definitions for sedimentation of habitat are not applicable because of the definitions for negligible and high.

12.6.2 Hydrogeology

12.6.2.1 Cumulative Impact Assessment

12.6.2.2 Key Question CHG-1: What Cumulative Impact Will the Underground Mine for the Snap Lake Diamond Project Have on Groundwater Quantity and Groundwater Levels?

12.6.2.2.1 Linkage Analysis

Effects are limited to the Lockhart River drainage basin

The underground mine will not change the groundwater level or quantity of the shallow groundwater located in the active layer above the permafrost (Section 9.2.2). However, the development of the mine beneath Snap Lake will result in groundwater beneath the permafrost and within the taliks of nearby lakes (deep groundwater) being induced to flow downwards into the mine. This will lower the groundwater levels within the bedrock in the vicinity of the mine. The decline in water level, however, is expected to be limited to the vicinity of Snap Lake and within the Lockhart River drainage basin.

There is no linkage to cumulative effects on groundwater quantity and levels from the mine

Thus, the linkage analysis indicates that effects from the project are limited to Snap Lake and an adjacent watershed which also drains into the Lockhart River drainage system. This drainage system is not connected to the Lac de Gras-Coppermine River system. Therefore, there is no valid linkage and no further assessment is required.

12.6.2.3 Key Question CHG-2: What Cumulative Impact Will the Underground Mine for the Snap Lake Diamond Project Have on Groundwater Quality?

12.6.2.3.1 Linkage Analysis

The quality of deep groundwater flowing towards the mine will be unaffected

Groundwater inflow to the underground mine will be collected in trenches and sumps located underground and then pumped to a treatment plant on surface. This water will be discharged to Snap Lake following treatment. During construction, operation and closure, deep groundwater flow (*i.e.*, groundwater beneath the permafrost or within the talik beneath Snap Lake) will be induced to flow towards the mine, and groundwater quality in the deep groundwater will be unaffected (Section 9.2.2).

Effects are limited to the Lockhart River drainage basin

Mine panels will be backfilled immediately after mining. The backfill will be placed as a slurry at very near saturation. During closure, the underground mine will be allowed to flood. Groundwater flowing into the mine will come in contact with such materials as backfill, explosive residue, grout, and crushed rock that may alter the groundwater chemistry (Section 9.2.2). At post-closure, when pre-project flow conditions are re-established, this groundwater, which has been altered by mining, will migrate in a north direction from Snap Lake to the North and Northeast lakes. Although the underground mine during post-closure will affect the deep groundwater quality, these effects will be limited to areas within the Lockhart River drainage basin.

There is no linkage to cumulative effects on groundwater quality from the mine

Thus, the linkage analysis indicates that effects from the project are limited to Snap Lake and an adjacent watershed which also drains into the Lockhart River drainage system. This drainage system is not connected to the Lac de Gras-Coppermine River system. Therefore, there is no valid linkage and no further assessment is required.

12.6.2.4 Key Question CHG-3: What Cumulative Impact Will the Surface Facilities for the Snap Lake Diamond Project Have on Groundwater Quantity and Groundwater Levels?

12.6.2.4.1 Linkage Analysis

Effect on groundwater quantity and level from surface facilities is limited to the Lockhart River drainage basin

Surface facilities are expected to have a small amount of change on the groundwater quantity and levels in the shallow active layer on the northern peninsula (Section 9.2.2). However, these effects will be limited to the vicinity of the mine and entirely contained within the Lockhart River drainage basin. In addition, surface facilities are expected to have no impact on the groundwater quantity and levels in the deep groundwater flow regime (beneath the permafrost and within the taliks of the lakes) because of the presence of low permeable permafrost (Section 9.2.2).

There is no linkage to cumulative effects on groundwater quantity and level from surface facilities

Thus, the linkage analysis indicates that the effects from the project on groundwater quantity and level in the active shallow layer are limited to Snap Lake and an adjacent watershed which also drains into the Lockhart River drainage system. This drainage system is not connected to the Lac de Gras-Coppermine River system. Therefore, there is no valid linkage and no further assessment is required.

12.6.2.5 Key Question CHG-4: What Cumulative Impact Will the Surface Facilities for the Snap Lake Diamond Project Have on Groundwater Quality?

12.6.2.5.1 Linkage Analysis

Effect on groundwater quality from surface facilities is limited to the Lockhart River drainage basin

Surface facilities are expected to have a small amount of change on the quality of the groundwater within the shallow flow system in the active layer (Section 9.2.2). These effects will be limited to the vicinity of the mine and within the Lockhart River drainage basin. Surface facilities are not expected to affect the chemistry of the deep groundwater located beneath the permafrost (Section 9.2.2).

There is no linkage to cumulative effects on groundwater quality from surface facilities

Thus, the linkage analysis indicates that effect from the project on groundwater quality in the active shallow layer are limited to Snap Lake and an adjacent watershed which also drains into the Lockhart River drainage system. This drainage system is not connected to the Lac de Gras-Coppermine River system. Therefore, there is no valid linkage and no further assessment is required.

12.6.3 Hydrology

12.6.3.1 Cumulative Impact Assessment

12.6.3.2 Key Question CH-1: What Cumulative Impact Will the Snap Lake Diamond Project Have on Near-surface Water Tables and Flows, and Water Levels in Receiving Streams, Lakes, and Wetlands?

12.6.3.2.1 Linkage Analysis

Water level in Snap Lake are expected to increase slightly

While the release of treated waters, largely derived from mine dewatering, is expected to slightly increase water elevations in Snap Lake, no measurable changes are expected at downstream locations (Section 9.3.2). The next major waterbody downstream of the Snap Lake drainage is Lac Capot Blanc, which drains an area of 357 square kilometres (km^2). The Snap Lake drainage area (67.5 km^2) occupies approximately 19% of the Lac Capot Blanc drainage.

Changes in surface water hydrology will have no measureable effect on downstream locations

Given the small changes predicted for Snap Lake water elevations and outflow, and the relatively minor influence which the Snap Lake drainage has on Lake Capot Blanc outflow, the effect of mining operations downstream of the Snap Lake drainage would not be measurable. Similarly, potential effects are further reduced along the flowpath leading to MacKay Lake as numerous tributaries contribute flows from an area of 1,397 km^2.

Water level in the north lake may be reduced by 3 cm, but is within the range of natural variation

Small groundwater inflows to the north lake are sourced from Snap Lake. During operations, this inflow will be reduced, as mine dewatering will intercept some of this outflow. Estimates indicate that near the end of mining, the water elevation in the north lake may be reduced by up to 3 centimetres (cm). This amount is well within the range of natural fluctuation and would be further reduced at downstream locations (Section 9.3.2).

There is no linkage to cumulative effects on surface water hydrology from the Snap Lake project

Thus, the linkage analysis indicates that effects on surface water hydrology from the project are limited to Snap Lake and an adjacent watershed which also drains into the Lockhart River drainage system. This drainage system is not connected to the Lac de Gras-Coppermine River system. Therefore, there is no valid linkage and no further assessment is required.

12.6.3.3 Key Question CH-2: What Cumulative Impact Will the Snap Lake Diamond Project Have on Sediment Yields, and Sediment Concentrations in Receiving Streams, Lakes and Wetlands?

12.6.3.3.1 Linkage Analysis

Most total suspended solids will be captured in small ponds and wetlands before entering Snap Lake

Although runoff from the disturbed area near site facilities and storage areas will contain elevated concentrations of total suspended solids (TSS), runoff will pass through several ponded areas where suspended material will settle prior to transfer to the water treatment plant. Runoff from roads leading to the emulsion plant may also contain elevated TSS though it is expected that suspended particles will settle in numerous ponds and wetland areas prior to draining into Snap Lake (Section 9.3.2).

There is no linkage to cumulative effects on sedimentation levels from the Snap Lake Diamond Project

As the project is not expected to increase TSS levels in Snap Lake, no measurable changes are expected at locations downstream of Snap Lake or outside the Lockhart River drainage system. Therefore, the linkage is not considered valid and no further assessment is required.

12.6.4 Water Quality

12.6.4.1 Cumulative Impact Assessment

12.6.4.2 Key Question CA-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on Water Quality?

12.6.4.2.1 Linkage Analysis

Local impacts on water quality due to the Snap Lake project are provided in Section 9.4

The EA for the Snap Lake Diamond Project evaluated the local impacts of the project on water quality in the LSA (*i.e.*, near Snap Lake), and in the RSA (*i.e.*, Lockhart River watershed downstream of Snap Lake). The assessment considered all relevant project pathways, including the impact of water releases on surface water bodies and the impact of air emissions on acidification of lakes and streams. Potential cumulative effects pathways by which the project, in combination with other regional or global activities, could affect water quality are addressed below.

There is no valid linkage for cumulative impacts associated with water releases from the Snap Lake Diamond Project for water quality

The predicted impacts associated with water releases from the Snap Lake Diamond Project were restricted to the LSA. There are no other existing or planned activities in the LSA that could impact water quality. Similarly, there are no other existing or planned activities within the RSA that could impact water quality. Therefore, there are no valid linkage for cumulative effects of water releases on water quality, and no further assessment was required.

The linkage between regional air quality and cumulative impacts on water quality in the Lockhart watershed is not valid

The air quality cumulative impact assessment (Section 12.4) determined that there are no planned activities that could interact with air emissions from the Snap Lake Diamond Project. Therefore, there is no valid linkage for air emission to have a cumulative effect on water quality and no further assessment was required.

The linkage between persistent organic pollutants and cumulative impacts on water quality in the Lockhart watershed is not valid

The global release and transport and accumulation of persistent organic pollutants (POPs) is a phenomenon that occurs on a global scale. This potential issue was raised during regulatory discussions; however, there are no effects associated with the Snap Lake Diamond Project that could interact with the accumulation of POPs within the Lockhart River watershed. Furthermore, the Snap Lake Diamond Project is not expected to release any POPs and would not contribute to this global phenomenon. Therefore, there are no valid linkages for cumulative impacts of POPs and the Snap Lake Diamond Project, and no further assessment was required.

The linkage between global climate changes and cumulative impacts on water quality in the Lockhart watershed is not valid

Global climate change and potential influences on the Snap Lake Diamond Project are discussed in the Decommissioning and Reclamation Plan

(Appendix III.11). It was noted in Appendix III.11 that general circulation models are used to predict possible global warming scenarios and that, although the models agree on a global scale, they are less consistent for regional predictions. Based on the predictions that Arctic mainland temperatures may increase by 5°C, it is possible that permafrost thawing during the summer may deepen to greater than 16 m from current depths of 8 m. This could potentially increase the infiltration of water into the north pile and subsequent seepage of water into Snap Lake. The mine site water quality model predicted releases from the north pile based on mass loadings (Appendix III.2) and, therefore, increased flows would not result in an appreciable increase in predicted loadings from the north pile to Snap Lake. Therefore, there are no valid linkages for cumulative impacts of global climate change and the Snap Lake Diamond Project, and no further assessment was required.

12.6.5 Fish and Fish Habitat

12.6.5.1 Cumulative Impact Assessment

12.6.5.2 Key Question CAO-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on Fish and Fish Habitat?

12.6.5.2.1 Linkage Analysis

Linkages to fugitive dust and increased access were assessed

The potential linkage between activities associated with projects and cumulative effects on aquatic organisms and habitat was analyzed for fugitive dust and increased access.

Change in Abundance and Habitat Loss Due to Fugitive Dust

Fugitive dust is generated by many sources

Fugitive dust released from projects within and outside the RSA could potentially have an effect on Snap Lake area fisheries abundance, fish health and habitat. Mining activities can result in the release of dust from a number of activities including: extraction, crushing and quarrying, combustion emissions and road use. However, dust generated by operation of the Snap Lake Diamond Project is predominantly limited to the project site (Section 12.4).

The deposition of dust can lead to an accumulation of sediment in areas of fish habitat

Studies have shown that sediment accumulation on incubating whitefish eggs can decrease survivorship by physically limiting the exchange of oxygen and metabolic wastes with the water column (Fudge and Bodaly 1984). The minimum threshold for egg survivorship has been currently identified at 1 millimetre per year (mm/yr), levels above this have been observed to reduce egg survival.

The impact assessment for the project indicated no large accumulations of fugitive dust on fish habitat

Predicted annual dust deposition rates within Snap Lake are < 1 mm per year immediately adjacent to the mine and diminish with distance from the mine. As discussed in Section 9.5.2.3, these are below the threshold for affect on fish egg survivorship. When analyzed for total accumulation, the average annual accumulation for sites around the northeast peninsula and areas within Snap Lake is 0.00289 mm/yr. As described in the Section 7.3, the annual TSP deposition is expected to be 101.8 $\mu g/m^3$ across the RSA. When the area of the active mine site (limited to the northeast peninsula) is eliminated from the TSP calculations, the deposition is predicted to be 18.0 µg/m3. The criteria for acceptable limits annually are 60 µg/m3 in the NWT Section (Section 7.3.4.2, Table 7.3-23).

Results from the Air Quality Cumulative Effects Section 12.4 indicate that incremental effects on fish habitat will be negligible

Results from the air quality CEA (Section 12.4) indicate that the effects of Snap Lake Diamond Project in association with other active and proposed projects in proximity to Snap Lake will have little or no effect on cumulative fugitive dust deposition on fish habitat in Snap Lake. For example, the Snap Lake project will increase the annual TSP accumulation from 18.0 to 18.5 $\mu g/m^3$, which is an increase of 2.8% (Table 12.4-18; Section 12.4.4).

Deposition rates for fugitive dust in Snap Lake remain well below the 1 mm/yr accumulation threshold for an impact to fish egg survival

Table 12.6-3 outlines predicted TSP accumulation for areas in Snap Lake based on the air quality CEA model. In addition, dustfall (deposition in mm/yr) at the locations around Snap Lake depicted in Tables 9.5-30 and 9.5-31 for the local impact assessment were calculated using the CEA scenario. Under this scenario, deposition ranged from 0.00031 to 0.00816 mm/yr around the perimeter of the northeast peninsula and 0.00025 to 0.00093 mm/yr over the various lake trout spawning beds. As with the local impact assessment, the CEA scenario results are well below the 1 mm/yr threshold for fish egg survival.

Fugitive dust is not considered a valid pathway

Based on the above information, potential cumulative effects on fish habitat and fish abundance as a result of fugitive dust was not considered a valid pathway. Therefore, no further analysis is required.

Change in Abundance Due to Increased Access

The Snap Lake access road provides limited increased access for a limited period of time annually

The Snap Lake (winter) access road was considered to potentially have an effect on fish by increasing access to the upper reaches of the watershed. The Snap Lake access road is located 325 km, or a 13-hour drive, from Yellowknife, and exits at km 222 of the Tibbitt-Contwoyto winter road.

The average historical annual operating period of the Tibbitt-Contwoyto winter road is 67 days.

Table 12.6-3 Cumulative Effects Assessment for Fugitive Dust (TSP) Accumulation Along the Northeast Peninsula and Spawning Beds in Snap Lake

Northeast Peninsula Shoreline					
Point	**Easting (UTM)**	**Northing (UTM)**	**TSP Deposition Rate [kg/m²/yr][(a)]**	**TSP Density [kg/m³]**	**Dustfall [mm/yr]**
1	506531	7052196	0.00533	1220	0.004368
2	506910.2	7052517	0.00995	1220	0.008156
3	507003.4	7052961	0.00948	1220	0.007768
4	507109.1	7053378	0.00478	1220	0.003916
5	506674.8	7053426	0.00686	1220	0.005626
6	506252.2	7053191	0.01088	1220	0.008915
7	505789.3	7053027	0.00473	1220	0.00388
8	505411.9	7053084	0.00296	1220	0.002429
9	505131.3	7053361	0.00197	1220	0.001613
10	504781.9	7053104	0.00176	1220	0.001444
11	504334.7	7053070	0.00129	1220	0.001056
12	503904.3	7053117	0.00096	1220	0.000784
13	503426.4	7053084	0.00074	1220	0.000603
14	502949	7052937	0.00058	1220	0.000479
15	502489.8	7052853	0.00048	1220	0.00039
16	502571.4	7053079	0.00049	1220	0.0004
17	502266.5	7052793	0.00044	1220	0.000357
18	501854.7	7052661	0.00037	1220	0.000306
Spawning Beds					
Spawning Bed Centre	**Easting (UTM)**	**Northing (UTM)**	**TSP Deposition Rate [kg/m²/yr]**	**TSP Density [kg/m³]**	**Dustfall [mm/yr]**
1	508471.9	7053355	0.00093	1220	0.000761
2	508055.4	7052735	0.00113	1220	0.000926
3	508609.1	7052573	0.00076	1220	0.000625
4	510096.2	7052330	0.00036	1220	0.000295
5	510521.8	7052133	0.00031	1220	0.000252
6	508916	7052138	0.00068	1220	0.000557
7	510275.7	7051539	0.00037	1220	0.000301
8	509239.5	7051191	0.00062	1220	0.000512
9	508117.1	7050789	0.00085	1220	0.000693
10	508843.4	7050330	0.00056	1220	0.000459
11	508363.9	7050114	0.00059	1220	0.000487

(a) kg/m²/yr = kilogram per square metre per year.

Recent information on traditional land use in the Snap Lake regional study area by Aboriginal groups indicate that the area is not extensively used for fishing activities in winter or summer

Recent information on traditional land use in the Snap Lake RSA by Aboriginal groups indicate that the area is not extensively used for fishing activities in winter or summer. The Dogrib communities and the Yellowknives Dene First Nation have not identified the RSA as a fishing area (Section 6.3.1.2). The North Slave Métis Alliance indicated that they did have important fishing areas on MacKay Lake, the Snap Lake access road will not increase their use of MacKay Lake for fishing. The Lutsel K'e Dene First Nation stated that little fishing occurs in the area they refer to as the Na Yaghe Kue region (Lutsel K'e Dene First Nation 2001).

Recreational fishers have not used the access road and there is no commercial fishing

Over the two years of operation of the Snap Lake access road, no recreational vehicles have been observed using the road for access (Section 6.4). Presently there are no commercial fisheries located in the Lockhart River drainage basin.

Increased access was determined to be a non-valid linkage to a cumulative impact on abundance

Overall, increased access to the RSA created by the Snap Lake access road was not considered a valid pathway for a cumulative effect on fish abundance through traditional, recreational, or commercial fishing activities. Therefore, no further analysis is required.

