Tools For Assessing Cumulative Environmental Effects In The Slave Geological Province, N.w.t.: Development Scenarios, Ecological Footprints, Impact Hypotheses And Procedural Framework

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TOOLS FOR ASSESSING CUMULATIVE ENVIRONMENTAL EFFECTS IN THE SLAVE GEOLOGICAL PROVINCE, N.W.T.:
Sector:
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Analysis/Review

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14 September 1995

Robert Walker
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RE: *Tools for Assessing Cumulative Environmental Effects in the Slave Geological Province, N. W. T.: Development Scenarios, Ecological Footprints, Impact Hypotheses, and Procedural Framework .*

Dear Mr. Walker:

On behalf of the entire study team, I am pleased to submit our Final Report for the above-named project. As specified in the contract, wc have supplied 10 hard copies and 1 disk copy (WP6.0a Windows).

This report was revisal following the guidance supplied in your letter dated 25 August 1995, our telephone conversations of 29 and 30 August, and taking into account written comments from the six reviewers. We paid particular attention to the areas that you indicated in your letter were deficient in terms of the contract. We now believe that all of the outstanding issues have been adequately addressed, and that the enclosed products more than fulfill our contractual obligations.

We understand that this report will now be widely distributed, at least within the region. We ask your assistance in ensuring that recipients know the proper context for this report, and that their expectations be well managed. An accompanying letter / Preface from you and / or Hal Mills would go a long way toward that goal. As well, I encourage you to publish this report under the DIAND cover. As I have repeatedly mentioned, this project could well seine as an example to a far wider audience interested in cumulative effects.

Our project team is proud of the work that we have performed under this contract, and believe that we have assisted the West Kitikmeot/Slave study working group in making significant progress toward dealing with the complex issue of cumulative effects. As you and I both know, this project was only intended to set-ve as a starting point in your work on cumulative effects in the region. In this regard. our project team has considerably more to offer to you and the study working group as you endeavour to deal with this complex set of issues and problems. If we can be of additional assistance, please do not hesitate to call or send me an email.

Sincerely,

David P. Bernard
Senior Systems Ecologist

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ESSA TECHNOLOGIES

Tools for Assessing Cumulative Environmental Effects in the Slave Geological Province, N. W. T.:

Development Scenarios, Ecological Footprints, Impact Hypotheses, and Procedural Framework

Department of Indian Affairs and Northern Development

Tools for Assessing Cumulative Environmental Effects in the Slave Geological Province, N. W. T.: Development Scenarios, Ecological Footprints, impact Hypotheses, and Procedural Framework

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List of Abbreviations

CEA	Canadian Environmental Assessment
CEAA	Canadian Environmental Assessment Agency
CEE	Cumulative Environmental Effects
ct/t	carats per tome
DIAND	Department of Indian Affairs and Northern Development
EARP	Environmental Assessment and Review Process
EIA	Environmental Impact Assessment
g/t	grams per tonne
G. N.W.T.	Government of the Northwest Territories
ha	hecatres
km	kilometre
km^2	square kilometre
l	litres
LRTAP	long range transport of airborne pollutants
m	metres
m^2	square metres
n.a.	not available
N.W.T.	Northwest Territories
SGP	Slave Geological Province
VEC	valued ecosystem component

1.0 introduction

1.1 Overview

The Slave Geological Province (SGP) is a large region of the Canadian Shield located in Canada's Northwest Territories (N. W.T.). Positioned northeast of Great Slave Lake, the SGP extends from Yellowknife to the Arctic Coast (Figure 1.1). The area's geology makes the region a prime target for mineral exploration groups seeking gold, base metals, rare earths, and diamonds.

Figure 1.1: Slave Geological Province, N. W. T., shown in relation to the rest of Canada.

This region of the N.W.T. is still largely undisturbed by humans. In addition to its mineral wealth, the region contains many valuable natural renewable resources, particularly caribou, musk oxen, grizzly bears, wolves, raptors, waterfowl, and arctic charr. Some of these species are vital for traditional harvesting activities by Inuit and Dene people living in communities inside the SGP. This region also supplies other resources essential to the traditional and cultural values of these native communities. Non-native people, including N.W.T. residents, outfitting businesses, and tourists, also use the area's renewable resources, for activities such as hunting and wilderness recreation.

Economically, the SGP is an important source of base and precious metal reserves. Currently there are six operating gold mines distributed throughout the region (see Chapter 3 and Figure 3.1). The most recent base metal mine proposal, Inmet Corporation's (formerly Metall Mining Corp.) Izok project, would have involved an open pit mine, a 200 kilometre winter road, and a deep sea port to service the mine (Klohn-Crippon 1983). At the current time, the Izok project is delayed indefinitely because of high infrastructure costs. But other promising mineral deposits are known, and new development proposals (e.g. the Nicholas Lake, Damoti Lake, and Boston gold deposits) are likely in the future. In addition, there is the potential for new infrastructure developments, including hydroelectric facilities and an all-weather road.

Beginning in 1991, a diamond staking rush began in the SGP. Some companies have already begun advanced exploration activities on their properties. One group, BHP Diamonds Inc. in consultation with the Blackwater Group, has applied to begin a diamond mining operation in the Lac de Gras area. Presently, the BHP proposal is being reviewed by a Federal Environmental Assessment Panel.

Many people are concerned that the pace and scale of mineral and transportation development mitigation might lead to detrimental environmental impacts on the renewable resource base of the region. Government and environmental agencies are now attempting to evaluate potential impacts of the relatively sudden expansion in mineral exploration and mining activity. To date they have identified the need for a framework that can assist them in evaluating cumulative environmental impacts (see Chapter 2.0) on renewable resources from proposed activities in the SGP.

Given the shifting jurisdictional mandates and responsibilities brought about by land claim settlements and changing federal and territorial responsibilities, such a framework would be especially valuable at this time. Not only would such a framework help reduce uncertainty concerning the process that agencies must follow in making permitting and resource management decisions, but it would also help ensure a clear and fair process for the review of proposed projects, a point of particular interest to proponents who are planning major mineral developments. The framework would be helpful if it clearly indicated how and when aboriginal groups and communities in the region could most effectively voice their concerns and opinions about environmental, social and economic impacts of proposed developments.

To begin addressing these issues and concerns, a group of over 70 people met in Yellowknife in early February, 1994. Participants were drawn from aboriginal groups, communities, industry, federal and territorial governments, and non-government organizations. Discussions focused on processes and procedures for addressing potential cumulative environmental effects (CEE) of development in the SGP.

Partly as a result of the workshop and its conclusions (summarized in ESSA, 1994), the Minister of the Department of Indian Affairs and Northern Development (DIAND) and the Minister of Renewable Resources, Government of the Northwest Territories (G.N.W.T.) jointly announced, in December 1994, a regional study to investigate environmental, social, and economic issues related to potential developments in the SGP. This study is intended to provide important data related to possible cumulative environmental effects of potential mining and related infrastructure developments.

At the end of February, 1995, the two governments jointly hosted a workshop for representatives of aboriginal groups, industry, government, and environmental organizations. The purpose of the meeting was to decide on the design and structure of the *Regional Study of the Slave Geological Province*. One important issue discussed at that second workshop was cumulative environmental effects. On this topic, the workshop participants agreed on the need for development scenarios and a framework to help in identifying potential CEE associated with developments and activities in the SGP.

1.2 Objectives and Approach

In response to the needs expressed at the workshop, the Yellowknife office of DIAND contracted a project team composed of scientists, engineers, and natural resource experts from ESSA Technologies Ltd., Hornal Consultants Ltd., and Bryant Environmental Services Ltd. To guide the study team the following objectives were set forth by DIAND:

1. provide realistic development scenarios (high, medium, low) for the SGP covering a 10-15 year time frame. The scenarios were to be composed of "elements" representing potential projects and major activities in the SGP;

2. develop generic "footprints" for each of the major scenario elements; and

3. formulate an analytical framework capable of identifying potential cumulative environmental effects associated with different scenarios.

This report provides the results from that project.

The basic approach taken in this study was to develop a set of prototype tools that would be useful aids in helping analysts recognize and appraise the significance of potential cumulative environmental effects in the SGP. Consistent with the objectives, our efforts focused on creating three complimentary "tools:" i) future development scenarios; ii) generic footprints; and iii) a framework for linking effects of human activities to those natural resources that might be expected to be significantly affected. These three tools were designed to be used together, and were intended for use by environmental assessment experts.

As described more fully in the next chapter, for the foreseeable future, analysis of cumulative effects is not a standardized "cookbook" science and will continue to involve application of expert judgement. Effective cumulative effects analyses require substantial amounts of technical expertise and first-hand knowledge of the systems under consideration. The tools described in this report are intended to seine in a decision support role, not to replace the disciplinary experts who are assigned responsibility for identifying and evaluating cumulative environmental effects.

To construct future scenarios for the SGP, we began by identifying existing and proposed developments in the SGP. Many of these developments involve two or more separate "elements." For example, a large new mine (or cluster of mines) may involve at least four "elements:" i) mineral exploration; ii) mine construction/operation; iii) community development, and iv) transportation infrastructure. In constructing future development scenarios, special attention was devoted to identifying developments and "elements" which have the potential to result in significant cumulative environmental impacts. Undoubtedly there are many other activities and developments that are, and may later be, taking place in the SGP. At some future time these could be included as part of an exhaustive inventory of SGP developments and activities. However, investigators examining cumulative effects are well advised (especially in times of government cut-backs and fiscal restraint) to focus first on activities that represent the greatest potential risk to natural resources. Properly evaluating the potential cumulative environmental effects of even this abbreviated set of developments and "elements" is a great challenge. Prematurely expanding the list of activities to be examined in an analysis of CEE could rapidly result in increasing the complexity to the point where the analyses become extremely difficult to perform and far more expensive than is really necessary. The future development scenarios presented in Chapter 3 have, therefore, been constructed using developments and "elements" judged to be most important for initial analyses of cumulative environmental effects. The list of developments and "elements" was presented to the Steering Committee at a meeting in Yellowknife, and subsequently revised according to their recommendations.

The second major component of this project involved identifying generic footprints. It is interesting to note that the word "footprint" is a nice example of what Lister Sinclair once called "plastic words" in his CBC show, *Ideas.* He defined plastic words as terms that are in general use within our language-and that everyone believes that they understand—but for which there are no generally accepted definitions, resulting in a situation where many people actually have in mind different ideas, all of which are labelled with the same term. In this context it is very important to acknowledge that the phrase ecological footprint is such a term. Currently there is no singular, authoritative, and widely held definition for this term. In it's most common use, it refers to the land and water area needed to exclusively provide the natural resources and services needed by a specified human population and to assimilate the wastes they generate, using prevailing technology (Wackernagel and Rees 1994). The phrase "appropriated carrying capacity" is often used interchangeably with ecological footprint. For the purposes of this project, DIAND defined footprint as the zone of influence on key environmental components resulting from current developments (e.g. existing mines, roads) and past development activities (e.g. mines, exploration activities) that have left a legacy of residual impacts.

The third element in our toolbox was a tool designed to illustrate linkages between the human activities associated with development activities in the SGP and the renewable natural resources that might be expected to be significantly affected. In order to construct such a tool, we began by identifying some indicators that could provide an integrated assessment of the "health" and integrity of SGP ecosystems. Valued ecosystem components (VECs) are one type of indicator that has proven useful in such applications. VECs are individual species (or assemblages of species and / or ecosystems) of importance to the region (Beanlands and Duinker 1983). They may be selected based upon: i) legal status (e.g. rare and endangered species); ii) political or public concerns over resource use conflicts; iii) scientific judgement (e.g. ecological importance); or iv) commercial / economic importance. Using a particular VEC as the focal point, it is then possible to construct a set of linkages that together describe how certain human actions or activities could result in changes to the VEC (see Figure 1.2). The resulting vignette is called an impact hypothesis diagram. By using a VEC that represents ecosystem "health" or integrity as the endpoint in an impact hypothesis diagram, emphasis naturally becomes focused on activities that potentially pose the greatest threat to the environment.

Impact Hypotheses

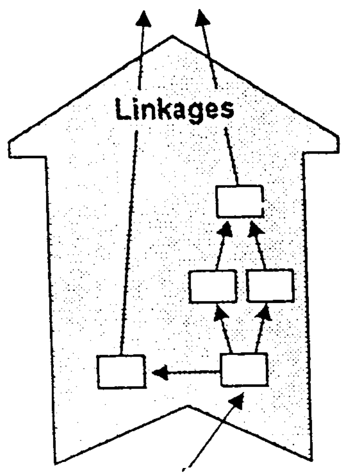

Figure 1.2: An impact hypothesis diagram.

Impact hypothesis diagrams can also be used to develop an understanding of potential interactions between multiple actions (stressors) or multiple sources of similar stress. As described in Chapter 5, this approach can be useful for identifying potential cumulative environmental effects, although it is essential to keep track of spatial relationships between the actions/stressors and the VECs. Consequently, the "bookkeeping" needed for evaluating CEE can quickly become quite complex.

1.3 Context

AS noted in the preface, this project is but one of several that together are addressing the many issues that are associated with potentially expanded mining, industrial, and community activities in the SGP. In this regard it is important to note that this current report was not intended—nor does it attempt-to address all the issues. In particular, this project has focused on developing a framework for identifying a supporting analysis of cumulative ***environmental*** effects. A similar, and parallel effort should be undertaken to address cumulative *social/economic / cultural* effects.

Readers of this report should note that the tools we have developed in this project are fully fictional. But, they are still in a developmental stage, and will need further refinement as users gain experience in applying them to actual cases within the SGP.

As well, it is important to acknowledge that there are already more than 50 pieces of legislation pertaining to mineral-related activities, and the control of impacts from such activities, applicable in the N.W.T. Nevertheless, despite this complex array of legislation, policies, procedures, and so forth, there remains considerable concern by people from a number of sectors regarding the ability of the current management system to adequately protect the region's renewable resource base. In this project, we have described what needs to be done in order to evaluate cumulative environmental effects, but have not tried to identify how the proposed scheme relates to current legislation and policies.

1.4 Report Organization

This report deals with a complex technical subject. Nonetheless, whenever possible we have tried to use simple, non-technical language to ensure that the contents are available to the broadest audience. To assist non-technical readers, we have also added a List of Abbreviations (see page facing the start of Chapter 1), and a Glossary (see Chapter 7.0) covering some of the more technical terms that are used in this report.

In an ecological context, the assessment of cumulative environmental effects is an attempt to anticipate "the straw that breaks the camel's back." While this is an easy concept to grasp at a theoretical level, it is notoriously difficult to put this idea into practice. To help non-technical readers, a brief introduction to the theory of CEE assessment is provided in Chapter 2. Although much has been written about this subject in recent years, Chapter 2 is not a summary of that burgeoning literature. Instead, it is intended simply to introduce non-specialists to a few of the more important concepts surrounding CEE, as a practical inauguration to this complex subject.

Chapter 3 presents scenarios concerning what might happen in the SGP by the year 2010, given a low level of development, a moderate level of development and a high level of development. These development scenarios are composed of discreet "elements" (e.g. base metal mines, roads, hydroelectric developments), and are intended to take into account existing activities, as well as possible alternative developments and activity patterns. The scenarios reflect different potential rates of development for mineral exploration, mine development, development of new transportation infrastructure and hydroelectric sites, expansion of tourism and outfitting, as well as development of community-related activities such as hunting, fishing and food gathering. Appendix A provides additional detail about mineral properites in the SGP, which may at some point be developed as mines.

For each major element in the scenarios developed in Chapter 3, a generic "footprint" or "environmental halo" was developed, and described in Chapter 4. Where possible these footprints were based on experience from past developments or current standards. The footprints are intended to describe zones of influence extending outward from the scenario element through the biophysical and socio-economic environment of the region.

Chapter 5 describes an analytical framework capable of allowing investigators to identify potential cumulative environmental effects, based on information and data pertaining to the scenarios and footprints. This chapter presents and discusses a number of impact hypotheses. However, many more impact hypotheses are required to capture the effects of activities described in the scenarios. Some of these are presented in Appendix B, as an aid to those who must undertake the next steps toward preparing CEE assessments for the SGP.

Chapter 6 concludes the report by providing a few suggestions for future work.

2.0 Cumulative Environmental Effects

2.1 Why Study Cumulative Environmental Effects in the Slave Geological Province?

While government agencies and proponents already routinely consider both direct and indirect environmental and socio-economic effects of all major projects, most assessment practitioners admit to having difficulties in evaluating what has come to be known as cumulative effects. It is important to recognize that at this time there are no widely accepted definitions of, or methods for identifying and evaluating, cumulative environmental effects. This is very much an evolving "science." As a result, there are very few good examples from which to draw lessons on how best to proceed. Many portions of the planet already have local ecosystems that are significantly modified by human activities, making assessment of cumulative effects more complex. In comparison, the SGP is relatively undisturbed. Moreover, the level and types of development and use being forecast for the next few decades are modest compared to the amount and scope of development occurring elsewhere on the planet. Consequently, it should be easier to identify likely causes and consequences of CEE in the SGP than for many other areas. In this regard, the opportunity to evaluate cumulative environmental effects in the SGP may result in creation of a "model case study" that others may research in the years ahead.

2.2 Definitions and Methods for Analysis

The new *Canadian Environmental Assessment Act* (CEA Act) explicitly refers to cumulative environmental effects, but does not actually define what is meant by that term. It does, however, provide guidelines concerning which effects should be considered cumulatively, along with a seven-step framework for assessing and managing cumulative environmental effects (CEAA, 1993). It is important to note that the CEA Act defines environmental effects very broadly, but only includes socio-economic effects that result directly from changes in the environment. For example, if a proposed project could affect caribou harvests by reducing herd size, say through removing habitat and influencing migration patterns, then the effects on the caribou harvests would be part of the cumulative effects analysis. The resulting social and economic implications of changes to caribou harvests would not be part of the assessment of cumulative environmental effects. Presumably, however, it would necessarily be part of the socio-economic assessment process.

There are in use a number of definitions for cumulative effects. For instance, according to the Presidents Council on Environmental Quality (CEQ 1994):

> Cumulative impacts are causal by the aggregate of past, present, and reasonably foreseeable future actions. Impacts of a proposed action on a given resource must include present and future impacts that will occur when added to the impacts that have already taken place in the past. Such impacts must also be added to effects (past, present, future) caused by actions taken by other entities, insofar as they also cumulatively impact the same specific resource.

There are at least three cardinal features of this definition. One is the notion that analysts must take into account not only present and proposed actions and environmental effects, but also those that have occurred in the past and are likely to occur in the reasonably foreseeable future. This immediately suggests that regional scenarios must play an important role in the analysis of CEE. The second cardinal feature is the suggestion that CEE analyses focus on specific resources or ecosystems. This means that specific and relevant resources (e.g. caribou, grayling), sometimes called VECS or Valued Ecosystem Components (Beanlands and Duinker 1983), will be chosen as the subject of the cumulative environmental effects analysis. And finally, the definition suggests that the analysis of CEE will be comprehensive, and take into account actions by other entities. This means that the environmental effects on a specific resource of each proposed project must be evaluated within the context of all other projects (past, present, future) that could also affect the resource. (This is not to say that a given proponent must be responsible for providing all the elements of such an evaluation.)

Many methods have been advanced for the analysis of cumulative environmental effects; these are reviewed in the Presidents Council on Environmental Quality (CEQ 1994). Those authors identify six "core" methods (ad hoc techniques, checklists, networks and systems diagrams, map overlay techniques, trends analysis, and matrices), and five "elective" methods (mathematical and simulation modelling, ecosystem analysis, synoptic landscape approach, economic impact models, and social impact assessment). They also identify two types of tools that are well suited to the analysis of CEE: geographic information systems and remote sensing. The framework presented in Chapter 5 is a hybrid that incorporates the best features of several methods.

2.3 Scoping

Scoping is an essential part of the CEE assessment process. During scoping, time and space parameters are approximated and future scenarios are prepared. Scoping is also useful in identifying what the concerns are, so that the analysis can be focused where needed to disclose important impacts and to help managers select preferred actions that are environmentally responsible.

Determining the scope of a cumulative environmental effects analysis for the Slave Geological Province requires answers to a number of key questions. Most of these important questions were already identified and discussed during the Yellowknife workshop held in February 1994 (ESSA 1994) and are reproduced in Table 2.1. In addition, there are two other important questions that need to be addressed in designing the assessment: a) what are the proposed actions and scenarios; and b) what are the likely mechanisms that would cause CEE in the SGP?

Table 2.1: Key design questions for a cumulative environmental effects study in the Slave Geological Province, N.W.T.

- What geographic area must be considered?
- What period of time must be considered?
- What past and known developments must be considered?
- What environmental indicators(VECs) must be assessed?
- What interactions between indicators must be assessed?
- What social, economic and cultural activities affect the VECs?

[1] Mechanism: the agency or means by which an effect is produced (Random House Dictionary of the English Language, 1966)

Cumulative environmental effects can be created in at least two basic ways. In the first instance are those cases in which actions influence a *single mechanism* that, in turn, affects a specific resource. An example would be actions that affect the area of land available to caribou for feeding, Assuming that there are certain lands that represent critical caribou habitat, loss or alienation of the critical habitat through whatever means would be the mechanism through which a CEE could be produced. This could occur through simple addition of individually minor, but collectively significant, actions taking place over a period of time. These repetitive actions, although seemingly minor in and of themselves, could accumulate or interact to cause direct, indirect, and cumulative environmental impacts. In this case it makes no difference if the CEE is created through multiple instances of any one type of action (e.g. many individual exploration camps) or through several different types of action (e.g. mines and roads).

The second way in which CEE can be created is through interactions of *multiple mechanisms*. A simple example can be seen in a case where grizzly bear populations are reduced through a combination of direct mortality (e.g. hunting, road kills) and reduced food availability (e. g, loss of critical resources). In this example, a CEE could be produced through the integration of these two mechanisms: removing animals from the population *and* loss of critical habitat. This could occur even though each of the two mechanisms, operating alone, would not be sufficient to cause a significant effect. Thus, the multiplicity of mechanisms becomes an important consideration in scoping for CEE.

2.4 Analytical Considerations

To help guide the evaluation of CEE, there are at least four important considerations:

1. cumulative environmental effects need to be analysed in terms of the specific resources or ecosystems being impacted;
2. all influences on a given resource or ecosystem should be considered as a whole, not just influences that can be attributed to a particular project;
3. each impacted resource must be analysed in terms of its own time and space parameters; and
4. the impacts of potential actions should be evaluated in terms of whether they affect the long term viability or productivity ofa resource or ecosystem.

The rationale for each consideration is given below.

It is impractical to analyse the cumulative impacts of an action on the entire universe. Thus, the list of environmental effects to be examined must be focused on impacts and affected resources that are truly meaningful. To be helpful to decision makers, and understood by other interested parties, analyses of CEE must be expressed in terms that can be grasped non-specialists. For this reason, it is suggested that cumulative environmental effects be analysed in terms of the specific resources or ecosystems being impacted. All significant issues and impacts would then be covered out to the point where they are no longer significant or of interest to the affected parties.

There needs to be an understanding of where the resources and ecosystems of concern are most susceptible to impacts. This involves not only knowing about the contents of the ecosystem, but both the potential mechanisms that may cause CEE, as well as understanding how the components of a given ecosystem interrelate. Because of the web of interactions in an ecosystem, all influences on a given resource or ecosystem should be considered as a whole, not just those influences that occur from a particular action or project. Individual impacts may, over time or over a larger space, add up or interact to cause CEE not apparent when looking at the individual impacts one at a time.