12.7 TERRESTRIAL RESOURCES

12.7.1 Introduction

12.7.1.1 Component Description and Organization

The Snap Lake Diamond Project will have localized effects on geology, vegetation (ecological landscape classification; ELC), terrain, biodiversity, and wildlife and wildlife habitat. These effects may combine with effects from other projects in the SGP and potentially alter these components of the ecosystem. To assess the potential cumulative effects of the Snap Lake Diamond Project on terrestrial resources, this section has been divided into the following three subsections:

- geology;
- ELC, terrain and biodiversity; and,
- wildlife and wildlife habitat.

Each subsection includes a number of components

The geology subsection assesses the information on permafrost and ground thermal regime. Soils, terrain and vegetation are included in the ELC. The

ELC approach captures the close association among soil (type and amount), terrain (*e.g.*, bedrock) and vegetation in the SGP (Section 10.3). The wildlife section includes wildlife and wildlife habitat; wildlife health is included in Environmental Health (Section 12.8).

Spatial boundary for assessing cumulative effects on geology, terrain, ELC, and biodiversity

Results of the local EA indicated that there would be no adverse negative effects from the Snap Lake Diamond Project on the physical environment, ELC and biodiversity beyond the boundaries of the RSA (Sections 10.2.2 and 10.3.2). Physical disturbances are confined to the mine site with the exception of the borrow material to be extracted from the Esker Borrow pit. The esker and winter access roads are also expected to result in very limited physical disturbance to the geology and terrain or biodiversity of the region (Sections 10.2.2 and 10.3.2). The CEA study area encompasses a radius of 31 km (3,019 km^2; Figure 12.7-1) from the active mine site, which includes the typical range of landform features and interspersion of landform and wetlands representative of the physiographic region of the Taiga Shield Ecozone within which the mine site is situated.

Study area for wildlife was defined by the annual home range of the Bathurst caribou herd

The spatial boundary for wildlife was defined by the annual home range of the Bathurst caribou herd. Traditional knowledge and information from female caribou fitted with satellite collars Resources, Wildlife and Economic Development (Section 10.4), indicates that annual home range size varies among years, but typically falls within the boundary outlined in Figure 12.7-1. Grizzly bears, wolves and wolverines also travel large distances over this area of the SGP and have the potential to be influenced by several projects (McLoughlin *et al*. 1999; Mulders 2000; Walton *et al*. 2001).

12.7.1.1.1 Key Issues and Key Questions

Three key questions were developed to address the issues

The issues related to the cumulative effect of the Snap Lake Diamond Project on terrestrial resource components were placed in the context of the following three questions:

CG-1: What cumulative impacts will the Snap Lake Diamond Project have on permafrost and ground thermal regime?

CELCTB-1: What cumulative impacts will the Snap Lake Diamond Project have on ELC, terrain and biodiversity?

CW-1: What cumulative impacts will the Snap Lake Diamond Project have on wildlife and wildlife habitat?

Figure 12.7-1 Spatial Boundaries for Assessing Cumulative Effects on Terrestrial Resources

The following approach was used for the assessment of impacts:

- development of linkages for each key question;
- determination of the validity of each linkage within each key question;
- analysis of residual impacts; and,
- classification of residual impacts.

12.7.1.1.2 Residual Impact Criteria

Criteria for assessing the residual impacts from projects or activities are described in detail in Section 12.1.6.1. Direction, duration, reversibility and frequency are defined in Table 12.1-4 (Section 12.1.6.2). Because the method for determining magnitude changes from one component to another, the magnitude for each terrestrial resource component is defined in Table 12.7-1.

Table 12.7-1 Definitions of Magnitude for Terrestrial Resource Components

Magnitude	Terrestrial Resource Component			
	Ground Thermal Regime	Terrain and ELC	Biodiversity	Wildlife and Wildlife Habitat
Negligible	no measurable effect on the ground thermal regime	no measurable effect (<1% change from baseline) in the area or quality of ELC units, terrain, VECs, or plant health	no measurable effect (<1% change from baseline) in the areas of high, moderate and/or low biodiversity potential	no detectable change from baseline conditions
Low	an increase in the depth of the active layer by 50% or less	<10% change or loss in the area and/or quality of ELC units, VECs, terrain and/or plant health	<10% change in the area of high, moderate and/or low biodiversity potential	exceeds the average value for baseline conditions, but within the range of natural variation and well below a guideline value
Moderate	an increase in the depth of the active layer by more than 50%, but less than 100%	10 to 20% change and/or loss in the area and/or quality of ELC units, VECs, terrain and/or plant health	10 to 20% change in the area of high, moderate and/or low biodiversity potential	exceeds the average value for baseline conditions, approaches the limits of natural variation, but below or equal to a guideline value
High	complete thawing of the permafrost	>20% change and/or loss in the area and/or quality of ELC units, VECs, terrain and/or plant health	>20% change in the area of high, moderate and/or low biodiversity potential	predicted to exceed baseline conditions or a guideline value so that there will be a detectable change beyond the range of natural variation (*i.e.*, change of state from baseline conditions)

Note: ELC = ecological land classification; VEC = valued ecosystem component.

12.7.2 Geology

12.7.2.1 Cumulative Impact Assessment

12.7.2.2 Key Question CG-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on Permafrost and Ground Thermal Regime?

12.7.2.2.1 Linkage Analysis

Permafrost and ground thermal regime

The cumulative effects with respect to permafrost and the ground thermal regime are the impacts of changes in ground temperature resulting from the Snap Lake Diamond Project combined with potential changes in the thermal regime from other existing and proposed industrial activities in the RSA.

The linkage for cumulative effects on permafrost and ground thermal regime is not valid

As indicated in Table 12.1-2, the distance between the Snap Lake site and all other project sites (except the Tibbitt-Contwoyto winter road) are in excess of 100 km, and well beyond the RSA (Figure 12.7-1). In addition, all impacts on the permafrost and the ground thermal regime associated with the Snap Lake Diamond Project are contained within the LSA (Section 10.2.2), and therefore, should not interact with potential effects from the Tibbitt-Contwoyto winter road. Because of the distances separating current and proposed projects from the Snap Lake LSA, there will be no interaction between changes in the ground thermal regime or permafrost as a result of the Snap Lake Diamond Project and impacts on the permafrost from other projects. Thus, the linkage between the Snap Lake Diamond Project and other existing and proposed projects, and the change in permafrost and the ground thermal regime within the RSA is not valid. No further assessment is required.

12.7.3 ELC, Terrain and Biodiversity

12.7.3.1 Cumulative Impact Assessment

12.7.3.2 Key Question CELCTB-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on ELC, Terrain and Biodiversity?

12.7.3.2.1 Linkage Analysis

Ecological land classification units are used to describe terrain and biodiversity

For the CEA of the Snap Lake Diamond Project, ELC units are used to describe soil, terrain, vegetation and biodiversity. Because the ELC units are influenced directly by the geology, soil and terrain (Section 10.3.1), any cumulative impact on ELC unit(s) would be associated with cumulative effects on these physical components, and vegetation and biodiversity (*i.e.*, loss of rare plants, landscape fragmentation). No cumulative impacts from the Snap Lake Diamond Project on permafrost or ground thermal regime are expected (Section 12.7.2.1).

Ecological land classification classifies areas into ecologically distinctive areas

ELC classifies and delineates ecologically distinctive areas on the landscape within the SGP. Each area can be viewed as a discrete system which has resulted from the mesh and interplay of geologic, landform, soil, vegetative, climatic, wildlife, water and human factors which may be present (Ecological Stratification Working Group 1995).

Ecozones, ecoregions, and ecodistricts describe ecological land classification

There are three hierarchical levels of organization used in describing ELC units. Ecozones, which are large and very generalized units, are characterized by large-scale interactions between abiotic and biotic factors and represent the coarsest level in the ELC system. Ecoregions represent a finer scale, and are subdivisions of ecozones characterized by distinctive regional landforms, small order macro or mesoclimates, vegetation, soils, water and land use. Finally, ecodistricts are subdivisions of ecoregions and are characterized by distinctive assemblages of landform, relief, surficial geologic material, soil, water bodies vegetation and land uses (Ecological Stratification Working Group 1995). Each ecodistrict is given a unique number.

Snap Lake is in a different ecozone, ecoregion and ecodistrict from other developments

The Snap Lake Diamond Project is located in the Taiga Shield Ecozone, the Coppermine River Ecoregion, and ecodistrict number 253. The EKATI™ Diamond Mine, Diavik Diamond Mine, Jericho Diamond Project and the Lupin Gold Mine are all located in the southern Arctic Ecozone, the Takijuq Lake Ecoregion, and ecodistrict number 168. In addition, all other projects (except the Tibbitt-Contwoyto winter road) are greater than 100 km from Snap Lake and well beyond the RSA. Because the Snap Lake Diamond Project is located in a completely different ecozone, ecoregion and ecodistrict from these other developments, there will be no cumulative effects with respect to ELC, terrain, vegetation and biodiversity in the RSA or among the three levels of landscape classification.

A portion of the Tibbitt-Contwoyto winter road is located in the Taiga Shield Ecozone, Coppermine River Ecoregion and ecodistrict number 253. However, approximately 72% of the entire road is constructed on frozen lakes (EBA 2001), and the road is operational for 10-12 weeks of the year during winter when other ELC units are covered in snow and ice. Thus, it is expected that cumulative changes to ELC units, terrain, vegetation and biodiversity within the RSA due to the Tibbitt-Contwoyto winter road should be negligible.

Other activities in the RSA are of limited geographical extent

Other activities, such as tourist lodges, are located in the Taiga Shield Ecozone, Coppermine River Ecoregion, and ecodistrict number 253, but are of very limited geographical extent and widely separated (Section 12.3). Any effects these activities might have on ELC, terrain and biodiversity in the RSA would be negligible.

Cumulative effects assessment is not required

Overall the linkage between Snap Lake and the cumulative impacts on ELC, soils, terrain and biodiversity is not valid. No further assessment is required.

12.7.4 Wildlife and Wildlife Habitat

12.7.4.1 Cumulative Impact Assessment

12.7.4.2 Key Question CW-1: What Cumulative Impacts Will the Snap Lake Diamond Project Have on Wildlife and Wildlife Habitat?

12.7.4.2.1 Linkage Analysis

Linkage analysis was conducted for all valued ecosystem components assessed in the local environmental assessment

The local EA for the Snap Lake Diamond Project evaluated the impacts of the project on eight wildlife species / species groups or valued ecosystem components (VECs). These species or species groups included the Bathurst caribou herd, barren-ground grizzly bears, wolves, wolverines, Arctic and red foxes, upland breeding birds (passerines, shorebirds and ptarmigan), raptors (peregrine falcon and gyrfalcon) and waterfowl. The local EA determined that the Snap Lake Diamond Project would generate a range of impacts on all these species, and their associated habitats within the RSA (Section 10.5.4). This section of the EA is meant to determine if effects from the Snap Lake Diamond Project can be linked to changes in wildlife and wildlife habitat beyond the RSA.

The first step was to define a biological population

A key aspect of linking the wildlife VECs with cumulative effects from the Snap Lake Diamond Project was to delineate the population or sub-populations that may be influenced by more than one of the projects within the spatial boundary of the SGP (Figure 12.7-1; Table 12.7-2). For the purpose of this assessment, a biological population is defined as a group of individuals that are genetically, demographically and/or spatially separated from another group of individuals (Wells and Richmond 1995). For example, if the distance between two populations is greater than the maximum home range size or the effective dispersal distance (likelihood of successful emigration) of individuals, then the populations are distinct. In contrast, if the annual or seasonal home range of several individuals within an area overlap extensively, then the likelihood that these individuals can be delineated into separate populations or sub-populations decreases.

Table 12.7-2 Projects Considered as Potential Linkages in the Cumulative Effects Assessment for Wildlife

Project	Project Phase	Distance from Snap Lake (km)
De Beers Snap Lake Diamond Project	permitting	--
EKATI™ Diamond Mine	operational	119
EKATI™ Diamond Mine Expansion	permitting	119
Diavik Diamond Mine	construction	102
Tahera Jericho Diamond Mine	permitting	268
Lupin Gold Mine	operational	242
Tibbitt-Contwoyto winter road	operational	22.5

Method for linking valued ecosystem components with the cumulative effects of projects

Identification of wildlife VECs that require assessment of cumulative effects was based on two biological parameters: annual migration movements, and annual / seasonal home range movements. For each parameter, it was determined whether or not an individual from the population or sub-population affected by the Snap Lake Diamond Project could be influenced by one or more other projects within the CEA study area (Figure 12.7-1; Table 12.7-2). This included that portion of the Tibbitt-Contwoyto winter road extending from Yellowknife to the junction of the winter access road for the Snap Lake Diamond Project. A CEA was deemed necessary for a wildlife VEC if one parameter resulted in a positive response (*i.e.*, the linkage is valid). For upland breeding birds, waterfowl and raptors, the operation of the Tibbitt-Contwoyto winter road will occur subsequent to birds migrating south and prior to birds returning in the spring, which makes the linkage invalid.

Caribou and grizzly bears may be influenced by several projects

Using the above definition of a biological population, the Bathurst caribou herd represents a single population. Annual migration and annual home range size in caribou are largely inseparable, and during the northern and southern migration caribou may be influenced by all projects within the SGP (Table 12.7-3). Similarly, the large home range size and extensive movement of individual female and male grizzly bears among three potential population units (or sub-populations) suggests that barren ground grizzly bears in the SGP should be considered as one population

(McLoughlin 2000). Although grizzly bears do not migrate, annual home range size of grizzly bears, particularly males, suggests that individuals could contact all projects within the CEA study area (Figure 12.7-1; Table 12.7-3). The exception is the Tibbitt-Contwoyto winter road, which is only operational (January to March) during the period when grizzly bears are hibernating (late October to mid-April).

Table 12.7-3 Identification of Wildlife VECs that Require Cumulative Effects Assessment

Wildlife VEC	Average Annual or Seasonal Home Range Size (km^2)	Annual Migration Overlaps Other Projects	Annual/Seasonal Home Range Overlaps Other Projects	CEA Required
Caribou [a]	annual: 250,000	yes	yes	yes
Grizzly bears [b]	annual: females = 2,074 males = 6,685	n/a	yes	yes
Wolves [c]	summer: females = 1,130 males = 2,022	yes	yes	yes
Wolverine [d]	annual: adults = 126 – 404	n/a	yes	yes
Foxes [e]	annual: adults = 15 – 25	n/a	no	no
Upland breeding birds [f]	breeding season: < 0.5	no	no	no
Waterfowl [g]	breeding season: < 5	no	no	no
Raptors [h]	breeding season: 23 - 319	no	no	no

(a) Case *et al.* 1996.
(b) McLoughlin *et al.* 1999.
(c) Walton *et al.* 2001.
(d) Mulders 2000.
(e) Banfield 1974; Larivière and Pasitschniak-Arts 1996.
(f) Based on migratory songbirds (Schoener 1968). BHP 2001, Snap Lake Baseline.
(g) Based on mallards (Mauser *et al.* 1994).
(h) Mearns 1985; White and Nelson 1991.

The wolf population breeding within the Snap Lake regional study area may be influenced by four projects

Wolves typically move with the northern and southern migration of caribou, and recent genetic analysis suggests that sub-populations of tundra wolves may exist in the SGP (Cluff *et al.* 2001). Although wolves follow caribou during the northern and southern migration, they will concentrate activities around natal den sites from June through August (Walton *et al.* 2001). Thus, wolf packs reproducing in the MacKay Lake and Lac de Gras area may represent a separate sub-population from wolves denning near Contwoyto Lake and Point Lake (*e.g.*, Lupin Gold Mine and Tahera project). Given the estimates of home range size during the summer period (Walton *et al.* 2001), it is assumed that wolves denning in the area of MacKay Lake and Lac de Gras may be influenced by activities at the Snap Lake Diamond Project, Diavik mine, and EKATI™ mine during hunting excursions (Table 12.7-3). Wolves migrating through this area may also contact that segment of the Tibbitt-Contwoyto winter road influenced by the Snap Lake Diamond Project (Section 12.1.5). Therefore, the linkage is valid for the wolves denning near these three mining projects and the Tibbitt-Contwoyto winter road.

Wolverines inhabiting the MacKay Lake and Lac de Gras area may be influenced by four projects

Current estimates of annual home range size of wolverines in the SGP (Mulders 1997, 2000) and other northern populations (Magoun 1985; Banci 1987) indicates that an individual's home range (Table 12.7-3) may overlap projects within the MacKay Lake and Lac de Gras area. Preliminary results also suggest that female and male wolverines may travel an average distance of 133 – 231 km during long-distance excursions or shifts in home range (Mulders 2000). Subsequently, the potential cumulative impacts of the Snap Lake Diamond Project, Diavik mine, BHP mine and the Tibbitt-Contwoyto winter road influenced by the Snap Lake Diamond Project were considered a valid linkage for a sub-population of wolverines occupying this area.

The linkage between foxes and cumulative effects from projects is not valid

In contrast, estimates of annual home range size of foxes suggests that populations influenced by the Snap Lake Diamond Project should not be affected by other projects in the SGP (Table 12.7-3). The distance between the Snap Lake Diamond Project and other projects, including the Tibbitt-Contwoyto winter road, should mitigate any potential cumulative impacts on foxes affected by the Snap Lake Diamond Project. Considering the short-term operation of the Tibbitt-Contwoyto and Snap Lake winter access roads, any potential effects from these activities on a group of individuals is anticipated to be equivalent to local impacts of the project (Section 10.4). Therefore, there is no valid linkage for potential cumulative impacts on the fox population inhabiting the RSA.

The linkage between upland breeding birds and waterfowl, and cumulative effects from projects is not valid

Assuming that the RSA of the Snap Lake Diamond Project represents the northern limit of the annual home range of populations of raptors, small upland birds and water birds breeding within the RSA, then no other project, besides Snap Lake, should influence these populations during migration (Figure 12.7-1). Home range size of nesting species of upland birds has been reported to vary between 0.5 and 5 ha (*i.e.*, < 0.5 km^2; Schoener 1968). Using the reciprocal of density estimates (*i.e.*, area/abundance) from the EKATI™ mine (BHP 2001) and Snap Lake Diamond Project (baseline studies) generates values from 0.1 – 1.4 ha per individual. Although this ratio is a crude estimate of nesting home range size for upland birds in the Arctic, it provides confidence in assuming that the daily activities of individuals, during this critical biological period, likely are contained within a 5 ha area. Similarly, the home range size of waterfowl during the breeding period will preclude individuals from being affected by other projects in the SGP during most of period that they inhabit the region (Table 12.7-3). Therefore, there is no valid linkage for potential cumulative impacts on upland birds and waterfowl breeding within the RSA.