Each impacted resource must be analysed in terms of its own time and space parameters, not in terms of the proposed action or project. Cumulative environmental effects on a given resource or ecosystem are rarely aligned with political or administrative boundaries. There is a tendency to put resources into boxes with sides built of agency jurisdictions, land claim areas, geological provinces, and so forth. Unfortunately, impacted resources are not so aligned, and each political entity ends up managing only a small piece of each resource, but rarely the entire ecosystem. Cumulative environmental impacts may also last for many years, often far beyond the life of the action or project that caused the impacts. For example, acid mine drainage, damage to permafrost, and species extinction may all persist for long periods of time or even permanently. Science and sophisticated analytical processes must be brought into play to help foresee and head off such consequences.

Likewise, when tracing footprints from a particular action or project it is important to recognize that each facet must be analysed in terms of its own time and space parameters. For example, the footprint associated with hydrologic impacts resulting from an all-weather road will likely be very different from the footprint associated with contaminants that get into surface water and ground water from mining operations.

2.5 Judging the Significance of a Cumulative Environmental Effect

The cumulative environmental effects framework proposed in this study involves taking mechanisms identified in impact hypotheses (see Appendix B), quantifying them using the footprint data, determining their potential for addition and synergy and evaluating the significance of the result using scenario information, expert judgement and available data. Inevitably, this process must embody a high degree of uncertainty.

The accuracy of any CEE prediction is limited by a number of factors, including:

1. the degree of certainty regarding the elements of a future scenario;
2. incomplete understanding of the processes that link those elements; and
3. the inevitable element of chaos associated with natural processes.

Cumulative effects assessment is an act of prediction that involves considering both natural and human activities, both of which are generally incompletely understood. As a result, the state-of-the-science for cumulative environmental effects assessment is still in evolution.

The framework for cumulative effects assessment presented in Chapter 5 is a step in that evolution. It relies substantially on expert judgement to fill in knowledge gaps on potential interactions between environmental impacts, and on sensitivities of valued ecosystem components (and of whole ecosystems) to impacting activities. Occasionally, the projected cumulative effects will be readily quantifiable and understood. More frequently, expert judgement will be insufficient to fill the knowledge gaps, with the result that the potential cumulative effects of a set of projects will be poorly understood, or even unknown.

Where "expert" understanding of natural and human processes is lacking, there can be difficulty in determining appropriate policy. These difficulties are accentuated in cases where stakeholders have different resource management priorities, and where development scenarios are in flux, as is the case in the Slave Geological Province. Uncertainty concerning cumulative environmental effects may even lead some stakeholder groups to conclude that a combination of mitigation strategies, technological improvements, and low density of proposed activities will be adequate to protect the SGP from cumulative effects. There are, however, a number of problems with these assumptions.

First, in some types of cumulative effects, damages to the valued ecosystem component or the ecosystem itself, do not occur until some threshold level is reached. In the time prior to reaching the threshold, there may be few if any indications of an impending cumulative environmental effect. At that early stage, it maybe impossible to prove that a cumulative effect process is occurring. In other words, before the last straw is loaded onto the camel, the camel's back is not yet broken, yet the stresses have been accumulating to the point where the next straw will appear to have broken the camel's back.

Secondly, if it can be accepted that cumulative effect processes maybe occurring without outward evidence, then the question becomes one of risk. What is the risk that a cumulative effect situation may be developing in the Slave Geological Province? To continue the metaphor, an experienced expert would have to examine the load of straw and to determine whether a given camel, in this case the SGP, can carry that much straw, or that much development activity. Such expert judgement, especially where a complex natural and human system is the subject of debate, is often at odds with the opinion of certain segments of the population. In our society, there is also a fundamental distrust of ''experts" that has resulted in part from the scientific community failing to communicate technical information in an easy-to-understand form, and in its occasional failure to acknowledge limits to scientific knowledge.

Thirdly, there is great difficulty in proving the harmlessness of a technology, process or activity, since that exercise demands negative evidence. For instance, as a prominent philosopher has observed, it is very difficult to prove that all swans are white, because one would have to examine all swans, but it is easy to disprove the hypothesis by producing one black swan. In fact, it may be virtually impossible to prove that something is safe, since there may always be a new test which may uncover a previously unsuspected negative effect.

Therefore, the crux of an analysis of cumulative environmental effects is agreement on what institutes sufficient negative evidence to render a cumulative effect hypothesis insignificant, and who decides on the required evidence. Ideally, determination of "acceptable risk" for cumulative effects must be determined by consensus of the stakeholders. For the consensus to be meaningful, these stakeholders must be informed as to the potential cumulative effects, their likelihoods where known, their significance where known, the important knowledge gaps, and the research resources available to close those gaps.

Given the difficulties in identifying and evaluating CEE, it may be tempting to disregard cumulative effects assessment as impractical, and to downplay cumulative effects themselves as insignificant. Nonetheless, under the new CEA Act it is now the legal responsibility of resource managers to use existing knowledge and the research resources at their disposal to analyse those cumulative effects that fall within our understanding, and to identify as far as possible those that do not.

3.0 Development Scenarios

3.1 Introduction

Scenarios of the future must be developed for the prediction of future impacts. Cumulative environmental effects cannot be analysed unless proposed projects and actions are clearly stated. If the proposed actions are not clearly stated, then the true impacts may be overlooked, or based on wrong assumptions. Accuracy and completeness of a CEE assessment can be no better than the description of the entire life of the proposed actions or projects.

It is also very important to communicate to all involved that these are scenarios, not actual planning decisions or resource commitments. They are projections of *possible* future projects or actions that could be set in motion by implementing the proposed scenario. They are intended only for use in helping to predict future CEE, and are not resource commitments.

What follows is an attempt to describe a series of three development scenarios relating to the Slave Geological Province but impacting on the communities of Coppermine, Cambridge Bay, Umingmaktok, Yellowknife, Lutsel K'e (Snowdrift), Dettah (T'ereheda), Rae Edzo, Snare Lake (Wekweti), Rae Lakes (Gameti) and Wha Ti (Lac la Martre). The three scenarios represent three different rates of development in the SGP, slow, medium and high. Each scenario attempts to describe what may happen in the SGP during the period 1995 to 2010 and more particularly what will exist in the SGP by the year 2010.

3.2. Elements in Each Scenario

The scenarios build upon the same base case—what was happening in the SGP in 1994. They use information about past levels of activity to predict future levels of activity. The activities considered in the scenarios include:

- mineral exploration
- mining
- community development
- transportation infrastructure development
- renewable resource harvesting
- hydroelectric power developments and
- tourism

3.2.1 Mineral Exploration

Most of the non-traditional activities in the SGP since the beginning of this century have been related to exploration for minerals. This activity has led to the development of a healthy gold mining industry in the region (see Section 3 .2.2) but the level of exploration activity has varied dramatically from year to year. Although some early phases of mineral exploration may involve only an airborne survey, most mineral exploration takes place on the ground and is conducted from a temporary camp.

Table 3.1 shows the number of camps in the SGP occupied by an exploration crew during the summers of 1990 to 1995. The number of camps has been determined by comparing the number of land use permits issued in the SGP for each year with the number of mineral properties said to be examined in DIAND's Exploration Overview for that year. Activities undertaken from these camps varies from prospecting and mapping to bulk sampling a deposit. The number of people in each camp may vary from 4 to over 100 but averages under 20. Many of the camps have a helicopter based at them and most camps would be supplied by fixed wing flights at least once a week. The duration of the camp depends on the success of the program. Most camps are occupied for one season of activity.

Table 3.1: Mineral exploration in the Slave Geological Province.

Year	Value Smillion	No. of Camps
I 995	I 05	60
1994	122	83
1993	70	52
1992	30	41
1991	24	30
1990	30	35

In the five years shown in Table 3.1 there is a variation of over 250% from the low ebb of exploration experienced in 1991 to the high point of the exploration cycle seen in 1994. Future exploration effort is often directly related to present exploration success. One good find such as the Lac de Gras kimberlite discovery can generate a flurry of exploration effort that peaks two to three years after the initial discovery and then declines quickly back to more conventional levels.

During the last 25 years the low points in the exploration cycle would average 20 to 25 exploration parties in the field. An average exploration year would see 30 to 40 camps occupied whereas an exceptionally high level of activity would see 50 or more camps occupied.

In 1994, expenditures for mineral exploration in the SGP approached the revenue generated from tourism in the entire N. W.T. ($134 million—see Section 3.2.7 below).

3.2.2 Mining

The purpose of the mineral exploration described above is to find ore deposits (mineral deposits which can be mined at a profit). The mining industry has become the N.W.T.'s largest goods producing industry. Six of the eight mines operating in the N.W.T. in 1994 are in the SGP. These mines are listed in Table 3.2. Ptarmigan shut down in that year and currently is not operating. The other mines also will shut down when they have exhausted their ore bodies. The Table provides a simple estimate of when this might be. The closure date has been calculated by dividing the reserve figure as of January, 1994 by the milling rate. Should the mine find additional gold or should the price of gold increase, the date of closure would be extended into the future.

Table 3.2: Producing mines in the Slave Geological Province, 1994.

Name	Location	Start up	Projected Closure	Reserves at start of 1994 (kt)	Ore Milled in 1994 (kt)	No. Of Employees 1994
Giant	Yellowknife	1948	2000	2,374 @ 11.0 g/t Au	3970	290
Con	Yellowknife	1938	2004	3,356 @ 10.6 g/t Au	322.0	350
Ptarmigan	Yellowknife	1989	I 995	30 @ 2.0 g/t Au	26.2	20
Lupin	Contwoyto Lake	1981	1998	2,959 @ 9.6 g/t Au	'725,8	450
Colomac	Indin Lake	I 993	2001	15,876 @ 1.7 g/t Au	1,232,0	260
Mon	Yellowknife	1992	2000	9 @ 12.0 g/t Au	1.5	9

In addition to the mines now operating, there exists a substantial inventory of mineral deposits in the SGP that might someday be profitably mined. Appendix A lists 27 such deposits. The list is incomplete but includes all properties for which mineral reserves have been published and a few recent discoveries which may have enough resources to make the calculation of reserves worthwhile, Many of these deposits have been known for 40 or more years but have not been mined primarily because of the high cost of developing a mine at their location and, in the case of the base metal deposits (zinc, copper and lead deposits), the high transportation costs of the concentrate produced.

3.2.3 Community Development

Tables 3.3 and 3.4 list the communities situated in the SGP and the communities bordering the SGP which may be impacted by developments within the SGP. The 1994 population for these communities was 21,390. The G. N.W.T. Bureau of Statistics forecasts that the population of these communities will increase to 32,660 by 2010, an increase of 53% in that period. However, these figures do not make provision for extraordinary events such as the creation of Nunavut and the opening and closing of large mines in the region.

At the end of 1994, of the 1,359 employees working at the operating mines (see Table 3.2), some 800 employees lived in the communities listed in Tables 3.3 and 3.4. Efforts are being made by the companies who fly their employees to the mine site to hire in the region. The BHP Dia Met partnership has estimated that direct employment from these communities at their operating mine could range from 60% to 70% (BHP Dia Met, 1995). Table 3. 5 lists mines now in operation and mineral deposits most likely to be developed in the SGP by 2010. For each of these mines the number of employees is given along with an estimate of the number of employees who live year-round in the Northwest Territories. The figures in this table have been used later in this chapter to calculate population changes in the region as a result of mine development.

The Government of the Northwest Territories does not encourage the creation of new communities at new mine sites. New communities are expensive to create and take people away from existing communities. However, should a number of large mines be developed in close proximity to each other, the workers at these mines might pressure both the government and their employers to create a new community.

The aboriginal communities in the next 15 years should benefit from the resolution of land claims and the establishment of regional governments, both of which should create employment opportunities within the communities, Yellowknife, however, may loose jobs as a result of the creation of Nunavut.

Table 3.3: Communities in the Slave Geological Province.