Information on home range size in peregrine and gyrfalcons is limited

Currently, there is a lack of information on the home range size of peregrine and gyrfalcons during the reproductive season in the SGP. In Alaska, White and Nelson (1991) followed an adult male peregrine in a helicopter for approximately 19.5 hours and estimated a foraging home range size of 319 km^2. The greatest straight-line distance from the nest to a resting site was 14.6 km. Another study of two breeding female peregrines in Scotland generated hunting ranges of 23 km^2 and 117 km^2 (Mearns 1985). White and Nelson (1991) also following a reproductive pair of gyrfalcons and estimated the straight-line travel distance from the nest site to be 3.2 km for the female, while the male ranged within 24 km of the nest site.

The linkage between raptors and cumulative effects from projects is not valid

The extreme estimate of breeding home range size for peregrine falcons (*i.e.*, 319 km^2) suggests that individuals affected by the Snap Lake Diamond Project may also be influenced by the Diavik and BHP projects. However, breeding peregrine and gyrfalcons must return to the nest site after hunting prey for their offspring, which doubles the distance travelled. It is highly unlikely that an individual nesting within the potential zone of influence of the Snap Lake Diamond Project would fly the distance necessary to contact the Diavik mine (up to a 200 km round-trip) during a hunting excursion. Therefore, it is assumed that the home range of raptors breeding near the Snap Lake Diamond Project would not overlap other projects within the SGP, which makes the linkage for cumulative effects on these species invalid.

Dispersal could not be used to link cumulative effects from projects on wildlife valued ecosystem components

Cumulative effects may also occur in species that travel relatively large distances during dispersal from the natal home range. Here, dispersal is the act of leaving the natal home range, travelling, and then establishing a new home range that is disjunct from the natal home range (Lidicker and Stenseth 1992). For individual wolves, foxes and wolverines that inhabit the SGP and disperse more than 100 km from their natal territory, the potential for contacting other projects will increase. Unfortunately, there is little information available on the effective dispersal distance for the species considered here, and subsequently, this biological parameter could not be used to confidently identify the potential for cumulative effects.

12.7.4.3 Cumulative Impact Analysis

12.7.4.3.1 Linkage of Mining Activities to Potential Effects

Activities associated with projects were linked to the following four key effects on wildlife and wildlife habitat:

- direct habitat loss;
- indirect habitat loss from fugitive dust;
- change in abundance; and,
- change in movement and behaviour.

12.7.4.3.2 Direct Habitat Loss

Direct habitat loss will occur at all projects

Direct habitat loss is the most visible impact which occurs when terrain is cleared for mine site facilities and road construction (*i.e.*, mine infrastructure or footprint). Habitat loss will also occur from lake dewatering for open pit mines, and storage of processed kimberlite and waste rock material for all mines. Of all possible sources of impact from project construction and operations, habitat loss is one of the most important as it reduces the landscape's capacity to support wildlife. Although, the amount of habitat loss at one project might be predicted to have minimal impact on wildlife, the cumulative loss of habitat from many projects may have a stronger effect.

12.7.4.3.3 Indirect Habitat Loss

Fugitive dust may reduce the suitability of habitat

In addition to the direct loss of wildlife habitat from site clearing, indirect loss of habitat can occur when disturbance alters the suitability of habitat adjacent to the mine footprint. For example, processes of mineral extraction (*e.g.*, quarrying and processing operations) are typically associated with an increase in dust levels (Farmer 1993). The result of fugitive dust is a reduction in operational habitat availability (or effective use of habitat) adjacent to the project footprint for wildlife.

The linkage between fugitive dust and the Tibbitt-Contwoyto winter road is not valid

During the snow-free period, roads are a common source of dust which has been associated with negative effects on Arctic plant communities (Farmer 1993). In contrast, during the winter months, the amount of dust generated along the Tibbitt-Contwoyto winter road should be negligible as trucks are typically not hauling material that produces dust. Thus, it is assumed that indirect habitat loss from fugitive dust along the winter road is not a valid linkage to cumulative effects.

12.7.4.3.4 Change in Abundance

Several activities can result in wildlife mortality

Details of how mine-related activities may influence the abundance of wildlife populations are provided in Section 10.4.2.4, and include the following:

- direct and indirect mortality from attraction to project footprint;
- direct mortality from wildlife-human interactions;
- direct mortality from vehicle/aircraft collisions;
- potential toxicity from north pile seepage;
- trapping of wildlife in processed kimberlite containment area (water management pond);
- direct and indirect mortality from toxic spills (*e.g*., antifreeze); and,
- increase in legal and illegal hunting and trapping activities from increased access due to the winter and esker access roads.

Wildlife can be attracted to human development

The presence of human development can also attract some species of wildlife through the potential supply of food and shelter, and lead to indirect mortality. For example, grizzly bears and wolverines may be attracted by food odours and food garbage, while caribou may use raised and open areas, such as roads, for insect relief. Animals attracted to human developments increase the chance of collisions with vehicles and aircraft, and the potential for human-animal encounters. These effects typically increase the risk of injury or death to individual animals.

Only three elements, however, were linked to a potential change in wildlife abundance due to the Tibbitt-Contwoyto winter road. These included:

- toxic spills;
- vehicle-wildlife collisions; and,
- increased accessibility for legal and illegal hunting.

12.7.4.3.5 Change in Movement and Behaviour

Sensory disturbance may result in an increase of energy expending activities

Mining activities may change the behaviour and movement patterns of wildlife adjacent to the project footprint. Sensory disturbance can result in increased levels of stress and energy expenditure, and disruption of feeding and/or mating behaviour, which can negatively influence survival and reproductive rates. Therefore, changes in movement and behaviour are also correlated with indirect habitat loss or habitat effectiveness. Physical and psychological barriers associated with project infrastructure may also result in the disruption of natural movement corridors. Wildlife typically move between habitats or areas on a daily and seasonal basis in search of suitable feeding, denning, or resting areas (Burt 1943). For example, caribou, wolves, wolverines and grizzly bears travel over large areas to find suitable shelter and food during different seasons of the year, and their movement may be hindered by mining projects.

Development could restrict the movement of animals between populations

Wildlife corridors also facilitate the movement of animals between populations (Soule 1991). With increasing development pressure and fragmentation of wildlife habitat, species may be confined to local populations or sub-populations. If isolated populations are not able to interact, a decrease in genetic diversity could result, leading to an overall decrease in the adaptability of the regional population.

12.7.4.3.6 Cumulative Impact Analysis For Snap Lake Diamond Project

Direct Habitat Loss

Cumulative effects were assessed for eight habitat types

For each project (except the Tibbitt-Contwoyto winter road) assessment of the magnitude of the effect from direct habitat loss on each species was based on the relationship between the home range size of an individual and expected habitat loss due to the project footprint. Although several habitat types will be directly influenced by the various projects (Table 12.7-4), the analysis was restricted to those habitats impacted by the Snap Lake Diamond Project and at least one other project (*i.e.*, there is a link to cumulative effects from the Snap Lake Diamond Project). Thus, the CEA for selected wildlife species included the following habitats: heath/boulder, eskers, heath tundra, spruce forest, birch seep, tussock-hummock, sedge wetland and water.

Data for habitat types temporarily influenced by the Tibbitt-Contwoyto winter road are not available

Information on the habitat types that are influenced by the Tibbitt-Contwoyto winter road is currently not available. Therefore, the magnitude of the effect from direct habitat loss on species was assessed by using the total area impacted (2.6 km^2). The estimate was based on the linear distance of the road from Yellowknife to the junction of the winter access road for the Snap Lake Diamond Project (256 km) and an average road width of 10-m (EBA 2001). The width of 10 m was based on measurements of the road width taken at six locations (range = 8 to 12 m) south of the tree line. However, given that approximately 72% of the road is constructed over frozen lakes (EBA 2001) and the remaining terrestrial habitat is covered by ice and snow, analysis of the loss of each habitat would contribute little to the assessment. The assumption here is that all habitats periodically affected by the Tibbitt-Contwoyto winter road are equally suitable to caribou, wolves and wolverines. In this context, the loss of habitat from an individual's home range due to the Tibbitt-Contwoyto winter road maximizes the potential effect on the population.

Table 12.7-4 Direct Loss of Existing Habitat Types Due to Each Project within the CEA Study Area

Habitat Type	Direct Habitat Loss (km^2)					
	Lupin Gold Mine	Diavik Diamond Mine	EKATI™ Diamond Mine [(a)]	Tahera Mine	Snap Lake Diamond Project	Total
Bedrock	0.00	0.07	0.81	0.00	0.00	0.88
Boulder	0.69	0.05	0.21	0.00	0.00	0.95
Heath / bedrock	0.00	0.75	3.76	0.00	0.00	4.51
Heath / boulder	0.35	1.70	4.71	0.00	4.34	11.10
Esker complex	0.00	0.14	0.16	0.43	0.005	0.74
Heath tundra	4.94	3.38	2.63	1.25	0.002	12.20
Spruce forest	0.00	0.00	0.11	0.00	0.48	0.59
Mixed deciduous forest	0.00	0.00	0.00	0.00	0.00	0.00
Birch seep	2.07	0.10	0.36	0.00	0.06	2.59
Riparian tall shrub	0.00	0.03	0.25	0.1	0.00	0.38
Tussock-hummock	1.73	1.48	3.07	0.00	0.57	6.85
Sedge wetland	1.73	0.24	0.16	0.20	0.12	2.45
Burn	0.00	0.00	0.00	0.00	0.00	0.00
Water	0.00	3.58	8.16	1.16	0.86	13.76
Lichen veneer	0.00	0.00	0.02	0.00	0.00	0.02
Disturbed	0.00	0.06	0.00	0.00	0.00	0.06
Unclassified	0.00	0.00	0.06	0.00	0.00	0.06
Total	11.51	11.57	24.47	3.14	6.44	57.13

[(a)] Includes expansion.

Cumulative habitat loss for caribou is less than 0.1% of an individual's home range

Due to the extensive home range of caribou, the proportion of total habitat lost within an individual's home range from the addition of the Snap Lake Diamond Project is less than 0.1% (Table 12.7-5). In addition, the cumulative loss of habitat from all projects is less than 0.1% of the annual home range.

Cumulative habitat loss for grizzly bears is less than 2.5% of an individual's home range

For grizzly bears, the cumulative loss of any key habitat, such as eskers, heath tundra, birch seep and sedge wetlands, from all projects is less than 1.0% of an individual's home range (Table 12.7-6). Depending on home range size, the proportion of total habitat lost within an individual's home range from the addition of the Snap Lake Diamond Project varies from 0.10 to 0.31%. The cumulative loss of grizzly bear habitat from all projects is less than 2.5% of the annual home range (Table 12.7-6).

Table 12.7-5 Predicted Proportional Loss (%) of Habitat Types Due to Each Project Within the Home Range of the Bathurst Caribou Herd. An Estimate of Annual Home Range is Provided in Parentheses.

Barren-ground Caribou (250,000 km^2)[a]							
	Project						
Habitat Type	Lupin Gold Mine	Diavik Diamond Mine	EKATI™ Diamond Mine	Tahera Mine	Snap Lake Diamond Project	Tibbitt-Contwoyto Winter Road	Cumulative Loss
Heath tundra	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01
Heath / boulder	<0.01	<0.01	<0.01	0.00	<0.01	-	<0.01
Spruce forest	0.00	0.00	<0.01	0.00	<0.01	-	<0.01
Esker complex	0.00	<0.01	<0.01	<0.01	<0.01	-	<0.01
Birch seep	<0.01	<0.01	<0.01	0.00	<0.01	-	<0.01
Sedge wetland	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01
Water	0.00	<0.01	<0.01	<0.01	<0.01	-	<0.01
Tussock-hummock	<0.01	<0.01	<0.01	0.00	<0.01	-	<0.01
Cumulative Loss	0.005	0.005	0.010	0.001	0.003	0.001	0.025

[a] Case *et al*. 1996.

Table 12.7-6 Predicted Proportional Loss (%) of Habitat Types Due to Each Project Within the Home Range of Grizzly Bears. An Estimate of Annual Home Range is Provided in Parentheses.

Grizzly Bears (2,074 – 6,685 km^2)[a]						
	Project					
Habitat Type	Lupin Gold Mine	Diavik Diamond Mine	EKATI™ Diamond Mine	Tahera Mine	Snap Lake Diamond Project	Cumulative Loss
Heath tundra	0.07 – 0.24	0.05 – 0.16	0.04 – 0.13	0.02 – 0.06	<0.01	<0.18 – 0.59
Heath/boulder	<0.01 – 0.02	0.03 – 0.08	0.07 – 0.23	0.00	0.06 – 0.21	0.16 – 0.54
Spruce forest	0.00	0.00	<0.01	0.00	0.01 – 0.02	<0.03
Esker complex	0.00	<0.01	<0.01	<0.01 – 0.02	<0.01	<0.04
Birch seep	0.03 – 0.10	<0.01	0.01 – 0.02	0.00	<0.01	<0.2
Sedge wetland	0.03 – 0.08	<0.01	<0.01	<0.01	<0.01	<0.2
Water	0.00	0.05 – 0.17	0.12 – 0.39	0.02 – 0.06	0.01 – 0.04	0.20 – 0.66
Tussock-hummock	0.03 – 0.08	0.02 – 0.07	0.05 – 0.15	0.00	0.01 – 0.03	0.11 – 0.33
Cumulative loss	0.16 – 0.52	0.16 – 0.51	0.29 – 0.93	0.05 – 0.15	0.10 – 0.31	0.76 – 2.42

[a] McLoughlin *et al*. 1999.

Cumulative habitat loss for wolves is less than 3.5% of the an individual's home range

Although the home range of wolves is smaller than caribou and grizzly bears, the maximum proportion of key habitats lost (eskers, heath tundra) from an individual's home range from all projects is still less than 2.0% (Table 12.7-7). Depending on home range size, the proportion of total habitat lost within an individual's home range from the addition of the Snap Lake Diamond Project varies from 0.32 to 0.57%. The combined loss of habitats from all projects is less than 3.5% of the home range of an individual (Table 12.7-7).

Table 12.7-7 Predicted Proportional Loss (%) of Habitat Types Due to Each Project Within the Home Range of Wolves. An Estimate of Summer Home Range is Provided in Parentheses.

Wolves (1,130 – 2,022 km^2)[(a)]					
	Project				
Habitat Type	Diavik Diamond Mine	EKATI™ Diamond Mine	Snap Lake Diamond Project	Tibbitt-Contwoyto Winter Road	Cumulative Loss
Heath tundra	0.17 – 0.30	0.13 – 0.23	<0.01	-	0.30 – 0.53
Heath / boulder	0.08 – 0.15	0.23 – 0.42	0.21 – 0.38	-	0.52 – 0.95
Spruce forest	0.00	<0.01	0.02 – 0.04	-	<0.1
Esker complex	<0.01	<0.01	<0.01	-	<0.1
Birch seep	<0.01	0.02 – 0.03	<0.01	-	<0.1
Sedge wetland	0.01 – 0.02	<0.01	<0.01	-	<0.1
Water	0.18 – 0.32	0.40 – 0.70	0.04 –0.08	-	0.62 – 1.10
Tussock – hummock	0.07 – 0.13	0.15 – 0.27	0.03 – 0.05	-	0.25 – 0.45
Cumulative loss	0.53 – 0.94	0.96 – 1.71	0.32 – 0.57	0.13 – 0.23	1.94 – 3.45

(a) Walton *et al*. 2001.

Cumulative habitat loss for wolverines varied from 9.7 to 31.0% of an individual's home range

For a sub-population of wolverines occupying the area around MacKay Lake and Lac de Gras, the cumulative proportional loss of habitat from the home range of an individual wolverine ranges from 9.7 to 31.0% (Table 12.7-8). The incremental contribution of habitat loss from the Snap Lake Diamond Project is expected to be 1.58 to 5.10% of an individual's home range.

Cumulative habitat loss is likely overestimated for individual wolverines

It must be emphasized that the higher values for cumulative loss of habitats from all projects (*i.e.*, last column of Table 12.7-8) are associated with the lowest estimate of home range size in wolverines (*i.e.*, 126 km^2). It is unlikely that an individual with a home range of 126 km^2 would experience the full loss of habitat from the three mining projects and the full extent of the Tibbitt-Contwoyto winter road. Instead, habitat loss for such an individual inhabiting the Snap Lake RSA would likely be confined to the

Snap Lake Diamond Project and a portion of the Tibbitt-Contwoyto winter road. Thus, the higher range of values for the proportional loss of habitat from an individual's home range likely overestimates cumulative habitat loss. Individuals who have a larger home range size or make excursions outside the home range may incur a cumulative habitat loss that falls between the range of low and high estimates (*e.g.*, 15 – 20%).

Table 12.7-8 Predicted Proportional Loss (%) of Habitat Types Due to Each Project Within the Home Range of Wolverines. An Estimate of Annual Home Range is Provided in Parentheses.

Wolverines (126 – 404 km^2)[(a)]					
	Project				
Habitat Type	Diavik Diamond Mine	EKATI™ Diamond Mine	Snap Lake Diamond Project	Tibbitt-Contwoyto Winter Road	Cumulative Loss
Heath tundra	0.84 – 2.68	0.68 – 2.09	<0.01	-	1.52 – 4.77
Heath / boulder	0.42 – 1.35	1.17 – 3.74	1.07 – 3.44	-	2.66 – 8.53
Spruce forest	0.00	0.03 – 0.09	0.12 – 0.38	-	0.15 – 0.47
Esker complex	0.03 – 0.11	0.04 – 0.13	<0.01	-	0.07 – 0.24
Birch seep	0.02 – 0.08	0.09 – 0.29	0.01 – 0.05	-	0.12 – 0.42
Sedge wetland	0.06 – 0.19	0.04 – 0.13	0.03 – 0.10	-	0.13 – 0.42
Water	0.89 – 2.84	2.02 – 6.48	0.21 – 0.68	-	3.12 – 10.00
Tussock – hummock	0.37 – 1.17	0.76 – 2.44	0.14 – 0.45	-	1.27 – 4.06
Cumulative loss	2.63 – 8.42	4.83 – 15.39	1.58 – 5.10	0.64 – 2.06	9.68 – 30.97

[(a)] Mulders 2000.

Indirect Habitat Loss From Fugitive Dust

Indirect habitat loss from fugitive dust should be contained within the area of direct habitat loss

Fugitive dust will likely be distributed over large distances from a project, but the highest concentrations of dust are predicted to settle on areas within 100 m of the project footprint (Section 12.4). Therefore, most of the effect of dust should be contained within an area that has already been altered due to site clearing, which limits the cumulative effect of dust on wildlife habitat.