Community Name	Location	Population 1994	Population 2010'	Dominant Language 01 Residents	Current Economic Base
Dettah (T`ereheda)	62° 25'N 114° 18'W	160	180	Dogrib	Hunting, fishing & trapping
Lutselk'e (Snowdrift)	62° 24'N 11 O'44'W	280	350	Chipewyan	Hunting, fishing & trapping
Rae Edzo	62" 50'N 116° 3'W	1,600	2,000	Dogrib/English	Trapping & mining
Snare Lake (Wekweti)	64° 11'N 114° 11'W	130	150	Dogrib	Hunting, fishing & trapping
Umingmaktok (including Bathurst Inlet)	67° 42'N 107° 57'W	80	100	Inuktituk	Hunting, trapping & tourism
Yellowknife	62" 27'N 114° 22'W	16,060	25,600	English	Government mining & Transportation

[1] Based on forecasts prepared by the Northwest Territories Bureau of Statistics

Table 3.4: Communities near the Slave Geological Province impacted by activities in the Slave Geological Province.

Community Name	Location	Population 1994	Population 2010'	Dominant Language of Residents	Current Economic Base
Cambridge Bay	69° 7'N 105° 31'W	1,270	1,750	Inuktituk/ English	Hunting, fishing, transportation & tourism
Coppermine	67" 50'N 115° 6'W	1,150	1,660	Inuktituk/ English	Hunting, fishing, trapping & mining
Wha Ti (Lac la Martre)	63° 8'N 117° 16'W	400	530	Dogrib	Hunting, fishing & trapping
Rae Lakes (Gameti)	64° 7'N 117° 21'W	260	340	Dogrib	Hunting, fishing & trapping

[1] Based on forecasts prepared by the Northwest Territories Bureau of Statistics

Table 3.5: Forecasted employment at known and possible mine developments in the Slave Geological Province, 1995-2010.

Mine	Product	No. of Employees	No. of Northerner Employed[1]	Source
Giant	gold	290	290	Table 3.2
Con	gold	350	350	Table 3.2
Lupin	gold	450	80	Table 3.2
Colomac	gold	260	130	Table 3,2
Mon	gold	9	7	Table 3.2
Nicholas Lake	gold	175	105	Avery et al
Boston	gold	350	210	Avery et al
George Lake	gold	350	210	Avery et al
BHP Dia Met	diamonds	666-934	398-654 (934)	BHP Dia Met
Aber - Kennecott	diamonds	650	390 (650)	Avery et al
3rd Diamond Mine	diamonds	650	390 (650)	Avery et al
Izok	base metals	410	245	Klohn Crippen
High Lake	base metals	260	156	Avery et al
Hackett River	base metals	260	156	Avery et al

[1] If the mine is serviced by an all-weather road from Yellowknife 100% of the employees are northerners. If mine employees are flown in from a northern base, 60°A of the employees are northerners. In the case of the diamond mines the figures in brackets represent the number of northern employees if an all-weather road is built. In the case of Lupin and Colomac actual figures for 1994 are used (EMPR, pers. comm).

3.2.4 Transportation Infrastructure

Current mine operations in the SGP are supplied either by air or by an all-weather road to Yellowknife and by winter roads to Lupin or Colomac. Most of the gold mines that have operated in the SGP have used a winter road to bring in fuel and supplies. However, mines which produce large volumes of concentrate (i.e. base metal producers) would prefer to use all-weather roads to move their product to ocean ports. The value of base metal concentrate is such that it cannot be transported long distances by road economically. The base metal producers now operating in the N.W.T. are near the sea and transport their product by sea during the brief Arctic shipping season (May to October for Nanisivik).

An all-weather road has been proposed by Metall Mining Corporation (now Inmet Corp.) to run from their Izok Lake deposit to a port to be developed a few miles east of Coppermine. Funding for this road, as well as a more ambitious project, an all-weather road running north from Yellowknife through the diamond discoveries to Contwoyto Lake and then north to Izok Lake and Coppermine, has been difficult to obtain.

The BHP Dia Met group is not proposing an all-weather road to develop its diamond properties in the–vicinity of Lac de Gras. Both gold and diamond mines can transport their product easily by aircraft.

All but the smallest gold mines that have operated in the SGP since 1960 have built or had access to an airport to expedite the movement of people and product. It is anticipated that any new mine would build a runway early in its development stage.

Airport facilities exist at most of the communities in the region but some may require some upgrading to accommodate a larger, more mobile population.

In the scenarios that follow gold and diamond mines are forecast to come into production without an all-weather road. All base metal mines, except Izok, are forecast to require a winter road if they are more than 100 km from the sea coast. Izok, because of its extremely good grade of ore and the size of the deposit is forecast to start operations with a winter road but to gradually upgrade this road to an all-weather road over the first five years of operation.

3,2,5 Renewable Resource Harvesting

All of the communities listed in Tables 3.4 and 3.5 use the Bathurst caribou herd as a source of food. The harvest by resident hunters is determined annually by the Resident Hunter Harvest Questionnaire. The non-resident and non-resident alien harvest is reported annually by outfitters. The General Hunting License holders' harvest is estimated from harvest studies using community field workers. In the late 1980s the harvest by all hunters was estimated to be between 14,500 and 18,500 annually (Case, Buckland and Williams, in press) or between 4.1 and 5.3°A of the 1990 population estimate of the Bathurst herd.

Winter roads are particularly important for hunter access to the herd. Should the number of winter roads increase or should an all-weather road be built access to the herd would be improved. The population increase in the aboriginal communities can also impact the hunting statistics.
A maximum of 20,000 animals has been chosen by the authors of this report as the number of animals that could be harvested without harm to the herd.

The Bathurst caribou herd is also important for non-consumptive use. At least three lodges in the region cater to photographers and naturalists who visit the lodges, in part, to watch the caribou.

3.2.6 Hydroelectric Power Developments

In 1994 hydroelectric power developments existed on the Snare River and on the Yellowknife River. The Dogrib Power Corporation is in the process of expanding the power generation capability of the Snare system and has plans for further expansion of this system and for the development of a new hydroelectric plant on the Lac la Martre River.

Potential hydroelectric sites have been examined on the Lockhart River, on the Coppermine River and on the Hood and Bumside rivers, but no plans exist for the development of these sites. Several mining companies have considered using power from these sites but it has not been economically feasible for any one company to bear the full cost of development of any of these sites and the accompanying power line. Furthermore, there has been as yet no evidence that there would be a continuing need for the power if it were to be developed by the N.W. T. Power Corporation. Should three or more mines, each with a twenty-year lifespan, be developed in close proximity to each other and within a hundred or so kilometres from any one of the possible power sites, it is possible that a hydroelectric plant would be established.

3.2.7 Tourism

Tourism is the Northwest Territories' third-largest industry. In 1992 it generated $134,000,000 with $88,000,000 earned from non-residents and $46,000,000 earned from N.W.T. residents.

The G. N.W.T. Department of Economic Development and Tourism has estimated that 48,262 business and leisure visitors travelled to the N.W.T. between May and September 1994 (K. Colosimo, pet-s. comm.). The Western Arctic received 87% of the visitors and 8 1% of the revenue. Fifty-seven per cent of the visitors arrived by road and 43% arrived by air. The higher proportion of visitors in the Western Arctic was directly related to its accessibility by road. For example, over 6,300 people visited Inuvik by road (Dempster Highway) between July 1 and September 30, 1994. The main reason these visitors travelled to Inuvik was to "see *the Arctic.*"

There has been only a 6% increase in the number of visitors to the N. W.T. between 1989 and 1994. This modest increase is primarily attributable to the generally depressed North American economy and is consistent with levels of travel in other parts of North America.

The SGP is within two N.W.T. tourism administrative zones, the Northern Frontier Zone and the Arctic Coast Zone. These two zones receive approximately 30,000 or 62% of the N. W.T.'s visitors. The Northern Frontier Zone, which includes the City of Yellowknife, receives more than 27,000 visitors a year. Most of these visitors, however, do not travel beyond Yellowknife. They restrict themselves to the roads between Rae and Yellowknife

The City of Yellowknife has approximately 580 beds for rent (pers. comm). Another 50 beds are located in the smaller communities of Rae and Lutselk'e. Approximately 23 lodges and camps are scattered throughout the Slave Geological Province. Their individual capacity ranges from 4 to 30 beds with a total capacity of approximately 278 beds. (Facilities in the Bathurst caribou herd range area could accommodate over 4,000 people a season if booked to capacity.) Most of these facilities are open only during the summer between May and September, however, two or three of them have recently opened during a winter period between December and May (e.g. the Mackenzie Kho Camp).

The lodges and camps are bases for fishing, hunting and eco-wilderness activities such as camping, canoeing and nature photography. The eco-wilderness segment of the industry is growing.

Nine outfitters operate in the SGP. Six or seven tour companies also operate in the SGP.

One Yellowknife-based tour operator has been conducting aurora borealis tours specifically for Japanese tourists since 1989. Approximately 1,000 Japanese tourists participated in the tours during the December 1994 to April 1995 season, an increase of more than 50% since the tours started.

There are more than ten territorial parks with boating and camping facilities (about 140 camping sites) east-of Yellowknife along the Ingraham Trail. Residents, however, use these parks and their facilities more than non-residents. Park planning and development within the SGP is ongoing. The Coppermine River, for example, has been proposed as a Canadian heritage river.

The natural assets of the N.W.T. such as its rivers, lakes, wildlife and wilderness are the key attractions for visitors. In 1994, visitors rated fishing, boating/canoeing, community tours and hiking as the four most important activities.

If the tourist industry continues to grow at its current rate (6% over five years) then by the year 2010 some 36,000 tourists will visit the communities discussed in this report. Should an all-weather road be constructed to the Arctic coast these numbers are projected by the authors to increase by 50%.

3.3 Scenarios

On the next pages four scenarios are created based on the information contained in section 3.2 above. The four scenarios represent:

1. the present day (1 994);
2. a low development scenario for the year 2010;
3. a moderate development scenario for the year 201 O; and
4. a high development scenario for the year 2010.

3.3.1 Rationale

These development scenarios deal primarily with developments in the mining industry and with related infrastructure proposals. The authors acknowledge that other industries may have the potential to add to any CEE generated by the mining industry but in the SGP these impacts are likely to be minor. For example, the arts and crafts industry could impact the porcupine population should porcupine quill artwork become extremely popular. However the authors believe that the major issue now of concern to residents of the SGP is that of the potential CEES of a greatly increased level of mineral exploration and development.

The three future scenarios all assume that mineral development in the SGP remains a goal of all government and land claim organizations with responsibilities for resource management in the region and that regulations governing mineral developments do not become more onerous.

The scenarios are based on mineral prices that remain relatively stable and are adjusted only for cost of living changes.

Population figures are as predicted by the G.N.W.T. Bureau of Statistics for the aboriginal communities. These communities will supply workers to the mines but will not be subject to large immigrations or outmigrations. However, Yellowknife's population is adjusted up and down depending on the increase and decrease in the availability of mining jobs. For each job gained or lost the population is adjusted up or down by 1.85 people. (1991 statistics show that the average family size in Canada is 2.7 people. If every second miner is single and the other miner has a family, then the two-miners together, should they move to Yellowknife, would increase the population by 3.7 people.) The authors have adjusted the theoretical Yellowknife population by the removal of 2,000 people which represents the author's estimate of the net decrease in population resulting from the creation of Nunavut.

Since 1935, six major gold mines have opened in the SGP - Con, Giant, Discovery, Tundra, Lupin and Colomac. Of these six only two have operated for 20 or more years. A minimum of two moderately sized mines and a maximum of three should open in the next 15 years, given stable prices.

As yet no base metal mine has operated in the SGP but the Izok deposit has attracted much interest since its discovery and in recent years, Metall Mining Corporation (now Inmet Corp.) completed a feasibility study on the deposit. The authors believe that with further improvements to Arctic shipping, this deposit will become viable before 2010 and the opening of this mine may permit other base metal deposits to open.