Change in Abundance

Mine-related mortality of wildlife can occur

If mitigation strategies are effective, the risk of injury or death to wildlife from mining activities should be minimal. However, the success of mitigation will not become apparent until construction and operation of the mine. For example, the problems associated with the attraction and removal of individuals from the Lac de Gras wolverine population was not fully anticipated during the EA for the EKATI™ and Diavik projects. Since January 1998, 16 wolverines from the Lac de Gras area (including EKATI™, Misery, Diavik, and Nuna camps) have been relocated or destroyed (R. Mulders, pers. comm., RWED), and is likely having a cumulative effect on local population abundance. In addition, one grizzly bear cub that became habituated to the landfill site at Misery camp had to be destroyed (BHP 2001). In contrast, there have been no reports of losses for caribou, grizzly bears, wolves or wolverines related to the Lupin mine or the Tibbitt-Contwoyto winter road. From 1997-2000, no caribou or wolves were reported to be killed or injured as a result of mining activities at the EKATI™ mine (BHP 2001).

Attraction of wolverines to the Snap Lake project and Tibbitt-Contwoyto winter road

Proposed mitigation for the Snap Lake Diamond Project is expected to limit the number of wolverines attracted to the site and the associated risk of mortality. There is strong intention by De Beers to minimize the “attractiveness” of the Snap Lake Diamond Project to wildlife through rigorous application of the waste management program (Section 10.4.2.4.2). However, without information to test the effectiveness of these mitigation measures, the success of the waste management program is currently uncertain. Similarly, attraction of wolverines to activity along the Tibbitt-Contwoyto winter road should be negligible, assuming that the presence of food garbage and aromatic residues (oil, glycol) is minimal.

The sensitivity of mine-related mortality for grizzly bears and wolverines is higher than for caribou and wolves

Given the low population density and low reproductive potential of grizzly bears and wolverines relative to caribou and wolves, the sensitivity of the loss of an individual from the population is anticipated to be higher for bears and wolverines. In addition, the loss of even one grizzly bear or wolverine from the local population may be considered a low to moderate impact given their status as “species of special concern” (COSEWIC 2001).

Change in Movement and Behaviour

Caribou feeding behaviour is influenced by mining activities

Results from monitoring studies at the EKATI™ diamond mine during 1998 suggested that both nursery (groups with calves) and non-nursery groups (groups without calves) spent about 15% less time feeding within 7 km of the footprint (BHP 2001). During 1999, however, the behaviour of caribou did not appear to be influenced by mine-related activities. Because the migratory movement of caribou to their wintering grounds is unpredictable (Legat *et al*. 2001), the number of caribou travelling through the potential zone of influence will probably change from year to year. In addition, depending on the level of mining activities, the zone of influence may expand or contract in some years.

The incremental change in caribou movement and behaviour from the Snap Lake project is expected to be within the range of natural variation

The smaller footprint, much shorter hauling distances, and below ground operations associated with the Snap Lake Diamond Project relative to the size of the infrastructure and above-ground operations at the EKATI™ mine should result in a smaller zone of influence. In addition, baseline studies suggest that number of caribou passing through the Snap Lake RSA is relatively low and that less than 1% of the Bathurst herd may be exposed to mining activities at any given time. Although the cumulative effect will likely be beyond baseline conditions, any incremental change in movement and behaviour from the Snap Lake Diamond Project is anticipated to be within the range of natural variation exhibited by the Bathurst caribou herd during years of extreme insect harassment or poor winter range conditions.

Movement and behaviour of grizzly bears

Recent studies have demonstrated that, even with significant infrastructure and road traffic, grizzly bears continue to carry out daily activities within close proximity to development (Burson *et al*. 2000; Yost and Wright 2001). Current information from 3 bears fitted with GPS collars also shows that these individuals have maintained home ranges that overlap the BHP and Diavik footprints from June through September (Rob Gau, RWED, pers. comm. 2001). In addition, monitoring at the BHP mine has shown that the presence of grizzly bear sign in sedge wetland and riparian habitats was not related to distance from the project footprint (BHP 2001). However, these results do not show how grizzly bears use habitats adjacent to mine infrastructure.

Movement and behaviour of wolves

Studies at the EKATI™ mine in 2000 found that the average pup count per den site (two dens were within 11 km of the footprint) within the BHP study area was 4.3 pups / den (N = 4 dens). This was similar to an average pup count of 3.6 pups / den (N = 12 dens) observed on the barren-grounds during the same period (BHP 2001). Assuming that data from the den surveys (number of natal dens and pup production) reflect the health of wolf packs inhabiting the BHP study area, then these results suggest that the current level of disturbance from the mine has not negatively influenced the behaviour of wolves (BHP 2001).

Movement and behaviour of wolverines

There is limited information of how development affects wolverine movement and behaviour. However, wolverine track surveys completed at the EKATI™ mine during the past three years indicate that wolverines are currently still moving within or through the area (BHP 2001). The average density of wolverine tracks recorded within the Snap Lake area during 1999 and 2000 (0.23 tracks/km) was within the range of track densities (0.10 to 0.33 tracks/km) observed around the EKATI™ mine during 1998 to 2000 (BHP 2001).

Changes to the movement and behaviour of grizzly bears, wolves and wolverines are expected to be beyond baseline conditions but within the range of natural variation

Baseline studies at the Snap Lake Diamond Project indicated that grizzly bears and wolverines use habitat in the RSA, and wolves den and travel within the RSA. Given that the footprint of the proposed Snap Lake Diamond Project is substantially smaller than that of the EKATI™ site, it is predicted that the cumulative incremental change in movement and behaviour of grizzly bears, wolves and wolverines due to the Snap Lake Diamond Project will be above baseline conditions, but within range of natural variation.

Increase in traffic volume along the Tibbitt-Contwoyto winter road

During the period of operation of the Tibbitt-Contwoyto winter road (~67 days/year), it is expected that the potential effect of sensory disturbance from vehicle traffic on caribou, wolves and wolverines will approach the upper limit of baseline conditions. This is largely due to the expected increase in current traffic volume. For example, in 2000, the number of loaded trucks (which is half the total) using the road was 3,959 (EBA 2001), which amounted to an average traffic volume of 4.2 (loaded and unloaded) trucks per hour. From 2004 to 2015, the annual number of loaded trucks that will be using the road (including 2,800 for Snap Lake) is estimated at 10,000 (10.6 trucks per hour (loaded and unloaded)). Thus, there will be an incremental increase in sensory disturbance along the winter road from vehicle traffic associated with the Snap Lake Diamond Project on caribou, wolves and wolverines.

No change in genetic variability of populations is expected to be associated with development

For all species, the potential effect of habitat fragmentation from all projects on genetic integrity, and associated population health, is currently believed to be negligible. Given the distance and amount of associated undisturbed habitat between projects, there should be no effect on the movement of individuals between populations or sub-populations. Therefore, any change to the genetic variability within a population is not expected to be associated with the Snap Lake Diamond Project.

12.7.4.4 Residual Impact Classification

12.7.4.4.1 Direct Habitat Loss

Assessment of the magnitude of habitat loss

Current empirical and theoretical studies have examined the relationship between loss of suitable habitat and landscape type, and the likelihood of population decline (Andrén 1994; Fahrig 1997; With 1997; Mönkkönen and Reunanen 1999; Andrén 1999). These studies suggest that critical thresholds for declines in bird and mammal species occur between 10% and 60% of original habitat. In other words, a decrease in species abundance and diversity may be observed when the amount of suitable habitat lost exceeds a threshold value of 40 to 90%. Subsequently, the magnitude of cumulative habitat loss from the Snap Lake Diamond Project on caribou, grizzly bears, wolves and wolverines was determined by comparing the percentage of habitat lost within an individual's home range to these threshold value estimates.

Magnitude of direct habitat loss on caribou, grizzly bears and wolves is predicted to be negligible

The expected cumulative loss of habitat from the home range of caribou, grizzly bears and wolves is estimated to be less than 0.1%, 2.5% and 3.5%, respectively. A loss of less than 3.5% of an individual's home range is well below a threshold value of 40-90%. In addition, the incremental loss of habitat from the Snap Lake Diamond Project is expected be less than 1% for caribou, grizzly bears and wolves. Therefore, the magnitude of cumulative habitat loss from the Snap Lake Diamond Project on caribou, grizzly bears and wolves is predicted to be negligible (Table 12.7-9).

Table 12.7-9 Residual Impact Classification for Cumulative Effects of Direct Habitat Loss from the Snap Lake Diamond Project on Wildlife Populations

VEC	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Bathurst caribou herd	negative	negligible	regional	medium-term	low	reversible (long-term)	low
Grizzly bears	negative	negligible	regional	medium-term	low	reversible (long-term)	low
Wolves	negative	negligible	regional	medium-term	low	reversible (long-term)	low
Wolverines	negative	low	regional	medium-term	low	reversible (long-term)	low

Magnitude of direct habitat loss on wolverines is predicted to be low

In contrast, the cumulative loss of habitat for an individual wolverine is expected to range from 15 to 20%, depending on home range size and the distance travelled by individuals during excursions outside the home range. The incremental contribution of habitat loss from the Snap Lake Diamond Project is expected to be 1.58 to 5.10% of an individual's home range. Considering the theoretical distribution of threshold values for habitat loss, the magnitude of cumulative habitat loss from the Snap Lake Diamond Project on wolverines is expected to be low (Table 12.7-9).

Duration, geographic extent, frequency and reversibility

Direct habitat loss will be medium-term since activities that directly impact habitat will end at closure. Geographic extent of the cumulative impact is regional as no habitat will altered or lost outside the RSA (Table 12.7-9). The frequency of the cumulative effect of direct habitat loss is low (*i.e.*, will occur once during construction or operations), and reversible in the long-term.

Success of habitat reclamation in the Northwest Territories is currently uncertain

Although re-vegetation may take a number of years following post-closure, it is anticipated to occur within the successional time frame of the native plant species (*i.e.*, reversible within 100 years). Reclamation of development sites has been shown to be an effective means of replacing vegetation communities (and hence wildlife habitat) in western and central Alberta (*e.g*., McCallum 1989; Roe and Kennedy 1989). But reclamation techniques in the NWT are still being developed and consequently the long-term outcome of reclamation is uncertain.

Environmental consequence is low

The overall environmental consequence of the cumulative impact of habitat loss from the Snap Lake Diamond Project is anticipated to be low for caribou, grizzly bears, wolves and wolverines (Table 12.7-9).

12.7.4.4.2 Indirect Loss of Habitat From Fugitive Dust

Magnitude of indirect habitat loss from fugitive dust is predicted to be negligible for all projects

Impact analysis suggested that most of the effect of dust should be contained within an area that has already been altered due to site clearing, which limits the cumulative effect of dust on wildlife habitat. Therefore, the magnitude of the cumulative impact from fugitive dust on caribou, grizzly bear, wolf and wolverine habitat due to the Snap Lake Diamond Project is predicted to be negligible (Table 12.7-10).

Table 12.7-10 Residual Impact Classification for Cumulative Effects of Fugitive Dust from the Snap Lake Diamond Project on Wildlife Populations

VEC	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Bathurst caribou herd	negative	negligible	regional	medium-term	moderate	reversible (short-term)	low
Grizzly bears	negative	negligible	regional	medium-term	moderate	reversible (short-term)	low
Wolves	negative	negligible	regional	medium-term	moderate	reversible (short-term)	low
Wolverines	negative	negligible	regional	medium-term	moderate	reversible (short-term)	low

Duration, geographic extent, frequency and reversibility

The duration of indirect habitat loss is anticipated to be medium-term, as production of dust will cease at post-closure. Because there will be dust generated along the esker access road, the geographic extent is regional. In addition, the production of dust is expected to occur at a variable, but generally moderate frequency (Table 12.7-10). The production of dust will be suppressed during periods of moderate rainfall and snowfall.

Reclamation of indirect habitat loss from fugitive dust

The cumulative health effects of dust on plants are expected to be reversible within the lifespan of the Snap Lake Diamond Project (*i.e.*, short-term). Although this may occur in the short-term when the dust is washed off, there is a high level of uncertainty considering the small surface area of photosynthetic tissues of Arctic plants, short growing season, and limited amount of precipitation. It is possible that the impact may be reversible in the long-term rather than the short-term.

Environmental consequence is low

The overall environmental consequence of the cumulative impact of fugitive dust from the Snap Lake Diamond Project is anticipated to be low for caribou, grizzly bears, wolves and wolverines (Table 12.7-10).

12.7.4.4.3 Change in Abundance

The expected magnitude of change in abundance for caribou and wolves is lower than for grizzly bears and wolverines

Impact analysis predicts that the magnitude of the cumulative change in abundance from the Snap Lake Diamond Project on caribou and wolves will be negligible (Table 12.7-11). In contrast, the magnitude of change in abundance from applicable projects on the grizzly bear and wolverine populations is anticipated to be low to moderate.

Table 12.7-11 Residual Impact Classification for Cumulative Effects of Change in Abundance from the Snap Lake Diamond Project on Wildlife Populations

VEC	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Bathurst caribou herd	negative	negligible	regional	medium-term	moderate	reversible (short-term)	low
Grizzly bears	negative	low - moderate	regional	medium-term	moderate	reversible (short-term)	low
Wolves	negative	negligible	regional	medium-term	moderate	reversible (short-term)	low
Wolverines	negative	low - moderate	regional	medium-term	moderate	reversible (short-term)	low

Geographic extent, duration and frequency

The geographic extent of this cumulative effect on each species is regional as toxic spills or wildlife-vehicle collisions may occur on the esker access and winter access roads (*i.e.*, the zone of influence is restricted to within the RSA). Duration is classified as medium-term, while the frequency of any individuals lost from the population is predicted to be moderate (Table 12.7-11). The frequency of wildlife mortality from project-related activities is expected to be moderate (*i.e.*, periodic) since there may be more than one fatality during construction and operation. The definition of low frequency is that the event would occur only once, while high frequency implies a more or less continuous occurrence.

Effects of project-related mortality will cease upon closure of a project

Departure of humans at closure will end the potential for attraction to the site, and possible human-wildlife encounters, and vehicle/aircraft-wildlife collisions. While an impact at the individual level is predicted, it is expected that the incremental loss of individuals from the population due to the Snap Lake Diamond Project will be more than replaced by recruitment within the lifespan of the project (*i.e.*, reversible in the short-term).

Environmental consequence is low

The overall environmental consequence of the cumulative impact on change in abundance from the Snap Lake Diamond Project is anticipated to be low for caribou, grizzly bears, wolves and wolverines (Table 12.7-11).

12.7.4.4.4 Change in Movement and Behaviour

Magnitude of change in movement and behaviour on wildlife populations is expected to be low

Impact analysis predicted that the incremental change in movement and behaviour from the Snap Lake Diamond Project on wildlife populations would be within the range of natural variation. Therefore, the cumulative effect of change in movement and behaviour from the Snap Lake Diamond Project on caribou, grizzly bears, wolves and wolverines is expected to be low (Table 12.7-12).

Table 12.7-12 Residual Impact Classification for Cumulative Effects of Change in Movement and Behaviour from the Snap Lake Diamond Project on Wildlife Populations

VEC	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Bathurst caribou herd	negative	low	regional	medium-term	moderate	reversible (short-term)	low
Grizzly bears	negative	low	regional	medium-term	moderate	reversible (long-term)	low
Wolves	negative	low	regional	medium-term	moderate	reversible (short-term)	low
Wolverines	negative	low	regional	medium-term	high	reversible (short-term)	low

Geographic extent is regional for caribou

Results from the EKATI™ mine in 1998 suggested that caribou behaviour was significantly influenced when individuals were within 7 km of the mine footprint (BHP 2001). The BHP mine represents the largest continuous operation, in terms of geographic extent and activity level, among current and proposed projects. Diavik (1998b) also used a 7-km zone of influence to predict the impact on caribou movement from the airstrip (although most buffers were 2-3 km). The geographic extent of the cumulative incremental change in caribou movement and behaviour from the Snap Lake Diamond Project is expected to be limited to the RSA, which has radius of 31 km (Table 12.7-12).

Geographic extent is also regional for grizzly bears, wolves and wolverines

Studies at the EKATI™ mine have used a 10-km zone of influence to model the effect of disturbance on indirect loss of habitat (or change in movement and behaviour) for grizzly bears (BHP 2001). Although such an analysis has not been conducted for wolves and wolverines, it is assumed that the zone of influence for these carnivores should be similar to grizzly bears. Based on this assumption, the geographic extent of the cumulative incremental change in movement and behaviour from the Snap Lake Diamond Project on grizzly bears, wolves and wolverines is expected to be limited to the RSA (Table 12.7-12).

Duration and reversibility

The duration of the incremental change in movement and behaviour from the Snap Lake Diamond Project on all species is anticipated to medium-term, and any changes are expected to be reversible in the short-term. The cessation of mining activities at closure of the project will end the potential for sensory disturbance and any effects on movement and behaviour should be reversible within the lifespan of the project.

Frequency of cumulative effects

For caribou, grizzly bears and wolves, the frequency of the effect of change in movement and behaviour is expected to be moderate (*i.e*., periodic). Because of migratory movements, caribou and wolves will be exposed to project-related activities on a seasonal basis. Similarly, hibernation in grizzly bears results in periodic exposure to sensory disturbance and displacement from project activities. In contrast, because wolverines are active throughout the year and annual residents of a particular area, the potential effect of a project on movement and behaviour is high (*i.e.*, more or less continuous).

Environmental consequence is low

The overall environmental consequence of the cumulative impact on change in movement and behaviour from the Snap Lake Diamond Project is anticipated to be low for caribou, grizzly bears, wolves and wolverines (Table 12.7-12).

12.7.4.5 Discussion

The probability that cumulative effects from the Snap Lake project will occur is high

The probability that cumulative effects on caribou, grizzly bears, wolves and wolverines will be associated with the Snap Lake Diamond Project is high. Although small, there is a loss of quality habitat, such as birch seep, spruce forest and sedge wetland, associated with the Snap Lake Diamond Project and several of the other current and reasonably foreseeable projects.

The production of fugitive dust will also result in a negligible amount of indirect habitat loss. A decrease in habitat suitability adjacent to the footprint, which is related to the zone of influence of a project, and the associated change in movement and behaviour of individuals will likely occur. In addition, some project-related mortality is expected to occur during the life of a project. Overall, the environmental consequence of the cumulative incremental change in habitat, fugitive dust, abundance, and movement and behaviour from the Snap Lake Diamond Project is expected to be low for caribou, grizzly bears, wolves and wolverines.

There is a high degree of uncertainty in predicting the environmental consequence of cumulative effects

Thus, there is a large amount of confidence in predicting the likelihood of an incremental cumulative effect from an individual project on caribou, grizzly bears, wolves and wolverines. However, there is a high degree of uncertainty in predicting the magnitude or strength of the incremental effects from the Snap Lake Diamond Project on a population over space and time.

Uncertainty due to the accuracy and sensitivity of the measurement criteria

The uncertainty is related to several elements of the CEA for wildlife. There is uncertainty with the accuracy and sensitivity of the measurement scheme used to estimate the cumulative effect from the Snap Lake Diamond Project. For example, it is assumed that the rank-order values for magnitude, geographic extent, duration and reversibility correctly capture the relative strength (*i.e*. environmental consequence) of expected changes in habitat, mortality, and movement and behaviour on a population from the Snap Lake Diamond Project. It is also assumed that these effects are additive and respond linearly with year-to-year changes in population size. However, changes in effects over time and space may interact in a non-additive manner (*i.e*., augment or work against each other), and display non-linear relationships with population density.

Measurement criteria may not correctly capture the scale of project-related changes in habitat, abundance, and movement and behaviour

Natural and human-related cumulative effects can be predicted to occur on a number of temporal (seasonal, annual, decadal) and spatial levels (local, regional, SGP). But the ability to understand and predict the strength of cumulative effects depends on the scale and associated sensitivity of the measurement technique. Theoretically, quantitative measures (*e.g*., numerical change in individual survival, reproduction or behaviour associated with a project) provide the most accurate and precise estimates of changes in effects and associated impacts on a population. In contrast, qualitative measures, such as high or low and presence or absence, provide the least sensitive estimates. The sensitivity of the measurement technique used to estimate the criteria (*e.g.*, magnitude, geographic extent) of effects for this analysis falls between strict quantitative and qualitative estimates, but may still fail to correctly capture the scale of project-related changes to habitat, individual mortality, and movement and behaviour. Stated differently, the numerical relationship between the cumulative effect of any project and the behaviour, survival and reproduction of individuals within the population is largely unknown.

Uncertainty due to large-scale environmental variation such as climate change

In addition, the assessment does not explicitly account for the natural variation in environmental factors that shape the life history traits and dynamics of a population, or the interaction between populations in the ecosystem. For example, changes in weather patterns associated with climate change can modify the physiology, distribution and life cycle events of species (Hughes 2000). Although predictions of climate change have a high degree of uncertainty, an increase in atmospheric carbon dioxide (CO_2) concentration, temperature and precipitation has been associated with changes in the metabolic and developmental rates in several plant species (Keeling *et al*. 1996; Beerling and Kelly 1997; Myneni *et al*. 1997; Cannell 1998). Increases in mean annual temperature may also result in the northward expansion of the treeline and a correspondent decline in Arctic tundra habitat (Peterson 1994; Intergovernmental Panel on Climate Change 1995; Hughes 2000). A decrease in habitat containing lichens and forbs, which are critical for over-winter nutrition in caribou (Klein and White 1978), could affect survival and reproduction in the Bathurst herd. In addition, the northward advance of the treeline may result in reducing the effectiveness of migration by caribou as a strategy to escape predation from wolves (Heard and Williams 1992).

Effects of shifts in species' range

As with certain plant species, the species' range of some animals may move northward. For example, the range of 22 European butterfly species has shifted 35-240 km north during the past century and was correlated with recent climate trends (Parmesan *et al.* 1999). Similarly, poleward range expansions of bird species in both Europe and the USA, and small mammals in the southwest USA have been documented (Davis and Callahan 1992; Johnson 1994; Thomas and Lennon 1999). The subsequent movement of more southern species into northern clines will likely result in changes to already established competitor and mutualistic interactions, and predator-prey relationships (Hughes 2000). Such changes may be associated with a disruption in the current distribution and abundance of populations inhabiting the Arctic tundra ecosystem.

Effects of changes in the timing of critical life cycle events

Increases in mean annual temperature and the number of degree days above freezing could also cause changes in the timing of critical life history events, such as a decrease in the length of insect larval stages and earlier egg laying in birds (Crick and Sparks 1999; Hughes 2000). Similar advances in the timing of flowering and berry production may be expected, and could change the foraging behaviour and habitat use of several animal species including grizzly bears. Alterations in the temporal and spatial patterns of foraging behaviour and habitat selection in some species could also modify other species relationships in the ecosystem.

Estimating the combined influence of environmental variation and project development on wildlife populations is extremely difficult

Thus, large-scale environmental variation in weather patterns may modify the distribution and life history events of plant and animal species across space and time. However, there is a high degree of uncertainty in predicting the influence of large-scale environmental variation and concurrent project development on the stability and resilience of populations, and the ecosystem.

Any factor that influences population stability is a disturbance

Ecosystems and populations exhibit differences in stability and resilience. Stability is the ability of a population to return to an equilibrium state after a disturbance (*i.e*., reversibility). Any environmental factor (*e.g.*, predation, food resources, adverse weather, human development) that causes a shift in population size from the current equilibrium state represents a disturbance. Populations that return quickly to an equilibrium state, and with few fluctuations, exhibit the greatest stability (Holling 1973; Sinclair and Pech 1996).

Population resilience to a disturbance is tightly coupled with the likelihood of persistence

Resilience, on the other hand, is the ability of a population to persist during and after a disturbance by absorbing or responding to changes in environmental factors that influence life history traits (*e.g.,* survival and reproductive rates). Persistence, or probability of extinction, can be thought of as a product of the evolutionary history and adaptations accumulated by a species (or population) while experiencing a range of random fluctuations (*i.e.,* changes in population size) through space and time (Holling 1973). If the magnitude, duration, and geographic extent of a disturbance (*i.e*., environmental consequence), such as the cumulative effects of mining operations and environmental variation, are beyond that historically encountered and outside the adaptive ability (*i.e.,* little or no resilience) of a species, then the likelihood of persistence decreases.

Although disturbance may change the current state of an ecosystem, it may not be detrimental

Alternatively, the effect of disturbance may only alter the current state of the ecosystem without substantially changing the structure (*i.e.*, populations) and function. Similar to populations, ecological communities tend to preserve information about every event in their history and are continuously in the process of responding to their own unique history of interactions (Matthews *et al*. 1996; Landis *et al*. 2000a; Sandberg and Landis 2001). This theory suggests that ecological systems are complex, nonequilibrium systems and that our assumption that ecosystems can be "managed" in order to preserve or return to some pre-stressed state is spurious (Landis and McLaughlin 2000). Instead, ecosystem management must recognize that the post-development state of the ecosystem will be different – it may be equally functional with the desired structure, but it will not be the same as before development.

12.8 ENVIRONMENTAL HEALTH

The environmental health CEA includes an assessment of wildlife health (Section 12.8.1) and human health (Section 12.8.2).

12.8.1 Wildlife Health Impact Analysis

12.8.1.1 Introduction

A qualitative risk assessment approach was used to evaluate wildlife health

A qualitative risk assessment approach was used to evaluate wildlife health in the CEA. The risk assessment was qualitative because predicted concentrations of metals and other chemicals in soil, air, snow, and plants were not available from all of the sources considered in the CEA (Section 12.1). Therefore, a qualitative approach was used to assess the likelihood that unacceptable health risks could occur in wildlife in the CEA study region. Risk assessment principles were used throughout the assessment.

Study area for environmental health was defined by the annual home range of the Bathurst caribou herd

Due to the close association between wildlife and traditional land users the spatial boundary for environmental health was defined by the annual home range of the Bathurst caribou herd. Traditional knowledge (Section 10.4) and information from female caribou fitted with satellite collars (RWED), indicates that annual home range size varies among years, but typically falls within the boundary outlined in Figure 12.8-1. Grizzly bears, wolves and wolverines also travel large distances over this area of the SGP and have the potential to be influenced by several projects (McLoughlin *et al*. 1999; Mulders 2000; Walton *et al*. 2001).

12.8.1.1.1 Constraints to the Assessment of Cumulative Effects on Wildlife Health

There is a lack of knowledge of the cumulative effects of multiple environmental stressors

There are several major weaknesses in our existing knowledge of the cumulative effects of multiple environmental stressors. There is a lack of knowledge on how stressors that commonly occur together act when combined (*i.e.*, independent, additive, synergistic, antagonistic). For example, the combined effects of increased metals, increased persistent organic pollutants, and increased exposure to petroleum hydrocarbons is not

Figure 12.8-1 Spatial Boundary for Assessing Cumulative Effects on Environmental Health

well understood. Yet, this particular combination of stressors is very common. Furthermore, it is very difficult to predict the effect of multiple stressors in the presence of important environmental confounding factors. For example, the presence of organic carbon in soils or sediments can significantly affect the bioavailability and toxicity of certain metals. Other confounding variables include pH, the particle size of soils, water hardness, and the high natural variability of habitat use by migratory animals such as caribou. Studies of the effects of these variables in multiple stressor situations are lacking.

Studies of the cumulative effects of very low concentrations of toxic materials are lacking

Studies of the cumulative effects of very low concentrations of toxic materials are lacking. Our understanding of the effects of chemical stressors such as metals and pesticides is based largely upon laboratory studies that may not have used environmentally realistic concentrations, or upon field studies where frank pollution effects were evident because of lack of treatment (*e.g.*, abandoned mine sites; pulp mill effluents prior to secondary treatment). Modern facilities do not produce such high concentrations of environmental stressors. The effects of very low concentrations of toxic materials, plus other stressors such as decreased body condition are poorly understood.

Quantitative assessment of cumulative effects requires data from sophisticated scientific studies

Quantitative assessment of cumulative effects requires information on mechanisms of action of multiple stressors. This requires the ability to experimentally add, subtract, and vary the intensity of individual stressors. In large part, this can only be done through the use of artificial systems (*e.g.*, mesocosms). These experimental data must then be linked with data on temporal and spatial patterns observed in the field. These kinds of linkages have not received sufficient attention in past studies, although some promising approaches are being developed (*e.g.*, Culp *et al*. 2000). Furthermore, understanding of temporal patterns requires long-term data sets. Some examples of multivariate data analysis techniques for analyzing such long-term data sets are available (*e.g.*, Lowell *et al*. 2000).

This assessment relies primarily on logic and common sense

The general lack of knowledge of multiple stressor effects significantly constrains the ability to conduct a CEA. Consequently, this assessment relies primarily on logic and common sense.

12.8.1.2 Key Question CEH-1: What Cumulative Impacts Will the Snap Lake Diamond Project and Other Regional Developments Have on Wildlife Health?

12.8.1.2.1 Linkage Analysis (Problem Formulation)

The linkage analysis defines objectives and scope

The linkage analysis (or problem formulation) step of the wildlife health CEA defines receptors (*i.e.*, wildlife VECs or other species with the greatest potential for exposure to chemical emissions from the Snap Lake Diamond Project and other regional developments), the chemicals of concern, and the pathways by which wildlife may be exposed.

12.8.1.2.2 Receptor Selection

Wildlife receptors evaluated in the cumulative effects assessment are the same as evaluated in the application case

Wildlife receptors evaluated in the CEA are the same as those evaluated in the wildlife health application case (Section 11.3.2.1.1). However, for the CEA the receptors were categorized as animals with small home ranges, animals with large home ranges and migratory animals (Table 12.8-1). Animals with small home ranges will not be exposed to chemicals emitted from more than one project since they do not forage over large distances. Some animals with large home ranges or those that are migratory could forage throughout the study region (depending on their habitat area and seasonal habitat use). Therefore, it is possible that they could be exposed to chemicals in air, soil, plants, water, and snow from more than one project.

Table 12.8-1 Receptors Evaluated in the CEA

Receptor	Small Home Range	Large Home Range	Migratory
Caribou (Bathurst herd)			✓
Peregrine falcon			✓
Common loon			✓
Mallard duck			✓
Semi-palmated plover			✓
Wolverine		✓	
Grizzly bear		✓	
Wolf		✓	
Fox (red and Arctic)	✓		
Willow ptarmigan	✓		
Arctic ground squirrel	✓		

12.8.1.2.3 Chemicals of Concern (Chemical Identification)

There are four groups of chemicals of concern in the cumulative effects assessment case

Chemical screening for the CEA is different than in the impact assessment because predicted or measured chemical concentrations in soil, air, plants and snow are not available for all the regional sources. Therefore, instead of identifying specific chemicals of concern, groups of chemicals that wildlife could be exposed to from regional sources are identified. The following four groups of chemicals may be found in the regional environment (Table 12.8-2):

- metals that biomagnify (mercury, selenium);
- metals that do not biomagnify (aluminum, barium);
- polycyclic aromatic hydrocarbons (PAHs); and,
- persistent organic pollutants.

Table 12.8-2 Chemicals that might be Emitted by the Projects Evaluated in the Cumulative Effects Assessment

Chemicals	Snap Lake Diamond Project	Tibbitt-Contwoyto Winter Road	Diavik Diamond Mine	EKATI™ Diamond Mine	Tahera Diamond Mine	Lupin Gold Mine	Transboundary Air Pollution
Metals (non-biomagnifying)	✓	✓	✓	✓	✓	✓	
Metals (biomagnifying)							✓
PAHs	✓	✓	✓	✓	✓	✓	
Persistent organic pollutants							✓

Chemicals of concern in the cumulative effects assessment case are from varying sources

Metals that biomagnify in food chains, such as mercury, increase in concentration with each successive step in the food chain. This increase up the food chain can be related to the transformation of these metals (by bacteria) into methylated forms. The methylated forms are more readily taken up into tissues. Thus, even if concentrations in soil or water are low, animals at the top of the food chain (*e.g.*, grizzly bears) may be exposed to higher concentrations. Metals that biomagnify can be a component of transboundary pollution.

Non-biomagnifying metals are not readily absorbed by predators

Metals that do not magnify through the food chain are more readily metabolized by animals, are not subject to transformations that lead to enhanced uptake into tissues, and may also accumulate in non-digestible tissues such as exoskeletons or bone and thus are not absorbed through the digestive tract of predators. These metals can be emitted from processing and handling of kimberlite and gold and by burning fossil fuels.

Polycyclic aromatic hydrocarbons are emitted from diesel fuel emissions and burning wood

PAHs are products of incomplete combustion of fossil fuels (*i.e.*, diesel fuel in trucks and generators) and burning wood (*i.e.*, wood-burning stoves).

Persistent organic pollutants are readily absorbed and retained in fatty tissue of Arctic animals

Persistent organic pollutants (POPs) include pesticides (*e.g.*, DDT, mirex, toxaphene), industrial by-products (*e.g.*, dioxins and furans), and polychlorinated biphenyls (PCBs). The primary source of POPs in the north is airborne transport from other countries (Van Oostdam *et al*. 1999). This is due to a 'leap-frog' effect or 'cold condensation' effect, which results from chemicals that volatilize to air when used in tropical countries. Air currents transport these airborne chemicals to the north. As the temperature declines at northern latitudes, the chemicals deposit onto plants, soil and water. POPs are readily absorbed and retained in fatty tissue and since Arctic animals use fatty tissue as body insulation, they are at greater risk for high body burdens of these chemicals. Due to their persistence in the environment, the fact that northern climates are a sink for chemicals used in tropical countries and due to the fact that POPs biomagnify, POPs are a much greater concern for wildlife exposure than chemicals emitted from local industry (*i.e*., diamond mines).

12.8.1.2.4 Exposure Pathways and Linkage Analysis

Exposure pathways are the routes by which wildlife may be exposed

Exposure pathways are the routes by which wildlife may be exposed to chemicals. This forms the basis for the key questions and linkages that are evaluated in the CEA. As in the impact assessment, wildlife can be directly exposed to chemicals by drinking water or snow, or through inhalation and indirectly exposed to chemicals by eating plants, soil and prey.

Sources of chemicals are geographically distant from each other

The seven sources of chemical exposure for wildlife in the CEA are geographically distant from each other. It is not expected that the zone of influence of chemicals emitted from one project will overlap with the zone of influence of any of the other projects (with the exception of Diavik and EKATI™; Section 12.4). Therefore, extensive chemical exposure can only occur by the movement of wildlife from one project area to another. Animals with small home ranges (*i.e.*, Arctic ground squirrel, ptarmigan and fox) are likely to be exposed to emissions from one project only. They do not roam across large distances and therefore are not directly exposed to each of the projects. Transboundary pollution is omnipresent in the NWT; therefore it is possible that small mammals will be exposed to transboundary pollutants via inhalation (Table 12.8-3).

Table 12.8-3 Projects that May Affect Wildlife

Receptors	Snap Lake Diamond Project	Tibbitt-Contwoyto Winter Road	Diavik Diamond Mine	EKATI™ Diamond Mine	Tahera Diamond Mine	Lupin Gold Mine	Transboundary Air Pollution
Small Home Range							
Arctic ground squirrel	✓						✓
Ptarmigan	✓						✓
Fox	✓						✓
Large Home Range							
Grizzly bear	✓		✓	✓	✓	✓	✓
Wolverine	✓	✓	✓	✓			✓
Wolf	✓	✓	✓	✓			✓
Migratory							
Caribou	✓	✓	✓	✓	✓	✓	✓
Peregrine Falcon	✓						✓
Common loon	✓						✓
Mallard duck	✓						✓
Semi-palmated plover	✓						✓

Wildlife with large home ranges may be exposed to chemicals from more than one project

Migratory animals and wildlife with large home ranges have greater potential to be directly exposed to chemicals emitted from more than project. Caribou (migratory) and grizzly bear (large home range) could potentially be exposed to emissions from all of the CEA projects. That is, their roaming area is broad enough that they could be in the direct vicinity of any or all of the projects. Wolves (large home range), and wolverine (large home range) would not likely be in the vicinity of projects that are far north (*i.e.*, Lupin Gold Mine and Tahera Diamond Project) because the population that is influenced by Snap Lake would not contact projects in the far north (Section 12.7.4). The migratory range of loons, mallard ducks, peregrine falcon, and semi-palmated plovers does not extend to the more northerly projects; therefore, these species would be influenced only by the Snap Lake Diamond Project (Section 12.7.4).