The Izok deposit will first be served by a winter road from the mine site to Coppermine, but as cash flow permits, this road will be upgraded to an all-weather road. Should three or more diamond properties come into production in the Lac de Gras area, an all-weather road will become feasible. All other mines will be seined by winter roads and by airstrips.

It is likely that at least one diamond property will come into production before 2010. It is unlikely that more than three diamond properties of the size of the BHP Dia Met property would come into production before 2010. In Botswana three mines were opened in the first 15 years after the initial diamond development began in that country.

The Bathurst caribou herd will continue to supply the local communities with meat, but the number of animals taken per year will be capped at 20,000. This quota will not permit continued sports or commercial hunting of the herd.

Tourism will gradually increase with most of the tourists remaining on the road network. Should this network be expanded north from Yellowknife, tourism within the SGP will increase rapidly.

Hydroelectric capacity will increase on the Snare River and possibly on the Lac la Martre River. This power will be used primarily to serve Yellowknife, Rae and Edzo. It is possible that one other major hydroelectric development will&built provided that the project can be financed by guaranteed purchases.

3.3.2 Present Day (1994) (see Figure 3.1)

Mineral Developments

- six mines operating employing 1,380 people of which 800 come from northern communities
- 83 exploration camps spent $122 million on exploration

Community Development

- population in native communities is 5,330
- population in Yellowknife is 16,060

Infrastructure Development

- hydroelectric development on Snare and Yellowknife rivers only
- winter road from Yellowknife to Lupin mine and to major diamond exploration camps
- winter road from Rae to Colomac mine

Renewable Resource Development

- 14,500-18,500 caribou shot from Bathurst herd
- 30,000 tourists of which 1,500 go beyond Yellowknife

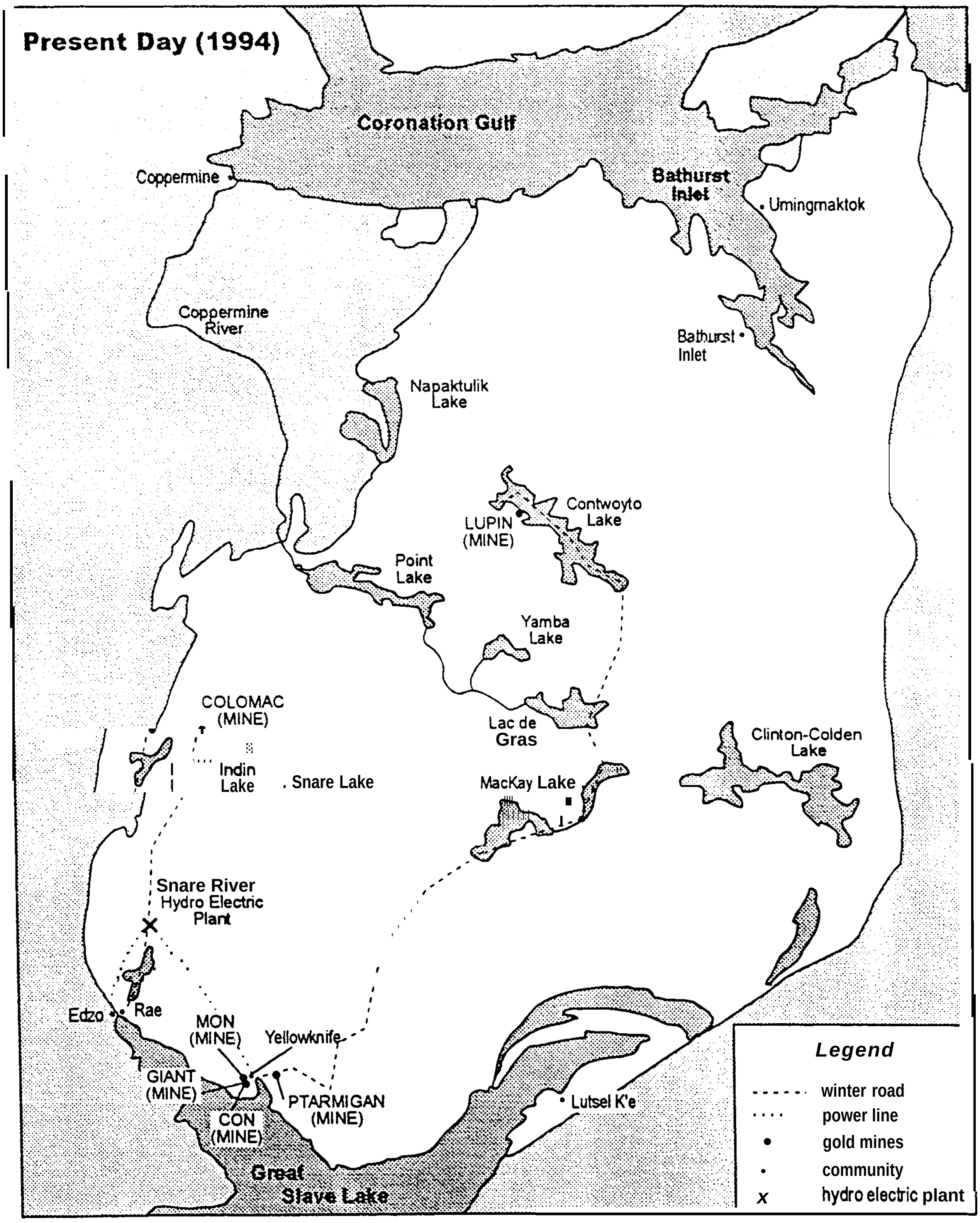

Figure 3.1: Map showing location of communities and major development activities in the Slave Geological Province in 1994.

3.3.3 Low Development Scenario for 2010 (see Figure 3.2)

Mineral Development

- Colomac mine operating employing 260
- Con, Giant, Lupin, Mon shut down
- Nicholas Lake and Boston gold mines opened and closed
- Izok operating as a base metal mine employing 410
- BHP-Dia Met diamond mine operating employing 934
- total employment at mines is 1,604 of which 1,029 come from northern communities
- 20 mineral exploration camps spent $20 million

Community Development

- population in native communities in 7,060
- population in Yellowknife is 23,900

Infrastructure Development

- winter road from Rae to Colomac mine
- winter road from the Izok mine to port near Coppermine
- winter road to BHP Dia Met diamond mine from Yellowknife
- further development of power potential of the Snare River

Renewable Resource Development

- 20,000 caribou shot from the Bathurst herd
- 36,000 tourists visit the region of which 2,000 go beyond Yellowknife

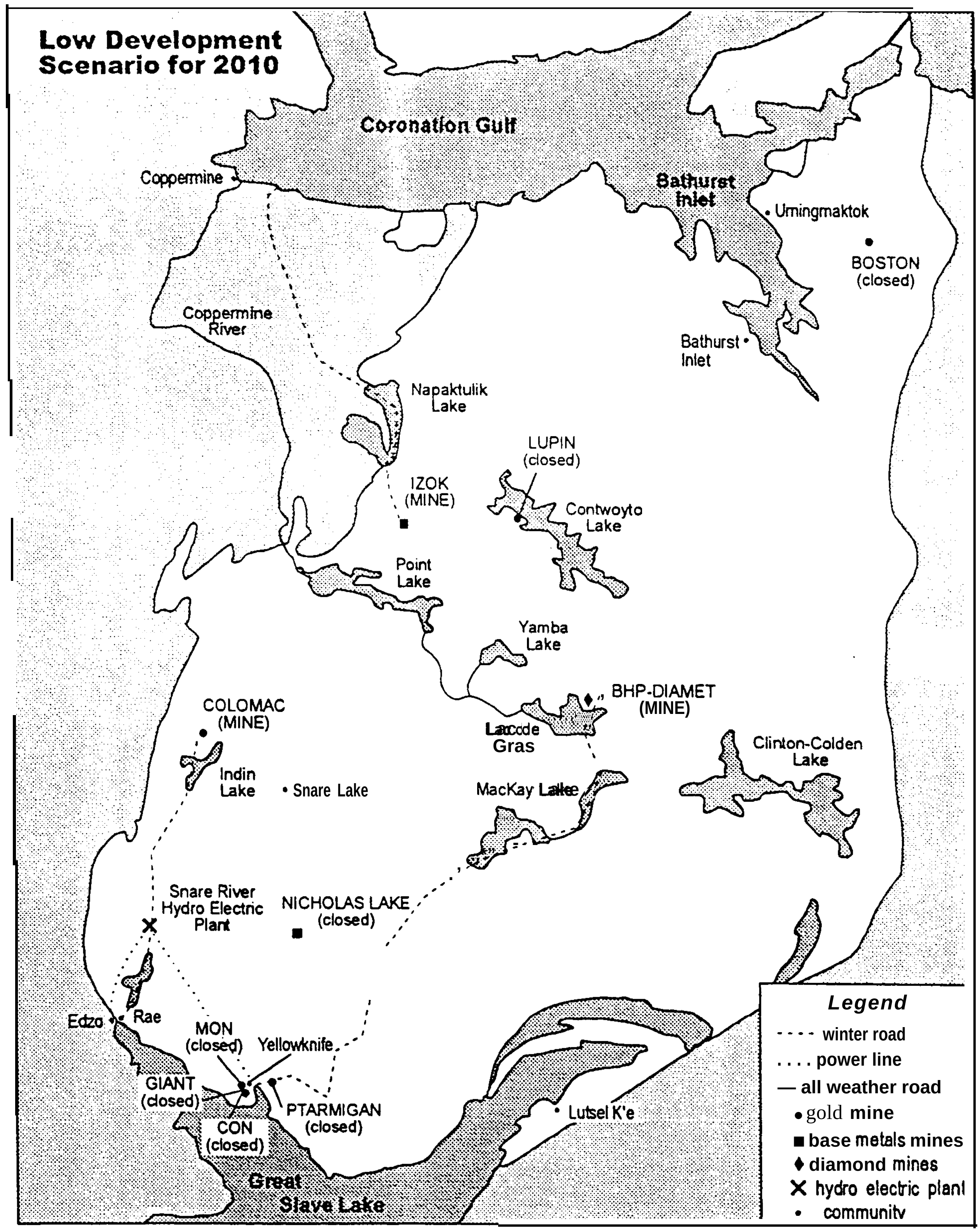

Figure 3.2 Map showing location of immunities and major development activities in the Slave Geological province in2010 for the low development scenario.

3.3.4 Moderate Development Scenario for 2010 (see Figure 3.3)

Mineral Development

- Colomac and Con mines still operating employing 610
- Giant, Lupin and Mon shut down
- Nicholas Lake gold mine opened and closed
- Boston gold mine operating employing 350
- Izok operating as a base metal mine employing 410
- High Lake operating as a base metal mine employing 260
- BHP Dia Met and Aber Kennecott operating 2 diamond mines employing 1,584
- total employment at mines is 2,604 of which 2,135 come from northern communities
- 40 mineral exploration camps spent $50 million on exploration

Community Development

- population in native communities is 7,060
- population in Yellowknife is 26,000

Infrastructure Development

- winter road from Rae to Colomac mine
- winter road from Boston mine to Attic coast
- all-weather road from Izok mine to Arctic coast
- winter road from High Lake mine to Arctic coast
- winter road to diamond mines from Yellowknife
- Snare River hydroelectric potential developed to maximum

Renewable Resource Development

- 20,000 caribou shot from the Bathurst herd (no commercial quota)
- 40.000 tourists visit the region of which 3,000 go beyond Yellowknife

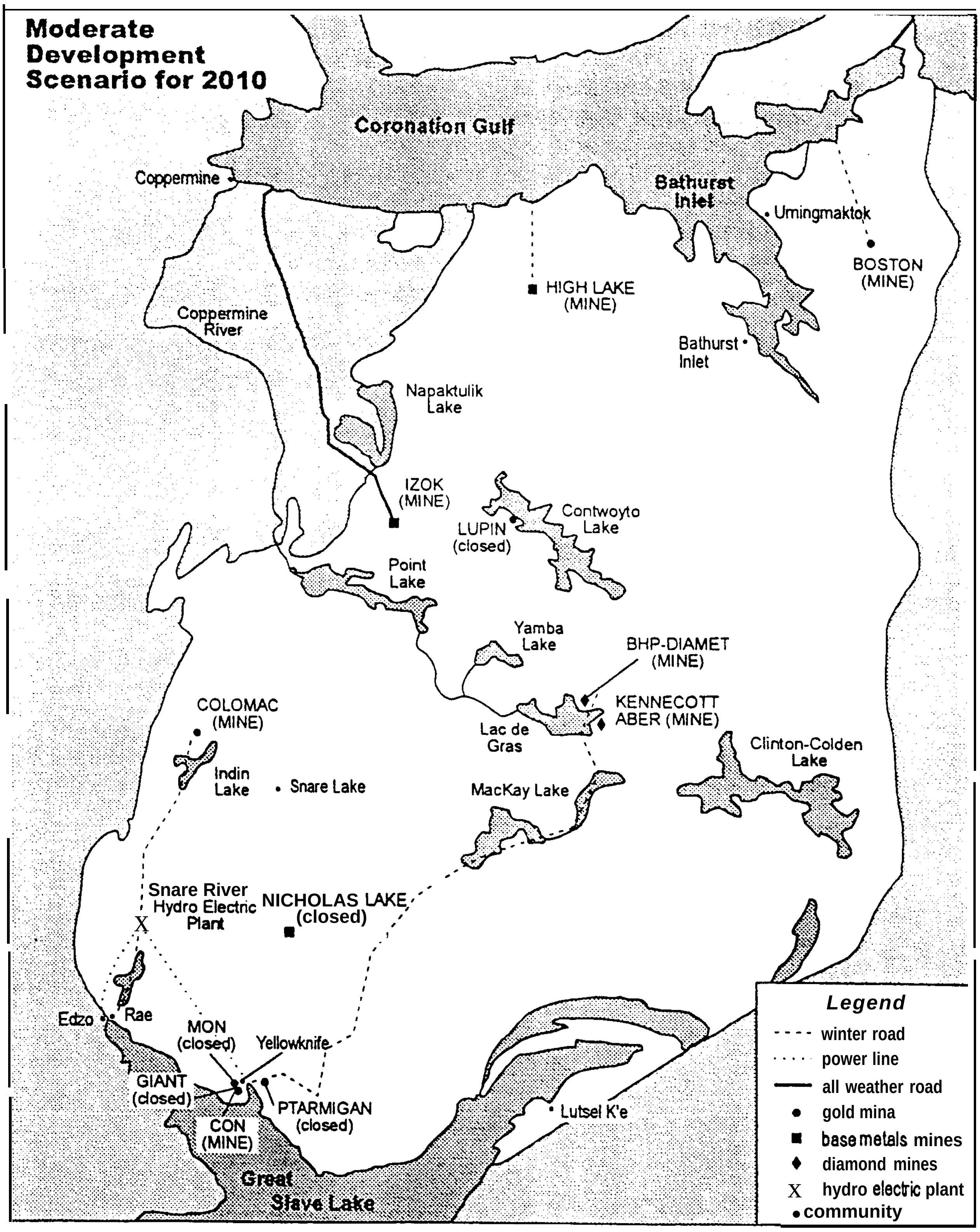

Figure 3.3: Map showing location of communities and major development activities in the Slave Geological Province in2010 for the moderate development scenario.

3.3.5 High Development Scenario for 2010 (see figure 3.4)

Mineral Development

- Colomac and Con mines still operating, employing 610
- Giant, Lupin and Mon shut down
- Nicholas Lake gold mine opened and closed
- Boston gold mine operating employing 350
- George Lake gold mine operating as a base metal mine employing 350
- Izok operating as a base metal mine employing 410
- High Lake operating a base metal mine employing 260
- Hackett River operating as a base metal mine employing 260
- BHP Dia Met, Aber Kennecott and a third company operating 3 diamond mines near Lac de Gras employing 2,234
- total employment at mines is 4,474 of which 3,590 come from northern communities
- 60 mineral exploration camps spent $100 million on exploration

Community Development

- population in native communities is 7,060
- population in Yellowknife is 28,800

Infrastructure Development

- winter road from Rae to Colomac mine
- winter road from Boston mine to Arctic coast
- winter road from High Lake mine to Arctic coast
- winter road from Hackett River mine to Bathurst Inlet
- all-weather road from Izok mine to Arctic coast
- all-weather road from Yellowknife to Lac de Gras
- new hydroelectric power developments on the Lac la Martre River to seine Yellowknife and on the Lockhart River to serve diamond mines

Renewable Resource Development

- 20,000 caribou shot from the Bathurst herd (all animals shot by General Hunting Licence holders and those with outfitter's permits)
- 48,000 tourists visit the region of which 6,000 go beyond Yellowknife

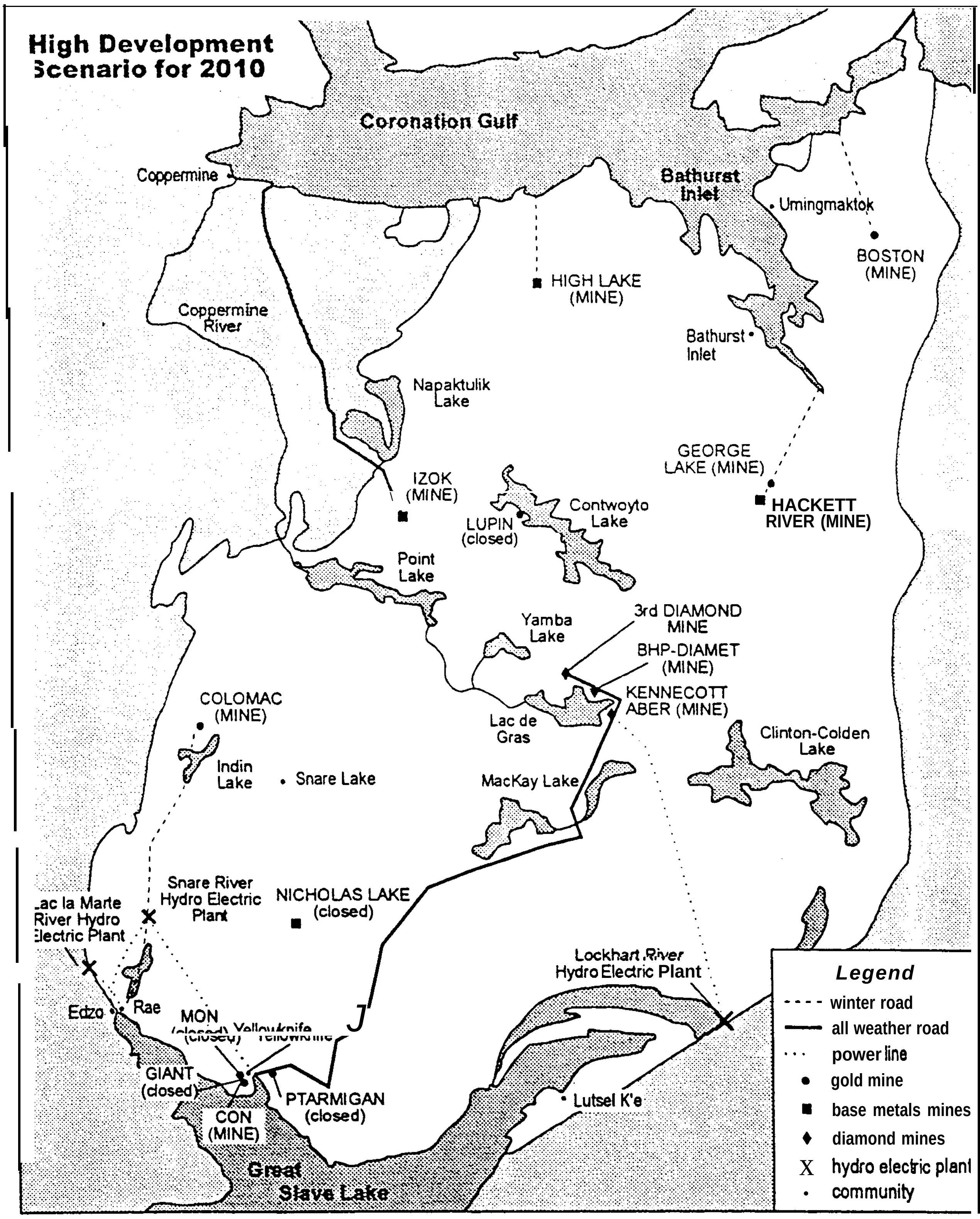

Figure 3.4: Map showing location of communities and major development activities in the Slave Geological Province in 2010 for the high development scenario.

4.0 Generic Footprints

4.1 Introduction

In order to assess cumulative environmental effects of proposed development scenarios it is necessary to know not only the impacts that each element in a development scenario would likely have on the environment, but also the extent to which those impacts would overlap in space and time. In practice, this means that for each major element presented in Chapter 3, a generic "footprint" or "environmental halo" must be described. These footprints describe zones of influence extending outward from the scenario element through the time and through the biophysical and socio-economic environment of the region.

Models of the "footprints" or impacts of future developments have been prepared for an exploration camp (see section 4.2), amine (see section 4.3), a winter road (see section 4.4), an all-weather road (see section 4.5), a hydroelectric development (see section 4.6), a transmission line (see section 4.7), an outfitting camp (see section 4.8), a community (see section 4.9), and tourism (see section 4. 10).

The generic footprints are each described in terms of the mechanisms of the impact. The five mechanisms that have been selected for inclusion are:

1. Decreased *quantity* of habitat (short term and long term changes):
   a) water
   b) land
   c) vegetation
   d) prey

2. Decreased *quality* of habitat (pollution, change in temperature or chemistry, change in vegetation, etc.)
   a) air
   b) water
   c) land
   d) vegetation

3. Anxiety (resulting from noise, presence of humans, chases during hunting, etc.)

4. Impairment of normal behaviour (e.g. blockage of caribou migration route; change in grizzly bear eating habits).

5. Direct mortality (e.g. hunting, killing of "nuisance" animals, collisions with vehicles).

These footprints are each size dependent. A small development will not have the impact of a larger development. Many of the mechanisms defining the footprint are controlled by regulation and normally can be ignored. However, it is important not to forget them when looking for mechanisms which can contribute to CEE.

Wherever possible these generic footprints should be based on information from past developments or from current standards. As an aid to estimating future impacts, observations from past and present developments in the SGP are tabulated in Appendix C.

4.2 Generic Footprint for an Exploration Camp

An exploration camp will be erected to conduct a winter drilling program beginning in 1996 and continuing the following winter (1997). Access will be by float plane and winter road. The generic impacts for this project are given in Table 4.1.