Linkages between emissions and wildlife health were evaluated

The potential linkages between the Snap Lake Diamond Project and other regional developments and wildlife health were evaluated to answer Key Question CEH-1. The following four linkages were analyzed:

- linkage between changes in air quality and wildlife health;
- linkage between changes in soil quality and wildlife health;
- linkage between changes in water and snow quality and wildlife health; and,

- linkage between changes in plant/prey tissue quality and wildlife health.

Air Quality Linkage

All wildlife are exposed to airborne chemicals

All wildlife receptors may be exposed to airborne chemicals that are emitted from the Snap Lake Diamond Project and transboundary pollution. Wolves and wolverines are also exposed to airborne emissions from the winter road, Diavik and EKATI™. Grizzly bears and caribou are exposed to all CEA sources due to the vast areas of their home ranges. Therefore, the air quality linkage is valid and was qualitatively evaluated further in the CEA.

Soil Quality Linkage

Wildlife inadvertently ingest soil while feeding

All wildlife receptors may be exposed to airborne chemicals that are deposited on soil from the Snap Lake Diamond Project and transboundary pollution. Wolves and wolverines are also exposed to chemicals in soil in areas near the winter road, Diavik and EKATI™. Grizzly bears and caribou are exposed to all CEA sources due to the vast areas of their home ranges. This linkage is valid for all species and ingestion of chemicals from soil was qualitatively evaluated in the impact assessment.

Water and Snow Quality Linkage

Snow is a source of drinking water

Fugitive dust emitted from the seven sources may deposit onto snow. Wildlife may use snow as a source of drinking water during winter. This linkage is valid only for wildlife species active in the study area during winter (*i.e.*, caribou, wolverine, wolf, and fox). Caribou could be exposed to all seven sources. Wolves and wolverines are exposed to chemicals deposited on snow in areas near the Snap Lake, the winter road, Diavik and EKATI™, in addition to deposition from transboundary pollution. Foxes could be exposed to deposition on snow from Snap Lake and transboundary pollution. Therefore, the linkage is valid and ingestion of chemicals in snow was qualitatively evaluated for these receptors.

Wildlife may drink from on-site collection ponds

Animals that may spend time in the vicinity of more than one project could drink from on-site standing water (*i.e.*, drainage collection ponds). Therefore, this linkage is valid for grizzly bears, wolves, caribou, and wolverine.

Wildlife may be exposed to chemicals in water throughout the study area

Grizzly bears, wolves, caribou and wolverine drink from water bodies throughout the CEA study area. As a result, these receptors could be exposed to chemicals in these water bodies. Chemicals may be present due to emissions from regional projects, transboundary pollution and also from naturally occurring sources. Therefore, this linkage is valid for grizzly bears, wolves, caribou, and wolverine.

Plant/Prey Tissue Quality Linkage

Wildlife may be exposed to chemicals by ingesting plants

Fugitive dust emitted from the seven sources may deposit directly onto the surface of plants or may deposit onto soils and be subsequently taken up through plant roots. Wildlife may be exposed to chemicals by ingesting plants that have taken up chemicals from the seven sources evaluated in the CEA. This linkage is valid for animals that eat plants as large component of diets from various regions (*i.e.*, caribou, and grizzly bear) and animals that eat plants in the Snap Lake Diamond Project LSA and RSA, including the area of the winter road (*i.e.*, ptarmigan and Arctic ground squirrel). Therefore, the linkage is valid and ingestion of chemical from plants was qualitatively evaluated for these receptors.

Wildlife may be exposed to chemicals by ingesting prey

Some of the wildlife species evaluated in the CEA are carnivores. These species may be exposed to chemicals if their prey have consumed impacted water, soil or vegetation. This linkage is valid only for wildlife species that are carnivorous (*i.e.*, grizzly bear, wolverine, wolf, peregrine and fox) and the loon, which eats fish. Therefore, the linkage was evaluated in the impact assessment for these receptors.

12.8.1.3 Impact Analysis

The impact analysis includes the following:

- exposure assessment – estimates the amount of a chemical a receptor may take into its body through all applicable exposure pathways;
- toxicity assessment – defines the toxicity of the chemicals of concern;
- risk characterization – defines the potential for a health risk to occur and,
- residual impact classification – defines the magnitude of impact and resultant environmental consequence of the Snap Lake Diamond Project and other regional developments to wildlife health.

12.8.1.3.1 Exposure Assessment

The exposure assessment determines the amount of exposure

The exposure assessment is a process for determining the amount of each chemical that each receptor is likely to be exposed to from all sources considered in the CEA.

Temporal and spatial boundaries are required for the cumulative effects assessment

Spatial boundaries are required to define the geographic area that each receptor is likely to inhabit. Temporal boundaries of the assessment are defined by the time-frame of exposure for each receptor relative to its life history and seasonal habitat use, the time-frame for each development's operational phase, and consideration of whether it is necessary to include exposure during the post-closure phase of each development.

Temporal and Spatial Boundaries

The timeline is the operations phase

The wildlife health exposure assessment includes the timeline for operational phases of all regional developments within the timeline of the operation timeline of the Snap Lake Diamond Project. The post-closure phase is not included because it was assumed that chemical concentrations at the various mine sites during the post-closure phase would be considerably decreased once emissions ceased. Furthermore, it was assumed that reclamation activities would greatly reduce the potential for exposure by isolating materials with elevated chemical concentrations under rock, soil or water covers.

The spatial boundary is the migratory range of caribou

The spatial boundary of the wildlife health CEA includes the migratory home range of the Bathurst caribou (Section 12.7.4). This area comprises the largest roaming area of any of the VECs.

Exposure Estimates

Professional judgement was used to predict concentrations of chemicals for the cumulative effects assessment case

It was not possible to produce quantitative estimates of the cumulative exposure to chemicals because chemical concentrations in soil, air, snow, and plants were not available for all regional sources (projects not including the Snap Lake Diamond Project). Therefore, a qualitative estimate of the relative concentrations associated with the other regional sources compared to the Snap Lake Diamond Project was developed. Exposure time and feeding habits were assumed to be the same as evaluated for the Snap Lake Diamond Project. It was also assumed that animals spent equal times within the zone of influence of each project.

Relative concentrations from regional projects were estimated

Data on chemical concentrations gathered during monitoring programs were available for air, soil, snow, and water at EKATI™ (BHP 1998a,b,c; 2000) and water data were available from Diavik Diamonds Project (1998a,b,d). These data were reviewed to estimate the relative concentration of metals measured in media in the vicinity of these projects in comparison to the Snap Lake Diamond Project. No data were available for any of the other projects. Concentrations from Diavik, in media other than water, were estimated to be similar to EKATI™. Tahera Jericho is a diamond project of smaller than the Snap Lake Diamond Project and includes open pit mining.

Because of the open pit mining, it was judged that relative concentrations associated with the Tahera Jericho project would be 1.5 times those predicted for the Snap Lake Diamond Project. Chemical data for the winter road were also estimated. Since the winter road is only operable during the winter, relative concentrations were estimated to be half that of the Snap Lake Diamond Project. This is likely over-estimated since the winter road does not in itself emit chemicals. Emissions are associated with the volume of traffic and the quality of air emissions from trucks.

Qualitative rankings of relative chemical concentrations are derived relative to the predicted concentrations at the Snap Lake Diamond Project

Qualitative rankings of relative chemical concentrations are presented in Table 12.8-4. The rankings are derived relative to the predicted concentrations at the Snap Lake Diamond Project. Chemical concentrations from the Lupin Gold Mine and from transboundary pollution were not compared to Snap Lake Diamond Project emissions because of their much different composition (see Table 12.8-2).

Table 12.8-4 Qualitative Rankings of Relative Concentrations from Diamond Mines and the Winter Road Compared to the Snap Lake Diamond Project

Media	Snap Lake Diamond Project	Diavik [(a)]	EKATI™ [(b)]	Tahera Jericho Project [(a)]	Winter Road[(a)]
Air	1	1	1	1.5	0.5
Soil	1	4	4	1.5	0.5
Vegetation	1	2	2 [1]	1.5	0.5
Snow	1	1.5	1.5	1.5	1
Water	1	2 [(c)]	2	1.5	0.5

[(a)] Estimated based on professional judgement.
[(b)] Based on data from BHP 1998a,b,d; 2000.
[(c)] Based on data from Diavik Diamonds Project 1998a,b,d.

12.8.1.3.2 Toxicity Assessment

Toxicity Assessment in CEA

There are no broadly accepted methods for estimating the toxicity of complex chemical mixtures

Assessment of the cumulative effects of exposure to complex chemical mixtures is very challenging because there are no broadly accepted methods. The lack of methods reflects the lack of basic scientific understanding of how chemical mixtures interact. The chemical groups identified in Section 12.8.1.2.3 behave differently in the environment and have different toxicity endpoints. Wildlife that roam throughout the CEA study area may be exposed to several different chemicals. Toxicity to individual animals resulting from exposure to a complex mixture of chemicals is difficult to determine. The effects on the overall population are even more difficult to predict.

Effects of combinations of non-biomagnifying metals cannot be predicted with any confidence

Studies of the effects of exposure to a mixture of non-biomagnifying metals are lacking. Although some observational studies have been useful in identifying the general attributes of metal-degraded ecosystems, the actual role of particular metals versus the role of metal mixtures is difficult to deduce from these data. Furthermore, the ecological processes leading to the resulting communities are not identified. Thus, the ability to predict the response of a particular population or community is limited. For example, it is usually impossible to predict with any confidence that a vegetation community will include specific taxa and the required biomass to support herbivore populations in the presence of a particular list of metals. This is because the relationships identified in the literature are almost always with grouped variables. These grouped variables usually include a list of several metals, plus modifying variables such as pH or soil texture.

Even fewer studies of combinations exist on mixtures and polycyclic aromatic hydrocarbons

Predictions of the effects of a combination of metals and PAHs are even more difficult. No studies of the effects of exposure to metals plus PAHs could be found in the literature.

There are very few generalized models of multiple stressor effects

The current literature provides, at best, a series of site-specific glimpses of the response of ecological communities and ecosystems to multiple stressors. The definition of the problem provided by authors is usually very focused on a particular site or a particular combination of stressors. There is seldom, if ever, any reference to a more generalized model of multiple stressor effects apart from the discussion of the expectations regarding additivity versus synergism. Many articles that purport to be multiple stressor studies do not go beyond an inventory of the various stresses and upsets affecting the ecosystem, without even attempting to assess the interactions among them (Bailey *et al*. 1996; Bont *et al*. 1999). Even the regional risk-ranking model of risk assessment championed by Landis *et al*. (1998; 2000b) merely adds up all the stresses affecting different areas within the region, without attempting to compute their interactive effects.

The most common assumption used in the multiple stressor literature is that interactions will be additive

We can anticipate that populations and communities will respond to stress in a predictable, linear fashion (above a lower threshold) because increasingly less sensitive individuals or species will be removed as the intensity of the stressor(s) increases. The effect of multiple chemical stressors is probably more often additive than synergistic or antagonistic at the population level (U.S. EPA 1998).

Because of the lack of data from each of the seven sources considered in this CEA and the lack of a generalized model of multiple stressor effects, this assessment had to rely on professional judgement

There is a lack of both theory and tools for dealing with the so-called "class 4" type of multiple stressor problem. A class 4 problem is one with multiple classes of stressors (chemical, physical and biological) from multiple sources with interactions acting upon multiple ecological receptors (Harwell and Gentile 2000). This CEA qualifies as a class 4 problem. "Class 4 assessments necessarily involve the statistical and modelling tools of less complex problems but further require weight-of-evidence approaches and, ultimately, expert judgement and adaptive management..." (Harwell and Gentile 2000). There were insufficient quantitative data to allow the use of modelling to predict exposure to the chemicals of concern in the CEA study area. There were also insufficient monitoring data to allow for a quantitative assessment of possible effects. Therefore, the assessment of the possible toxicity of the combination of chemical stressors in this CEA had to rely on professional judgement.

Information Used in the Toxicity Assessment

The toxicity assessment for the application case was carried forward to the cumulative effects assessment for the non-biomagnifying metals and polycyclic aromatic hydrocarbons

The potential toxicity of non-biomagnifying metals and PAHs (the chemicals of concern for the wildlife health assessment of the Snap Lake Diamond Project) is described in Appendix IX.1. This information formed the basis for the assessment of the potential for effects in the application case. The potential for effects was evaluated using exposure ratios (ERs), which are the ratio of predicted exposure to toxicity thresholds. The ERs for each of the chemicals of concern at the Snap Lake Diamond Project were carried forward to the CEA.

The toxicity assessment of transboundary pollutants was based on data from the Northern Contaminants program

The Northern Contaminants program (Arctic Environmental Strategy, DIAND) has monitored transboundary pollutants (pesticides, industrial by-products, PCBs and bio-magnifying metals such as mercury) across the north. These data formed the basis for the toxicity assessment of transboundary pollutants in the CEA.

Toxicity assessment of potential chemicals of concern at the Lupin mine was not possible because of the lack of data from this site

Toxicity assessment of potential chemicals of concern at the Lupin mine was not possible because of a lack of data. The only data found were some very limited measurements of some metals in lake sediments. Therefore, screening for chemicals of concern was not possible. Without a defensible list of chemicals of concern, no assumptions could be made regarding potential exposure to receptors at the Lupin Mine because there was no way of determining what chemicals exceeded soil or water quality guidelines or baseline concentrations. Notwithstanding the lack of data available from the Lupin Mine, it is unlikely that the Lupin Mine is a source of exposure to potentially harmful chemicals relative to transboundary pollution. The nature of the chemicals emitted from the Lupin Mine are different from transboundary pollution in that they are non-biomagnifying.

Results of the Toxicity Assessment

Exposure to transboundary pollutants has not been linked with effects, except in peregrine falcons

Results of the Northern Contaminants program (Jensen *et al*. 1997) indicate that with the exception of peregrine falcons, it is not possible to link concentrations of transboundary pollutants to effects on individual or population health effects in Arctic wildlife. However, effects shown in birds such as the peregrine falcon, indicate that some transboundary pollutants can cause effects on reproduction and egg development. Other effects of transboundary pollutants include endocrine and immune system effects. Bio-magnifying metals transported across boundaries are of concern because concentrations can reach toxic levels via the food chain. In general, biomagnifying metals affect organs (liver and kidney), the central nervous system and endocrine systems (Amdur *et al*. 1991).

Cumulative effects from exposure to potential chemicals of concern at the Lupin mine could not be estimated

The almost complete lack of data on potential chemicals of concern in soil, air, water or sediments at the Lupin Mine prevents the assessment of cumulative effects from exposure at this site. General experience with gold mines has shown that chemicals of concern often include arsenic and cyanide. Other metals may also be present. However, without any measured concentrations of arsenic, cyanide or other metals, concentrations relative to the Snap Lake Diamond Project could not be estimated and summed ERs could not be produced.

12.8.1.3.3 Risk Characterization

The estimated risk for the combination of non-biomagnifying metals and polycyclic aromatic hydrocarbons was based on crude calculations that assumed additivity of effects to the most-exposed species

The potential cumulative effects from exposure to chemicals of concern from diamond mines and the winter road were estimated by summing the ERs resulting from the relative concentrations at each of the sources (Table 12.8-4). This was done for the grizzly bear and caribou; the two receptors potentially exposed to all CEA sources. If the sum of the ERs was less than one for these two species, then it could be assumed that the summed ERs for the other receptors would also be less than one. This assumption is based upon two subsidiary assumptions: (1) the sensitivity of the receptors is similar; therefore, the toxicity thresholds are similar; (2) grizzly and caribou represent the maximum exposure with respect to CEA sources and exposure pathways.

All exposure ratios for non-biomagnifying metals and polycyclic aromatic hydrocarbons were less than one

All summed ERs for non-biomagnifying metals and PAHs were less than one, except for aluminum. Aluminum concentrations are naturally elevated in the north. In addition, it is difficult to estimate the availability of aluminum in soil (refer to Section 11.3.2.3.6). Therefore, CEA predictions are likely over-estimated. Since ERs for grizzly bear and caribou were less than one or due to naturally elevated concentrations, it was assumed that the ERs for the other receptors would also be acceptable.

The Snap Lake Diamond Project is not expected to significantly increase cumulative impacts from exposure to chemicals associated with diamond mines and the winter road in the cumulative effects assessment study area

The Snap Lake Diamond Project is not expected to contribute considerable additional risks from exposure to chemicals of concern in the CEA study area. The risks to wildlife health from the Snap Lake Diamond Project alone are negligible since ERs are less than 1 for each exposure pathway (or linkage) (Section 11.3.2.3.6) except for aluminum, which is naturally present at elevated concentrations. A cumulative ER one order of magnitude higher than calculated for the Snap Lake Diamond Project alone was estimated for animals that could be exposed to emissions from all of the other diamond projects and the winter road (*i.e.*, grizzly bear and caribou). The crudely estimated ERs are still much less than 1, except for aluminum, which is present in baseline conditions at a naturally elevated concentration.

A cumulative effect from exposure to Snap Lake Diamond Project chemicals plus transboundary pollution is unlikely

The additional cumulative health effect of transboundary pollutants plus chemicals from the Snap Lake Diamond Project cannot be estimated with any confidence because of the lack of any broadly accepted methods for estimating combined effects of such disparate chemicals. However, based on the lack of biological findings in the Northern Contaminants program (except for peregrine falcon) (Jensen *et al*. 1997) and cumulative ERs from diamond projects and the winter road, cumulative health effects would not be expected. Effects in peregrine falcon from body burdens of transboundary pollutants have been recorded; however, the chemicals of concern at diamond mines and the winter road are very different from those transported in transboundary pollution and are present in very low concentrations (barely above background). Therefore, cumulative effects on peregrine falcon from the combination of transboundary pollutants and chemicals from diamond mines and the winter road are not expected.

Cumulative effects from exposure to Snap Lake Diamond Project chemicals plus chemicals at the Lupin Mine cannot be estimated

There is no way of estimating relative chemical concentrations at the Lupin mine compared to the Snap Lake Diamond Project; therefore, assessment of cumulative effects was not possible.

Certainty

Level of confidence is rated high that the Snap Lake Diamond Project is not contributing to an incremental health effect in wildlife in the region

There is a high level of confidence that risk estimates for the Snap Lake Diamond Project have not been underestimated because of the layers of safety employed in the risk assessment (Section 11.3). Therefore, there is a high level of certainty that the Snap Lake Diamond Project would not contribute to an incremental health effect in wildlife in the region.