Table 4.1: Generic impacts of an exploration camp.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
1. Decreased Quantity of Habitat (short term & long term changes):					
a) water	use in drilling	during operation	100%	dependant on size of operation	water required for drilling
	ponding near culverts	as long as they exist	moderate	localized to specific site of installation	culvert required for trail construction
b) land	removal of land	during operation	high	localized within test area	test trenches or pits, blasting
c/d) vegetation/ prey	brush clearing	during construction	100%	confined to area of trail, camp and drill site	clearing necessary for construction
	vegetation covered with gravel or removed	during construction	100%	restricted to actual area of camp	gravel pad necessary for proper base
2. Decreased Quality of Habitat					
a) air quality	emissions from equipment	during operation	moderate	confined to proximity of equipment	equipment required for operation
b) water	debris in lakes	during operation	low	confined to particular water body	plane/boat dock left in over winter
	salt and other drilling additives contamination	operation	low	confined to particular water body	drilling additives improperly disposed of
	debris in streams	during construction	moderate	confined to particular stream bed	logs used for ice bridge construction
	erosion of shores	through-out operation	low	specific to particular shores near boat dock	float-plane and boat traffic causes waves
	fuel/oil spill	during operation	moderate to high	confined to particular water body	accidents during refueling and servicing of boats and float-planes

'Mechanism	Activity & pathway	*Time* scale	Probability	Magnitude	Assumptions
	sedimentation	during operation	moderate	confined to particular stream	culvert improperly installed and/or maintained
land	erosion	throughout operation	moderate	specific to site	steep grades in trail, exposed trench and drill sites
	permafrost degradation	during operation	moderate	localized within trail and campsite areas	ground cover damage due to heated buildings and/or ground cover damage
	holes in ground surface due to exposed drill holes	during operation	moderate	localized to specific drill sites	drill holes left unplugged
	heavy metal contamination	during operation	low to moderate	localized to core storage sites	leaching from exposed mineralize cores
	radioactive contamination	during operation	low	localized to core storage sites	improper handling of radioactive cores
) vegetation	vegetation damage	during construction and operation	high	localized areas	vehicles used off prepared trails, foot trails in camp
) Anxiety	noise due to blasting	during operation	high	few km surrounding blasting site	blasting performed during excavation
l) Impairment of Normal Behaviour	blockage of fish migratory routes	during construction	moderate to high	site specific	improperly sized and/or installed culverts
	attraction of animals to camp	during operation	high	within 20 km radius of camp	improper treatment of garbage and waste water
5) Direct Mortality	plowing over small mammals and birds	during construction	high	immediate area of trail and camp	large machinery used for trail and camp construction

4.3 Generic Footprint for a Mine

This mine is assumed to be situated on the south side of a lake on the tundra 300 km north of Yellowknife. Construction is scheduled to begin in 1996 and completed in 1997. The mine is expected to operate continuously from 1997 to at least 2003. The site will consist of a residential camp, a mill, an airstrip and a tailings pond (created from two natural ponds). Access by way of a winter road will be available until an all-weather permanent road is completed. These elements are illustrated in Figure 4.1.

The scale and operation of this mine will be similar to that of the Lupin mine. The impacts from this development are given in Table 4.2.

Table 4.2: Generic impacts of a mine.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
Deereased Quantity of Habitat (short term& long term changes):					
) water	draining lakes	within / year, permanent	50%	1 lake, 1 ha	lake drained to access part of mineral deposit
	filling small water bodies	within l year, permanent	50%	over site (140,000 m')	necessary to form stable surface
	stream diversion	within 1 year, permanent	50%	1 first-order stream, 200 m in length	stream re-routed around drained lake
I) land	clearing, trenching/ erosion from rapid snowmelt	during instruction until restoration	1 00%	140,000 m^2 site area	clearing required for mine construction/ waste rock, tailings impoundment erosion
:/d) vegetation/ prey	clearing, trenching	during Instruction & operation	high probability	140,000 m^2 site area	some vegetation/ prey will return during operation
!. Decreased Quality of Habitat					
a) air quality	gas emissions from incineration & stored fuels/oil	during instruction & operation	100%	within site (140,000 m^2)	no smelting or roasting operations at mine
	wind erosion tailings/vehicular traffic	during construction & operation	100%	within site (140,000 m^2)	fugitive dust from wind erosion of tailings and vehicular traffic
b) water	tailings discharge	during operation after abandonment	high	nearby down-gradient water bodies	heavy metal/other contaminants from tailings in pond
	spills	during instruction & operation	100%	nearby down-gradient water bodies	oil/fuel spills due to improper storage

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
	discharge from domestic waste acid reek drainage from waste reek piles contaminated mine water	during construction & operation	dependent on procedures used for sewage treatment & disposal	nearby down-gradient water bodies	improper procedures used
		during operation & after abandonment	high	nearby down-gradient water bodies	waste reek stockpiled, subject to leaching
		during operation	high	nearby down-gradient water bodies	
land	spills of fuels, oils & hazardous materials	during operation & after abandonment	high	within 140,000 m* mine area	mishandling of hazardous materials
	erosion	during operation & after abandonment	high	within site (140 000 m^2)	vegetation cleared allows for erosion
	tailings	during operation & after abandonment	high	within site (140,000 m^2)	exposed tailings
) vegetation	spills of fuels& hazardous materials	during operation & after abandonment	high	localized to spill area	accumulation of contaminants in wildlife
	tailings	during operation & abandonment	high	localized to tailings storage	accumulation of contaminants in wildlife
	deposition from wind erosion of tailings	during operation & abandonment	high	localized to tailings storage	accumulation of contaminants in wildlife from fugitive dust
;) Anxiety	air transportation	during construction and operation	low-moderate	in vicinity of airstrip	wildlife stress & alienation
	ground transportation	during construction and operation	low	along road corridor	
	instruction & operation of mine	during construction and operation	low	approximately *3 km* radius of mine	
	human presence	during instruction & operation	low-moderate	within mine site	
	accidental fires	during construction & operation	low	in immediate vicinity	

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
4) Impairment of Normal Behaviour	instruction of mine (draining/ filling lakes, water diversion, etc.)	during construction & operation	moderate during construction to possibly a period after abandon-ment	mine site and along road corridor	blockage of migratory movement
5) Direct Mortality	garbage disposal, feeding of wildlife	during construction & operation	70"/0	killing of "problem animals"	improper garbage disposal, feeding (based on 7 bears killed in 10 years at Lupin Mine)

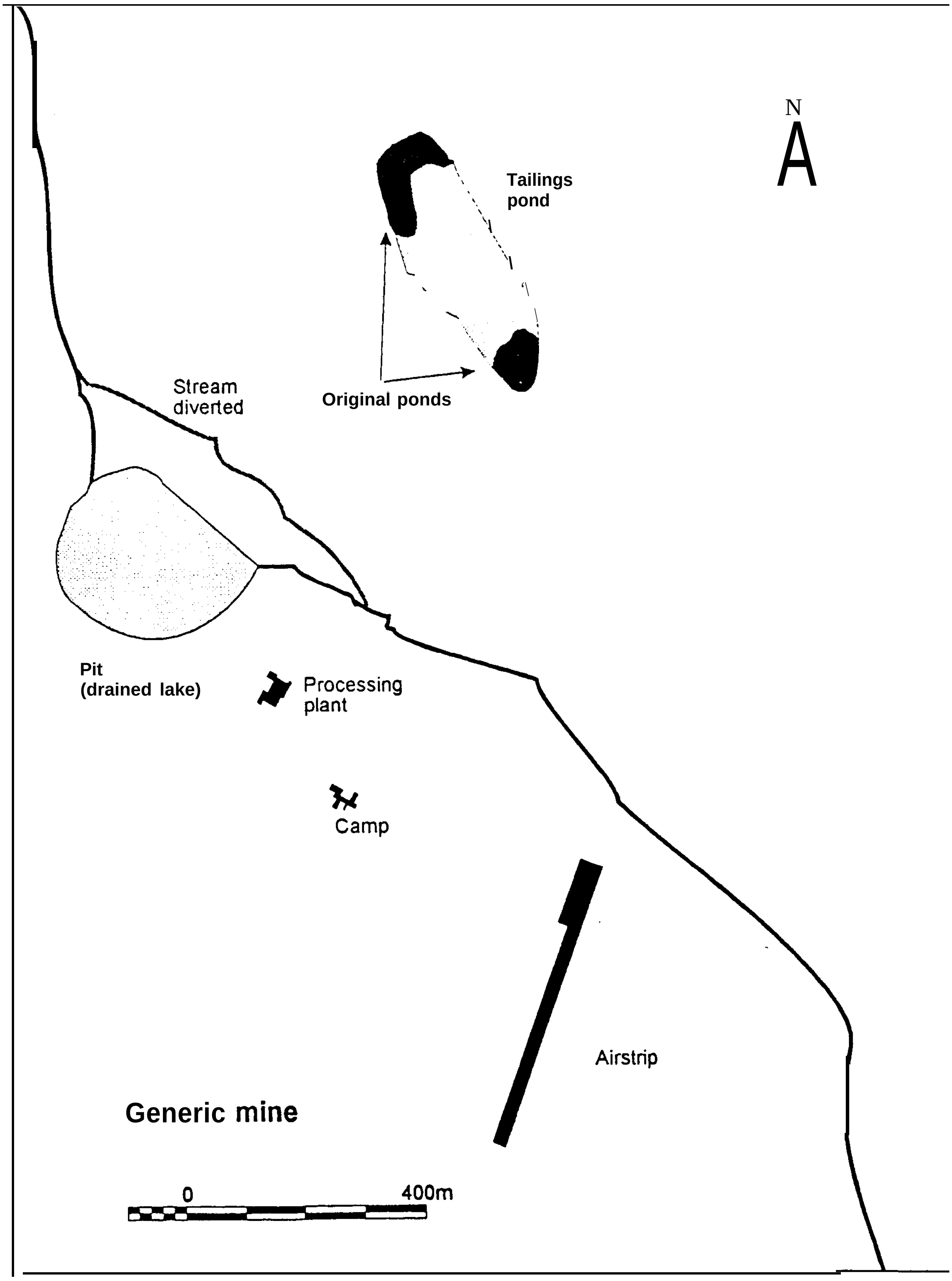

Figure 4.1: Generic mine development.

4.4 Generic Footprint for a Winter Road

A winter road will be constructed in order to supply the mine with supplies and construction materials while the mine is under construction and in the early stages of operation. The winter road will be 300 km in length with a 20 m right-of-way and will extend from the east end of the Ingram Trail to the mine site. Seventy-five percent of the road will be on lake ice. The generic impacts from the development are given in Table 4.3.

Table 4.3: Generic impacts for a winter road.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
Decreased Quantity of Habitat (short term& long term changes):					
) water	none	N/A	N/A	N/A	N/A
) land	laying gravel on ground surface	during instruction	100 %	for the length of portages, 8 m width	portages require smoothing
	portages cleared	during instruction	100%	for portages in treeline	clearing necessary for road construction
	instruction of borrow pits	during construction	100 %	1 sq. km every 100 km	for crushing and stockpiling road gravel
/d) vegetation and prey	small mammals killed	during operation	high	within corridor of road	road kills
	vegetation killed	during instruction	100 %	localized over 20 m width	
!. Decreased Quality of Habitat					
ı) air quality	emissions from equipment and vehicles	during instruction & operation	100 %	very localized, not continuous, winter only	gasoline and diesel -powered equipment used
)) water	water-courses	after operation	ıigh	water bodies affected	fill in lakes
	hazardous waste spills	during instruction & operation	Ow	site specific	improper disposal/ storage of equipment fuel, etc.
:) land	increased access to wilderness	during operation	100 %	50 km wide corridor in winter	road allows access for recreation, development
	fuel/oil spill	during construction/ operation	high	1 spill/yr. (winter road)	accidents in handling fuel and oil
1) vegetation	diversity of species changes	operation of road	20%	20 m width of portages	right-of-way cleared on portages
	damaged vegetation from vehicular traffic	operation	20 %	20 m width of portages	inadequate snow thickness &/or excessively heavy vehicles

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
) Anxiety	construction machinery noise	during construction	100%	in immediate vicinity	machinery required for construction
	sensory disturbances	life of road	high	species inhabiting road right-of- way	vehicular traffic
) Impairment of Normal Behaviour	road right-of- ways provide travel corridors	life of road	high	specific to species	cleared right-of-ways required
	blockage of migration routes	during use of road	moderate	specific to species	road traverses migration route
	attraction to camp facilities	during construction and operation	high	can affect some species up to 20 km away	improper treatment of garbage or waste
	withdrawal from area	during use	high	extends kilometres beyond actual width of corridor	intermittent high traffic and/or hunting pressures
	barrier to dispersal movements of small mammals	during use of road	low	within road corridor	raised road surface and vehicular traffic
	predators may congregate in right-of-ways	life of road	high	within corridor	cleared right-of-way
5) Direct Mortality	access allows increased hunting, fishing and trapping	life of road	100%	approximately 50 km on either side of road	general public has access to wilderness (hunting, etc.)
	large and small mammals and birds killed	during construction and use	high	on road surface	animal/ vehicle collisions

4.5 Generic Footprint for an All-weather Road

Construction of an all-weather road to serve the mine site and other mines will begin in 1998 and will take four years to complete, assuming 75 km of construction per year. The all-weather road will be 300 km in length with a 20 m right-of-way and will extend from the east end of the Ingram Trail to the mine site. The all-weather road has an expected life of 50 years. The generic impacts from the development are given in Table 4.4.