There is a high degree of uncertainty in estimates of exposure from the other six sources in the cumulative effects assessment study area

There is a great deal of uncertainty associated with exposure to transboundary pollutants and exposure that wildlife may be acquiring as a result of their large home ranges throughout the project boundaries of the other regional sources. Estimated exposure was based almost solely on professional judgement

Level of confidence in the overall assessment of cumulative exposure and effects is low because of the lack of broadly accepted methods for estimating effects of complex chemical mixtures

A confident assessment of the cumulative effects of exposure to the seven sources in the CEA study area was not possible because of the lack of a firm scientific basis for the evaluation of the effects of complex chemical mixtures. The crude estimates of total exposure to chemicals associated with diamond mines and the winter road are an attempt at illustrating what the relative risk may be from non-biomagnifying metals and PAHs. However, the combined effects of non-biomagnifying metals, PAHs, transboundary pollutants and chemicals at the Lupin Gold Mine could not be estimated.

12.8.1.3.4 Residual Impact Classification

Residual impacts from the combined exposure to chemicals from all cumulative effects assessment sources could not be rated; however incremental effects on wildlife health from the Snap Lake Diamond Project are highly unlikely

The residual impacts from the combined exposure to chemicals of concern from diamond mines, the winter road, the Lupin mine and transboundary pollution could not be rated because of the lack of any broadly accepted method for evaluating the effects of complex chemical mixtures. However, considering the very low incremental contribution of the Snap Lake Diamond Project to cumulative exposure, it is highly unlikely that the project would lead to any incremental increase in wildlife disease, growth impairment or reduction in reproduction.

12.8.2 Human Health Impact Analysis

12.8.2.1 Introduction

A qualitative risk assessment approach was used for the human health assessment

A qualitative risk assessment approach was used to evaluate human health in the CEA. The risk assessment was qualitative because concentrations of metals and other chemicals in soil, air, snow, and plants were not available from all the regional sources considered in the CEA (Section 12.1.4.2). Therefore, a qualitative approach was used to discuss the likelihood that unacceptable health risks could occur in humans ingesting game hunted from the CEA study region. Risk assessment principles were used to throughout the assessment.

12.8.2.2 Key Question CEH-2: What Cumulative Impacts Will the Snap Lake Diamond Project and Other Regional Developments Have on Human Health?

12.8.2.2.1 Linkage Analysis (Problem Formulation)

The linkage analysis defines the objectives and scope

The linkage analysis (or problem formulation) step of the assessment defines the objectives and scope of assessment. It includes the definition of receptors (*i.e.*, members of the population that are most likely to be exposed to emissions from the Snap Lake Diamond Project and regional developments), the chemicals of concern and the pathways by which people may be exposed.

12.8.2.2.2 Receptor Selection

The human health assessment addresses consumption of traditional foods

The human health CEA addresses non-occupational, involuntary exposure to chemicals released by the Snap Lake Diamond Project and other regional developments. The most likely type of non-occupational exposure would be to people who consume traditional foods (*i.e.*, game) hunted from the CEA study area. Wildlife may accumulate chemicals from the Snap Lake Diamond Project and other regional developments; therefore, indirect exposure to people that hunt and fish may occur through consumption of traditional foods. People that hunt and fish in the area are unlikely to be exposed to more than one regional development because sources of airborne chemicals are distant from each other (Section 12.4).

12.8.2.2.3 Chemicals of Concern

There are four groups of chemicals of concern in the cumulative effects assessment case

As described in the wildlife health assessment, chemical screening for the CEA is different than in the impact assessment because chemical concentrations in soil, air, plants and snow are not available for all regional sources. Therefore, instead of identifying specific chemicals of concern, the same groups of chemicals that were evaluated in the wildlife CEA case were evaluated in the human health assessment.

12.8.2.2.4 Exposure Pathways and Linkage Analysis

Exposure pathways are the scenarios by which people may be exposed

Exposure pathways are the scenarios by which people may be exposed to emissions from the Snap Lake Diamond Project and other regional developments. This forms the basis for the key question and linkage analysis.

The potential linkages between emissions and human health were evaluated

The potential linkages between the Snap Lake Diamond Project and other regional sources, and human health were evaluated to answer Key Question CEH-2 (Figure 11.3-4). The following three linkages were analyzed:

- linkage between changes in air quality and human health;
- linkage between changes in water and snow quality and human health; and,
- linkage between changes in plant/animal tissue quality and human health.

Air Quality Linkage

People will not be exposed to chemicals from regional developments and the Snap Lake Diamond Project via direct inhalation

All chemical sources in the CEA emit airborne chemicals. However, chemical concentrations in air will not have a cumulative effect due to the distances that separate the projects (Section 12.4). Therefore, this linkage is invalid and was not evaluated in the assessment.

Water Quality Linkage

People will not be exposed to chemicals from regional developments and the Snap Lake Diamond Project via ingestion of water

People living in the closest communities to the Snap Lake Diamond Project do not receive drinking water from Snap Lake or any other surface water body directly affected by regional developments. Therefore, this linkage is invalid and was not evaluated in the assessment.

Plant Tissue Quality Linkage

Hunters do not bring large quantities of vegetation home

The majority of the vegetables and fruits eaten by people in the communities are from sources other than the CEA study area (Lutsel K'e Dene First Nation 2001). Although people may be indirectly exposed to chemicals in plants that have been consumed by game animals, the direct linkage between plants and people is invalid and was not addressed in the CEA.

Animal Tissue Quality Linkage

Consumption of game meat was evaluated

People may eat meat from animals (primarily caribou) that been exposed to chemicals throughout the CEA study area. Therefore, indirect uptake of chemicals through consumption of game is possible. Thus, the linkage between changes in meat quality and human health is valid and was evaluated in the CEA.

12.8.2.3 Impact Analysis

12.8.2.3.1 Exposure Assessment

The exposure assessment determines the amount of exposure

The exposure assessment is a process for determining the amount of each chemical to which each receptor is likely to be exposed when the regional developments are in operation.

Temporal and spatial boundaries define the area of exposure

Temporal and spatial boundaries are required to define the area that caribou may be exposed to the regional developments and which communities may ingest game obtained from the CEA study area.

Temporal and Spatial Boundaries

Community members may hunt and eat traditional foods from within local and regional study areas

Communities closest to any of the developments in the CEA study area would not be impacted by dust emissions or water emissions from the regional developments (Sections 7.3 and 9.4). However, individuals from the following communities are most likely to be hunting wildlife and therefore eating traditional foods from within the CEA study area:

- Yellowknife
- Dettah;
- N'Dilo;
- Lutsel K'e;
- Rae/Edzo;
- Rae Lakes (Gameti);
- Wekweti; and,
- Wha Ti.

Exposure Estimates

Concentrations of chemicals could not be predicted for the cumulative effects assessment case

It was not possible to predict the concentrations of chemicals in caribou meat resulting from exposure to regional chemical sources because chemical concentrations in soil, air, snow, and plants were not available for all of the regional sources (projects not including the Snap Lake Diamond Project).

Toxicity Assessment

The cumulative effects assessment for human health assessed the safety of traditional foods

The CEA for human health assessed the safety of traditional foods (*i.e.*, caribou). Animals such as caribou migrate large distances and can be exposed to chemicals from many regional sources. In addition, caribou are exposed to transboundary pollution. While caribou health may not affected by this exposure, ingestion of caribou may be of concern. However, the toxicity associated with ingestion of game is not well characterized.

Toxicity of some chemicals associated with diamond mining are presented in Appendix XI.1

The toxicity of non-biomagnifying metals and PAHs that are associated with emissions from the Snap Lake Diamond Project and other diamond facilities is presented in Appendix XI.1.

Persistent organic pollutants can affect child development

POPs, including biomagnifying metals (*i.e.*, mercury), have been found in breast milk of Aboriginal women, presumably resulting from eating game and particularly fish (Jensen *et al*. 1997). The health effects associated with this exposure are subtle. Child development may be affected in children who are exposed to POPs during infancy and early childhood. In addition, POPs are expected to have endocrine and immune system effects (Van Oostdam *et al*. 1999).

It is unlikely that persistent organic pollutants and non-biomagnifying metals and polycyclic aromatic hydrocarbons will act synergistically

There have not been any studies that investigate the effects of metals and PAHs (similar to the emissions from the Snap Lake Diamond Project and other regional diamond mines and the winter road) in combination with POPs. It is unlikely that POPs and non-biomagnifying metals will act synergistically because they have different toxicity endpoints.

12.8.2.3.2 Risk Characterization

Traditional foods are extremely important for the complete health of Northwest Territories Aboriginals

Traditional foods, particularly caribou, are extremely important for the physical health and spiritual well being of NWT Aboriginals. Physical health is benefited because traditional foods are an important source of nutrients (Van Oostdam *et al*. 1999; Jensen *et al*. 1997). Spiritual health is benefited because traditional foods are the foundation of the values and culture of northern peoples (Lutsel K'e Dene First Nation 2001; Jensen *et al*. 1997).

Current traditional food consumption poses very little, if any, risk to health

A study that evaluated the chemical exposure among adult Dene and Métis in the Western NWT (including North Slave, Deh Cho, and South Slave communities) indicated that current traditional food consumption poses very little, if any, risk to health (Berti *et al*. 1998). This study evaluated the concentrations of arsenic, cadmium, lead, mercury and POPs in various fish, land mammal, beluga, and bird tissues and plants. Chemical concentrations were highest in organs such as liver and kidney, but according to a survey conducted by the authors, these organs are not consumed on a regular basis and did not pose a health risk when consumed occasionally (Berti *et al*. 1998).

Reduced consumption of traditional foods can be detrimental to health

Reduced consumption of traditional foods can be detrimental to the physical health of northern peoples. Traditional foods are an important source of vitamins, minerals and protein. Reduced consumption of traditional foods is associated with obesity, dental concerns, anemia, increased rates of infection (*i.e.*, colds) and diabetes (Van Oostdam *et al*. 1999; Jensen *et al*. 1997).

The addition of the Snap Lake Diamond Project to the chemical burden in caribou meat is negligible

Characterization of the risk to human health for the CEA case is difficult to predict due to the lack of information available from projects other than the Snap Lake Diamond Project and due to the difficulty of predicting chemical burdens from multiple sources. However, the risks to human health from the Snap Lake Diamond Project alone are negligible since ERs for consumption of traditional foods are several orders of magnitude less than 1 (Section 11.3.3.3.6). In addition, the importance of traditional foods for physical and spiritual health of northern people far outweighs the potential exposure to chemicals in caribou meat. Therefore, the addition of the Snap Lake Diamond Project to the chemical burden in caribou meat is negligible.

12.8.2.3.3 Certainty

Level of confidence is rated as high

There is a high level of confidence that risk estimates derived in the impact assessment have not been underestimated because of the layers of safety employed in the risk assessment (Section 11.3). Therefore, there is a high level of certainty that the Snap Lake Diamond Project is not contributing to a substantial chemical burden in traditional food in the region. In addition, dietary studies have indicated that current chemical exposure via traditional food does not pose a health risk (Berti *et al*. 1998; Van Oostdam *et al*. 1999).

12.8.2.3.4 Residual Impact Classification

Residual impacts from the combined exposure to chemicals from all cumulative effects assessment sources could not be rated; however incremental effects on human health from the Snap Lake Diamond Project are highly unlikely

The residual impacts from the combined exposure to chemicals of concern from diamond mines, the winter road, the Lupin mine and transboundary pollution could not be rated because of the lack of any broadly accepted method for evaluating the effects of complex chemical mixtures. However, considering the very low incremental contribution of the Snap Lake Diamond Project to cumulative exposure, it is highly unlikely that the project would lead to any incremental increase in adverse human health effects.

12.9 CONCLUSIONS

Cumulative effects are natural and human-related

Cumulative effects represent the sum of all natural and human-induced influences on the cultural, physical, biological, and economic components of the environment within a period of space and time. Many components of the environment can be subject to various effects brought about by changes to current conditions. Some changes may be human-related, such as implementing new policy or industrial development, and some changes may be associated with natural phenomena, such as periodic harsh or mild winters, or year-to-year differences in rainfall.

The EA for the Snap Lake project identified a range of local impacts

The EA for the Snap Lake Diamond Project identified a range of local impacts on the various cultural, physical, biological and economic components. For example, the Snap Lake project will have both positive and negative impacts on community employment, economic development, and cultural practices and traditions (Section 5). Traditional and non-traditional resource use will also be influenced by the project (Section 6) along with local and regional changes to air quality, noise levels, and below and above ground water flows and quality (Sections 7 – 9). Vegetation, fish and wildlife populations and their associated habitats will be affected (Section 9 and 10), and negligible changes in wildlife and human health are anticipated (Section 11).

Goal of the cumulative impact assessment

The next step is to determine if these local and regional impacts would combine with the effects from other current and reasonably foreseeable projects and activities in the SGP. At the same time, the influence of natural changes in environmental conditions is considered. Thus, the goal is to determine the chance and strength of the incremental cumulative impact from the Snap Lake project on cultural, physical, biological and economic components of the environment.

The Snap Lake project will have no cumulative impacts on a number of environmental components

The chance that cumulative impacts from the Snap Lake Diamond Project would occur for a number of components was negligible or non-existent. This was largely because the zone of impact associated with the Snap Lake project did not overlap the zone of impact from other projects and activities. With the exception of the Tibbitt-Contwoyto winter road, which is 23 km from the Snap Lake project, the closest development is a mining project (Diavik) which is 102 km from Snap Lake. In addition, the Snap Lake Diamond Project is located in the Taiga Shield ecozone, while the Diavik, EKATI™ and Tahera diamond projects and Lupin Gold Mine are located in the southern Arctic ecozone. Although some other activities, such as tourist lodges and hunting/fishing camps, are within 28 – 30 km of the Snap Lake project, they are still well outside the zone of impact for several components. For other components, like environmental noise from vehicle traffic, the zone of impact may overlap the Tibbitt-Contwoyto winter road, but the relatively short and seasonal use of the winter road limits the amount of time for cumulative impacts to occur (Section 12.5, Figure 12.9-1).

Figure 12.9-1 Classification of the Cumulative Residual Impacts of Noise During the Operation Phase and to Air Quality

There will be no negative cumulative impacts on resource uses, environmental noise, some wildlife species, geology, vegetation, terrain and biodiversity

Because of the distance separating the Snap Lake project from other projects and activities there is no overlap of negative impacts on traditional and non-traditional land use, visual quality of the environment, and noise (Section 12.3 and 12.5). The small home range of many wildlife species, such as foxes, songbirds, waterfowl and raptors, also precludes these animals from coming in contact with other projects during their daily, seasonal and annual movements (Section 12.7). Similarly, the impact that the Snap Lake project has on protected areas, geology, terrain, vegetation and biodiversity in the Taiga Shield ecozone does not overlap the impact on these components from other projects in the southern Arctic ecozone (Section 12.3 and 12.7).

There will be no cumulative impacts on water quality, water flow regimes, fish habitat and fish populations

At post-closure, the Snap Lake Diamond Project is anticipated to have a low to moderate environmental consequence on water quality, fish populations and fish habitat (Section 9). However, the impact on the Lockhart River drainage system will be limited to two lakes immediately adjacent to Snap Lake. Thus, the zone of impact is confined locally, and does not extend into the RSA (Section 9). In addition, because water in the Lockhart River system does not interact with water in the Coppermine-Lac de Gras drainage system, there is no chance that local impacts from the Snap Lake project on water quality and flow regimes will affect the Coppermine-Lac de Gras drainage system. Similarly, fish populations and fish habitat in the Coppermine-Lac de Gras system will not be impacted. All the other projects considered in the analysis of cumulative effects are located within the Coppermine-Lac de Gras drainage system. The lack of overlap between the two drainage systems prevents the Snap Lake project from generating any cumulative impacts, in association with other projects, on aquatic resources (Section 12.6).

The Snap Lake project will produce cumulative impacts on socio-economic components

For other components, such as socio-economics, heritage resources, air quality, some wildlife populations and human health, the chance that local and regional impacts from the Snap Lake Diamond Project will overlap with impacts from other projects is high. Current projects in the SGP (Diavik, EKATI™, Lupin mine and Tibbitt-Contwoyto winter road) are influencing many socio-economic aspects of small and larger communities (Section 12.2). Such influences include changes to employment and income, demand for skilled labour, regional economic development, education, social services and Aboriginal cultural practices and traditions. The Snap Lake project will have an incremental cumulative impact on these socio-economic elements, and the impacts will be both positive and negative (Section 12.2). Positive impacts include increased employment and average family income, and increased education, skills and literacy rates, which may provide increased business venture opportunities and economic sustainability. Alternatively, work rotation schedules may interfere with key seasonal and traditional activities, such as hunting and fishing, which may result in a decrease in quality of life and wellness

(Section 12.2). In addition, the closure of current and future mining projects in the next 20 - 30 years could place increased demands on the social infrastructure and subsequent reliance on welfare and social services.

Cumulative impacts on air quality and ground level concentrations of chemical will be low and limited to the local footprint

Because the movement of air masses is not limited to a particular geographic area, emissions of particulate matter, NO_X, SO_2 and subsequent potential acid input from the Snap Lake project will combine with emissions from other projects and influence air quality. However, results from the air quality model indicates that the cumulative impact from the Snap Lake project will be confined to the LSA with negligible to low environmental consequence on air quality and the landscape (Section 12.4, Figure 12.9-1). For example, the Snap Lake project will contribute less than 20% to the cumulative air emissions from other projects in the SGP. In addition, predictions suggest that the incremental increase in ground level concentrations of particulate matter and potential acid input due to the Snap Lake project is less than 3% (Section 12.4).

The moderate environmental consequence on heritage resources is partially balanced by positive impacts

For heritage resources, the loss of 64 of 521 known archaeological sites in the SGP represents a moderate environmental consequence (Section 12.3, Figure 12.9-2). The Snap Lake contribution to this loss is less than 1%. The discovery of the 521 sites due to development (53 of which were discovered in the RSA of the Snap Lake project) represents a positive impact. This positive impact partially balances the loss of known archaeological sites.

Cumulative impacts will occur for caribou, grizzly bears, wolves and wolverines

As with air, the movement of some wildlife species can occur over large areas, and the chance of individuals coming into contact with several projects is high. The migratory behaviour of caribou and large home range of grizzly bears, wolves and wolverines make it entirely possible that individuals will be impacted by more than one project during their lifespan. Thus, there is a high probability that cumulative impacts from the Snap Lake project, and other current and future projects, will occur for these species (Section 12.7). Similarly, for people who eat caribou meat, there is a potential human health risk associated with the accumulation of contaminants in animals being impacted by several projects (Section 12.8).

The level of risk to people getting sick from eating caribou meat is negligible

There is a large amount of confidence in predicting the chance of cumulative impacts from the Snap Lake project on human health, caribou, grizzly bears, wolves and wolverines. There is also a high degree of certainty that the level of risk to people getting sick from eating caribou meat is negligible (Section 12.8). Although the strength of cumulative impacts on wildlife habitat, abundance, movement and behaviour is expected to be low (Figure 12.9-2 to 12.9-5, the level of confidence in these predictions is also low (Section 12.7).

Figure 12.9-2 Classification of the Cumulative Residual Impacts of Heritage Resources and of Direct Habitat Loss on Wildlife Populations

Figure 12.9-3 Classification of the Cumulative Residual Impacts of Fugitive Dust on Wildlife Populations

Figure 12.9-4 Classification of the Cumulative Residual Impacts of Change in Abundance on Wildlife Populations

Figure 12.9-5 Classification of the Cumulative Residual Impacts of Change in Movement and Behaviour on Wildlife Populations

Factors of uncertainty in predicting the strength of cumulative impacts on wildlife

There are a number of factors responsible for this low level of confidence (Section 12.7.4.5). All of these factors are related to uncertainty, and the limited knowledge of these species and the Arctic ecosystem. There is little information available for determining the contribution of current mining projects and natural disturbances on the changes in population size, movement and behaviour of these animals. Data on the ability of these species to adapt or persist in the wake of large-scale disturbances, such as climate change, is also lacking. Without such knowledge there can be little confidence in predicting the amount of incremental change on a population from the addition of another project to the ecosystem.

There is a large degree of uncertainty in predicting the strength of cumulative impacts on caribou, grizzly bears, wolves and wolverines

To summarize, there is a large amount of confidence in predicting the likelihood of an incremental cumulative effect from an individual project on caribou, grizzly bears, wolves and wolverines. However, there is a high degree of uncertainty in predicting the magnitude or strength of the incremental impact from the Snap Lake Diamond Project on a population over space and time.

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12.11 UNITS, ACRONYMS, GLOSSARY

UNITS

°C	degrees Celsius
µg/m^3	microgram per square metre
µm	micrometre
cm	centimetre
dBA	A-weighted decibel level

ha	hectare
keq/ha/yr	kiloequivalents per hectare per year; keq refers to the number of equivalent hydrogen ions (1 keq = 1 kmol H+)
kg/m²/yr	kilogram per square metre per year
km	kilometre
km^2	square kilometre
m	metre
mm/yr	millimetre per year
ppb	parts per billion
t/d	tonnes per day (look for tonnes per day)

ACRONYMS

CEA	cumulative effects assessment
CMHC	Canada Mortgage and Housing Corporation
CO_2	carbon dioxide
CONCAWE	The Oil Companies' European Organization for Environmental and Health Protection (established 1963)
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canada-Wide Standard
De Beers	De Beers Canada Mining Inc.
E	east
EA	environmental assessment
ELC	ecological land classification
ER	exposure ratios
EUB	Alberta Energy and Utilities Board
FAAQO	federal ambient air quality objectives

FTEs	full time equivalencies
GIS	geographic information system
GNWT	Government of the Northwest Territories
Leq	equivalent continuous sound level
LSA	local study area
MOE	Ontario Ministry of Environment
MVEIRB	Mackenzie Valley Environmental Impact Review Board
N	north
N	number
NA	not applicable (check if 2nd table is not avail or not app)
NNE	north-north east
NO	nitric oxide
NO2	nitrogen dioxide
NOX	oxides of nitrogen
NWT	Northwest Territories
O3	ozone
OLM	ozone limiting method
PAH	polycyclic aromatic hydrocarbons
PAI	potential acid input
PCB	polychlorinated biphenyls
PM_{10}	fine particles that are 10 microns or smaller in diameter
$PM_{2.5}$	fine particles that are 2.5 microns or smaller in diameter
QA	quality assurance
RSA	regional study area
RWED	Resources, Wildlife and Economic Development
SEIA	Socio-economic impact assessment

SGP	Slave Geological Province
SO_2	sulphur dioxide
TDS	total dissolved solids
TSS	total suspended solids
UNEP	United Nations Environmental Program
USA	United Stated of America
VEC	valued ecosystem component

GLOSSARY

a priori	relating to or derived by reasoning from self-evident propositions
acid forming compounds	compounds that will tend to form acids when deposited in the environment (*e.g.*, sulphur dioxide and sulphuric acid)
active layer	the near surface portion in permafrost, which is subject to melting during the summer
alignment	the ground plan (as of a railroad or highway)
ambient	existing or present in the surrounding air
application case	represents the impact predicted to occur due to the Snap Lake Diamond Project; this case is based on impact when the project is fully developed and the activities at the mine site will be at a maximum
atmospheric absorption	the effect of sound absorption by the atmosphere between source and receiver
attenuation	a reduction in sound level that occurs with sound propagation over distance by means of physical dissipation or absorption mechanisms, or a reduction in sound level that occurs by means of noise control measures applied to a sound source
A-weighted sound level	a measurement of overall sound pressure level which accounts for the frequency content of the measured sound and assesses it with a frequency response similar to that of the human ear
backfill	to refill (as an excavation) usually with excavated material

barren-ground	a term used to describe the Arctic tundra landscape
barrier attenuation	a noise shielding effect caused by intervening buildings, landforms, *etc*. between source and receiver
barriers	impediment to wildlife movement or behaviour, *e.g.*, roads, airstrips, facilities
baseline case	describes the current environmental setting, against which changes in the environment from the Snap Lake Diamond Project could be assessed
beyond regional	geographic area extends beyond the regional study area (RSA)
bioavailable	the amount of chemical that enters the general circulation of the body following administration or exposure
biodiversity	the variety of life at all levels of organization from gene to landscapes, and the ecological and biological processes through which these levels are connected
body condition	health of an organism, particularly relating to the amount of fat
buffer	a substance capable in solution of neutralizing both acids and bases and thereby maintaining the original acidity or basicity of the solution
CALPUFF	a transport and dispersion model that advects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes
component	any element or part of the cultural, biophysical and economic environment
criteria compounds	compounds for which the environmental regulatory agencies have established ambient air concentration limits
cumulative effect assessment (CEA)	presents the predicted ambient environmental quality in the region at some future date; it includes an assessment of the cumulative impacts from the Snap Lake Diamond Project in combination with other existing, approved, or reasonably foreseeable developments in the region
detection limit	the lowest concentration that a laboratory can determine; therefore, a concentration measured in water, soil, fish, plants, snow or sediment can never be reported as zero but is a number that is less than the detection limit (*i.e.*, <10); when a number such as <10 is presented in the text, it means that the concentration is too low to be measured; therefore, the concentration in that sample is something less than 10 units

direction	describes an impact or effect as being neutral or negative; the direction reflects the change, if any, from baseline
distance dissipation	the geometrical dissipation of sound with respect to distance
dry deposition	the removal of airborne compounds by direct contact with surface features (*e.g.*, vegetation)
duration	defined as the length of time that an impact will occur; duration and timing have been combined within the definition of duration used in this EA; duration is defined by the timing of the phases of the project
ecological resilience	the rate of ecosystem recovery following a disturbance or the capacity of an ecosystem to absorb disturbances
ecozone	large, very generalized units
employment catchment communities	the northern workforce may be drawn in part from these communities; *e.g.*, Fort Resolution, Hay River, Hay River Reserve (located in Hay River), Fort Smith, Fort Providence, and Enterprise, which are located further away from the project site
employment rate	the percentage of persons 15 years of age and over who were employed during the reference week (when the data were collected)
environmental consequence	the overall effect on the environment when the magnitude, geographic extent, duration, and irreversibility of the project's impact are considered together
environmental settings	the present state of the atmospheric environment; the environmental circumstances or events antecedent to development
environmental uncertainty	referring to both the natural environment and the working environment in which management decisions will be made.
equivalent capability	capability for an area to support similar ELC units elsewhere in the region
equivalent continuous sound level (Leq)	A single number descriptor commonly used for environmental noise measurements and criteria. It is used to quantify sound which constantly varies over time, such as that commonly occurring in outdoor environments. It is defined as the steady, continuous sound level over the measured time period that has the same acoustic energy as the actual fluctuating sound levels that occurred during the same time period. Measurement periods commonly used for Leq measurements and criteria are the daytime (07:00 - 22:00 hrs) and night time (22:00 - 07:00 hrs) periods.

esker	a long, low, narrow, sinuous, steep-sided ridge or mound composed of irregularly stratified sand and gravel that was deposited by a subglacial or englacial stream flowing between ice walls or in an ice tunnel of a continuously retreating glacier, and was left behind when the ice melted; it may be branching and is often discontinuous, and its course is usually at a high angle to the edge of the glacier; eskers range in length from less than a kilometre to more than 160 kilometres, and in height from 3 to 30 metres
exposure	the contact reaction between a chemical and a biological system, or organism
exposure assessment	estimates the amount of a chemical a receptor may take into its body through all applicable exposure pathways
exposure ratio (ER)	the ratio of the exposure estimate to the toxicity benchmark; a measure of the magnitude of the potential adverse effect to individual animals associated with exposure to chemicals emitted from the Snap Lake Diamond Project; an ER less than 1 indicates that there are no risks/impacts to wildlife health from the predicted exposures to the chemicals of concern; as ER greater than 1 indicates that there is a potential for effects on some individuals
facility noise	environmental noise in the vicinity of industrial buildings, where there is usually a steady background sound level that is slowly varying
flux	both wet and dry deposition values, in units of kg/ha/yr or keq/ha/yr
forb	a herb other than grass; *e.g.*, flase asphodel, saxifrage and Arctic harebell
fragmentation	examines the changes in landscape patterns as a result of natural or human disturbances; the process of reducing size and connectivity of habitats composing a landscape
frequency	how often an effect will occur
fugitive dust	dust that is difficult to grasp or retain
genetic diversity	the variety in the genetic makeup and phenomena of an organism, type, group, or condition
geographic extent	refers to the geographic location where the impact is predicted to occur; a local geographic extent is assigned if the effect is restricted to the LSA; a regional geographical extent is assigned if the effect extends beyond the LSA into some part of the RSA
ground attenuation	the effect of sound absorption by the ground as sound passes over various types of open terrain

ground thermal regime	the ground's temperature or heat regime
grout	thin mortar used for filling spaces; any of various other materials (as a mixture of cement and water or chemicals that solidify) used for a similar purpose
hardness	calculated from calcium and magnesium concentrations in water; the hardness of water is environmentally important since it is inversely related to the toxicity of some metals (*e.g.* copper, nickel, lead, cadmium, chromium, silver, and zinc); in other words, some metals are toxic at lower concentrations when the hardness of water is lower; lakes are often referred to as soft-water lakes if the hardness is low
heritage resources	non-renewable resources that may be located at or near ground level or may be deeply buried; include the sites where events took place in the past or are currently on-going, all of the objects they contain, and contextual information that may be associated with them that will aid in their interpretation; contextual information can include, but is not limited to, natural specimens and documents, or verbal accounts
increase in sound level	The perceived increase in loudness of a sound does not correspond directly to numerical increases in dBA values. Typically, an increase of less than 3 dBA is barely noticeable, an increase of 5 dBA is noticeable, an increase of 10 dBA is perceived as a doubling in apparent loudness, and an increase of 20 dBA is perceived as a four-fold increase in apparent loudness.
inhalable particles (PM10)	particles that are 10 microns or smaller in diameter; fine particulate matter that can reach the lungs
irreversibility	an indicator of the potential for recovery from the impact. The irreversibility category is classified as reversible in the short-term, reversible in the long-term, or irreversible.
isopleth	a curve joining points of equal maximum concentrations or deposition values
kimberlite	an agglomerate biotite-peridotite that often occurs in pipes and that often contains diamonds
land classification unit	units of land categorized based on specific properties or suitability for specific purposes
level of confidence	directly related to the degree of certainty in the impact prediction

lichen	complex plants made up of an alga and a fungus growing in symbiotic association on a solid surface; lichens take up chemicals efficiently and readily via dust deposition, thus are commonly used as indicator species
linkage diagram	diagram that is used to depict cause and effect pathways
linkage pathway	illustrates how various project activities of the Snap Lake Diamond Project can contribute to environmental changes; also demonstrates linkages among different topic areas in the EA
magnitude	a measure of the intensity or severity of an impact; it is a measure of the degree of change in a measurement or analysis endpoint
mine footprint	the area covered by the mine site
natural variation	disparity in an environmental condition that occurs under natural conditions, without human-induced disturbance
non-nursery	group of animals composed of adult females, adult males, adult females and males
non-renewable resource	a resource that is not capable of being replaced by natural ecological cycles
north pile	an area for storing and containing the processed kimberlite material and potentially acid generating rock
nursery	group of animals composed of adult females with calves, adults with calves
open areas	terrain classification determined mainly by topography in the Snap Lake Watershed; this terrain classification includes lakes and land
ozone limiting method (OLM)	method of converting the NOx predictions to NO2; the OLM assumes that approximately 10% of the NOx emissions are in the form of NO2, with the balance being in the form of NO
passerines	small perching birds
permafrost	a permanently frozen layer at variable depth below the surface in frigid regions of a planet; permafrost reduces soil water infiltration
polycyclic aromatic hydrocarbon (PAH)	a chemical byproduct of petroleum-related industry; aromatics are considered to be highly toxic components of petroleum products; PAHs, many of which are potential carcinogens, are composed of at least two fused benzene rings; toxicity increases along with molecular size and degree of alkylation of the aromatic nucleus

potential acid input (PAI)	a composite measure of acidification determined from the relative quantities of deposition from background and industrial emissions of sulphur, nitrogen, and base cations
probability of occurrence	the likelihood that the environmental consequence indicated in the impact prediction will occur if the project goes ahead
relative humidity	the ratio of the amount of water vapour actually present in the air to the greatest amount possible at the same temperature
renewable resource	a resource that is capable of being replaced by natural ecological cycles or sound management practices
residual impact	the amount of impact remaining after mitigation
respirable particles (PM2.5)	particles that are 2.5 microns or smaller in diameter; fine particulate matter that is able to reach the lungs, and go deeper into the respiratory tract and may have greater deleterious health impacts than the coarser inhalable particles (PM10)
reversibility	refers to changes that occur after the impact ceases allowing the environment to return to a capability or condition equivalent to the baseline
riparian	a band of terrestrial habitat that is adjacent to and directly influenced by streams, rivers or lakes
risk	the likelihood or probability that the toxic effects associated with a chemical or physical agent will be produced in populations of individuals under their actual conditions of exposure; risk is usually expressed as the probability of occurrence of an adverse effect, *i.e.*, the expected ratio between the number of individuals that would experience an adverse effect at a given time and the total number of individuals exposed to the factor
risk characterization	compares the amount of exposure predicted for each receptor (exposure assessment) to the chemical dose at which toxic effects may begin to occur in wildlife receptors (toxicity assessment)
sedge	any of a family (Cyperaceae, the sedge family) of usually tufted marsh plants differing from the related grasses in having achenes and solid stems; especially any of a cosmopolitan genus (Carex)
sensory disturbance	mining activities that change the behaviour of wildlife; can lead to increased levels of stress and energy expenditure in wildlife, and disruption of feeding and/or mating behaviour

sub-populations	a group of local populations that do not interbreed, but are connected by dispersal (*i.e.*, together they form a metapopulation); the distance between local or sub-populations may be large enough that they experience different environmental factors
taiga	a moist subarctic forest dominated by small conifers (spruce and fir); represents the transition zone between the boreal forest and the Arctic tundra
talik	a layer of unfrozen ground above, within, or beneath the permanent or temporary permafrost
topography	the configuration of a surface including its relief and the position of its natural and man-made features
total suspended particulate matter (TSP)	the fraction of airborne particulates that will remain airborne after their release in the atmosphere; the average diameter is nominally of 30 µm (micrometres) and below
total suspended solids	an index of the amount of suspended substances in a water sample
toxicity	the inherent potential or capacity of a material to cause adverse effects in a living organism
toxicity assessment	defines the toxicity of the chemicals of concern and the chemical dose at which toxic effects may begin to occur in wildlife receptors
trace metal	an amount of a chemical metal constituent not always quantitatively determinable because of minuteness
traditional knowledge	information obtained more often through observations during extensive time spent in one geographic location than through information obtained formally by the scientific method, *e.g.*, Aboriginal traditional knowledge
tundra	a level or rolling treeless plain that is characteristic of Arctic and subarctic regions, consists of black mucky soil with a permanently frozen subsoil, and has a dominant vegetation of mosses, lichens, herbs, and dwarf shrubs
uncertainty	inability to definitely know, which is related to natural variability (both spatial and temporal), model uncertainty, uncertainty of future emissions, measurement errors and data errors
uncertainty about values	referring to individuals' and organizations' values that will shape both management decisions as well as the perception of particular impacts

uncertainty regarding impact magnitude and distribution	referring to the differences in magnitude of impact that will be felt by different individuals and communities, depending on existing and evolving socio-economic conditions
uncertainty regarding mitigation effectiveness	referring to the degree by which impacts may or may not be effectively mitigated, depending on factors such as level of commitment, funding, and adequacy of implementation
upland areas	terrain classification determined mainly by topography in the Snap Lake Watershed; this terrain classification includes elevated areas generally exposed to wind
valued ecosystem component (VEC)	a component of the environment that is representative of traditional, public and scientific values, *e.g.*, rare plant potential and traditional plant potential
wage economy	when goods or services rendered to another are exchanged for money
water balance	the ratio between the water assimilated into the water body and that lost from the water body.
wet deposition	the removal of airborne compounds by precipitation
wetland	term for a broad group of wet habitats; wetlands are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water; wetlands include features that are permanently wet, or intermittently water-covered such as swamps, bogs, muskegs, potholes, swales, glades, slashes and overflow land of river valleys
wildlife corridors	corridors of habitat which facilitate the movement of animals between larger patches of habitat
wind gradient	enhances sound propagation in downwind directions and attenuates sound propagation in upwind directions
windrose	a single figure that presents both wind speed and direction information
worst-case	a semi-quantitative term referring to the maximum possible exposure, dose or risk, that can conceivably occur, whether or not this exposure, dose, or risk actually occurs is observed in a specific population; it should refer to a hypothetical situation in which everything that can plausibly happen to maximize exposure, dose, or risk does happen; the worst-case may occur in a given population, but since it is usually a very unlikely set of circumstances in most cases, a worst-case estimate will be somewhat higher than what occurs in a specific population
zone of influence	the geographic area where animal behaviour and activities may be influenced by mining activities