Table 4.4: Generic impacts for an all-weather road.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
. Decreased Quantity of Habitat (short term& long term changes):					
) water	culvert placement restricts water flow	life of road	1 00%	approx. every 20 km, 1 m in Dia Meter	culverts necessary to maintain water body connections
	parts of water bodies filled in	permanent from construction	100 %	approximately 1 ha	necessary for establishing stable surface
	water sprayed on road surface	during construction of road	high	road surface	water required for instruction
) land	laying gravel on ground surface	during instruction	100 %	for the length of road, 8 m width	gravel required for road construction
	entire right-of-way cleared	during construction, permanent	100%	for the length of road, 20 m width	clearing necessary for road construction
	instruction of borrow pits	during construction	100 %	1 sq. km every 25 km	for crushing and stockpiling road gravel
:/d) vegetation prey	vegetation removed	during construction, permanent	100 %	length of road. 8 m width	land not available for vegetation
	small mammals killed	during construction	high	within corridor of road	clearing required for road
	vegetation killed by dust suffocation	during instruction & operation	100 %	localized over 20 m width	fine gravel required for proper road surface
!. Decreased Quality of Habitat					
ı) air quality	emissions from equipment and vehicles	during construction & operation	100%	very localized, not continuous duration	gasoline and diesel-powered equipment used
	fugitive dust	during construction & operation	100%	very localized (in right-of-way)	dust spread for short duration

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
waler	salt contamination from CaCl	during operation	high	down-stream water bodies affected	CaCl used for dust control
	sedimentation in water-courses	during operation	high	down stream water bodies affected	erosion of fill around culverts
	hazardous waste spills	during construction & operation	high	site specific	improper disposal/ storage of equipment fuel, etc.
	sewage effluent discharge	during construction	varies depending on treatment	downstream water bodies affected	construction camp wastes
land	increased access to wilderness	during operation	100%	50 km wide corridor	road allows access; recreation, development
	permafrost degradation	during construction	moderate	20 m width	darnage to peat layer during construction
	fuel/oil spill	during construction/ operation	high	20 m width, 1.1 spills/yr. (all-weather road)	accidents in handling fuel and oil
vegetation	diversity of species changes	operation of road	80 %	20 m width	right-of-way cleared
	damaged vegetation from vehicular traffic	construction/ operation	50-75%	20 m width	inadequate snow thickness &/or excessively heavy vehicles
Anxiety	construction machinery noise	during construction	100%	in immediate vicinity	machinery required for construction
	sensory disturbances	life of road	high	species inhabiting road right-of-way	vehicular traffic
Impairment of Normal Behaviour	road right-of-ways provide travel corridors	life of road	high	specific to species	cleared right-of-ways required
	blockage of migration routes	during use of road	moderate	specific to species	road traverses migration route
	attraction to camp facilities	during construction	high	can affect some species up to 20 km away	improper treatment of garbage or waste
	withdrawal from area	during use	high	extends kilometres beyond actual width of corridor	intermittent high traffic and/or hunting pressures
	feeding in road right-of-ways	life of road	high	width of corridor (20 - 30m)	cleared right-of-ways necessary

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
	range abandonment	uring usc of oad	high	lependant on size of area transected by road	continuous heavy traffic and/or hunting pressures
	blockage of fish spawning routes	ife of road	moderate	lependant on number of streams blocked	improperly placed culverts
	barrier to dispersal movements of small mammals	luring use of oad	ow	within road corridor	raised road surface and vehicular traffic
	impaired territorial boundaries (birds)	ife of road	noderate	within corridor	raised road surface
	range extension of some birds	ife of road	igh	within corridor	cleared right-of-way
	predators may congregate in right of ways	ife of road	igh	within corridor	cleared right-of-way
	roads, bridges, cutbanks and culverts provide nesting sites	life of road	igh	within corridor	bridges, cutbanks and culverts are used in construction
	attraction of birds to roads for grit, salt and mud	life of road	igh	within corridor	road is constructed of gravel and calcium chloride is used for dust control
) Direct Mortality	access allows increased hunting, fishing and trapping	life of road	100%	approximately 50 km on either side of road	general public has access to wilderness (hunting, etc.)/ development opportunities
	small mammals destroyed by large equipment	during construction	high	within road corridor	heavy machinery required for construction
	vegetation destroyed by gravel overlay	during construction	100%	on road surface	gravel required for al weather road
	large and small mammals and birds killed	during construction and use	high	on road surface	animal/ vehicle collisions

4.6 Generic Footprint for a Hydroelectric Development

A hydroelectric development may be constructed in order to supply the mine and its infrastructure with electricity Construction and operation of the hydroelectric development will require 5,000 ha for the dam and reservoir. The generic impacts from this development are given in Table 4.5.

Table 4.5: Generic impacts for a hydroelectric development.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
Decreased Quantity of Habitat (short term& long term changes):					
water	diversion changes in water flow	life of development	100%	minor adjustments to steams flowing into reservoir	darns require water to be diverted from their normal channel
	areas are flooded	permanent	100 %	approximately 5,000 ha flooded	necessary for establishing reservoir
	altered chemical characteristics in the reservoir leading to imposition and abundance	permanent	high	minor	contaminants not high as reservoir does not flood much vegetation
	loss of streams	permanent	high	within flooded area	necessary for establishing reservoir
) land	laying gravel on ground surface	during construction	100 %	for roads and construction areas	gravel required for road construction
	project clearing	during instruction, permanent	100 %	5 ha	clearing for roads & dam
	construction of borrow pits	during instruction	100 %	2 ha	for crushing and stockpiling road gravel
:/d) vegetational prey	vegetation removed or flooded	during instruction, permanent	100%	length & width of reservoir	land not available for vegetation
	small mammals killed from the flooding	during construction	high	within reservoir area minor	most animals will escape during the gradual filling of the reservoir
	vegetation killed by dust suffocation	during construction & operation	100 %	localized over 20 m road width	gravel required for proper road surface
2. Decreased Quality of Habitat					
a) air quality	emissions from equipment and vehicles	during instruction	100%	very localized, not continuous	gasoline and diesel -powered equipment used

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
water	sedimentation in water-courses and reservoir	during operation	high	down stream water bodies affected	sedimentation in reservoir
	hazardous waste spills	during instruction & operation	low	site specific	improper disposal/ storage of equipment fuel, etc.
	sewage effluent discharge	during construction & operation	varies depending on treatment	downstream water bodies affected	instruction and operations wastes
land	permafrost degradation	during operation	moderate	under reservoir	
	fuel/oil spill	during instruction/ operation	high	localized	accidents in handling fuel and oil
vegetation	diversity of species changes	operation of road/reservoir	low	in reservoir	
	damaged vegetation from vehicular traffic	construction/ operation	50-75%	20 m width and under reservoir	
) Anxiety	construction machinery noise	during construction	100 %	in immediate vicinity	machinery required for construction
	sensory disturbances	life of road	high	species inhabiting road allowances	vehicular traffic
) Impairment of Normal Behaviour	sass roads provide travel corridors	permanent	high	specific to species	clearing required
	blockage of migration routes	during use of road & reservoir	low	specific to species	road or reservoir traverses migration route
	attraction to camp facilities	during construction & operation	high	can affect some species up to 20 km away	improper treatment of garbage or waste
	withdrawal from area	during use	high	extends kilometres beyond actual development	intermittent traffic and/or hunting pressures
	range abandonment	during operation	high	dependant on size of area flooded	
	blockage of fish spawning routes	life of development	low	dependant on number of fish using river	no fish ladder constructed
	barrier to dispersal movements of small mammals	during use of reservoir	low	within reservoir	
5) Direct Mortality	garbage disposal, feeding of wildlife	during dam construction	moderate	killing problem animals	improper garbage disposal, feeding wild animals

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
	river flows	permanent	high	high	fluctuations in water levels will affect fish & fish habitat
	access allows increased hunting, fishing and trapping	life of development	100%	approximately 50 km on either side of development arid access roads	dam operators have access to wilderness (hunting, etc opportunities)
	small mammals destroyed by large equipment	during construction	high	within road corridors	heavy machinery required for instruction
	vegetation destroyed by gravel and water overlays	during construction & permanent	100%	in the reservoir & on road surfaces	gravel required for all weather road
	large and small mammals and birds killed	during construction and USC	high	on road surfaces	animal/ vehicle collisions

4.7 Generic Footprint for a Transmission Line

In order to service the mining operations, power from the new Hydro Generating Station must be transmitted to the mine site by way of transmission lines. The line is 100 km in length and is situated on a cleared corridor 20 m in width. The impacts for this project are given in Table 4.6.

Table 4.6: Generic impacts of a transmission line.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
Decreased Quantity of Habitat (short term arid long term changes)					
) water	use in drilling	during operation	100%	dependant on sue of operation	water required for drilling
) decreased land quantity	permafrost damage	during construction	high	site specific	equipment removes or damages revering vegetation
'd) de-creased vegetation/	destroyed vegetation	during construct ion	high	specific areas within cutline	tires or tracks of construction equipment run over surface vegetation
prey quality	shrubs/ trees removed	during obstruction	100%	total area of cutline	clear cutting necessary for installation of poles and line
	small mammals and ground nesting birds	during construction	high	within cutline	equipment necessary for construction
.. Decreased Quality of Habitat					
.) air quality	emissions from equipment	during construction	high	localized within construction area	fuel powered equipment necessary for construction
	magnetic field	life of transmission line	low	localized witbin immediate area of lines	current running through lines may cause magnetic field
›) decreased water quality	fuel/oil spill	during construction	high	localized within cutline	fuel powered equipment required for construction
:) decreased land quality	permafrost degradation	during instruction	high	localized	incorrect erection of poles and/or equipment tires and tracks penetrating revering vegetation
d) decreased vegetation quality	darnaged ground cover	during construction	high	within cutline	equipment tires and tracks tear up ground vegetation
3) anxiety	machinery noise	during construction	high	immolate area surrounding cutline	machinery necessary for clear cutting and pole erection

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
) Impairment of Normal Behaviour	roosting on poled towers	for as long as it exists	high	limited to poles, towers and wires	poles, towers and lines are necessary
	feeding on new vegetation in clearing	as long as cutline is kept clear	high	area of cutline	cutline kept clear of shrubs
	predators of small mammals and birds congregate in clearing	life of transmission line	high	area of cutline	cutline kept clear
	range extension of some bird	life of transmission line	moderate	-area of cutline	cutline kept clear
	impair territorial boundaries of birds	life of transmission lines	low	area of cutline	cutline kept clear
i) direct mortality	electrocution of birds	life of transmission line	high	limited to actual lines	lines are active
	collision of birds with lines	as long as lines are present	moderate	limited to actual lines	aerial lines required
	increased hunting	as long as cutlines are present	1 00%	several km either side of cutline	clear cutting required
	small mammals and birds destroyed	during construct ion	high	limited to area of cutl ine	equipment necessary for construction

4.8 _ Generic Footprint for an Outfitting Camp

A new outfitter sets up operations on the Coppermine River north of Rocknest Lake. The generic impacts of the development are given in Table 4.7.

Table 4.7: Generic impacts of outfitting.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
Decreased Quantity of Habitat (sh rt term and long term changes)					
) land	clearing	for duration of camp	100%	5.1 ha	land required for camp buildings
) vegetation	clearing	during construction & operation	high probability	< 1 ha	some vegetation will be lost during construction & operation
Decreased Quality of Habitat					
) air quality	:as emissions rom ncineration of uels/oil	during construction & operation	100%	within site (2 ha)	normal heating and cooking requirements
	vind erosion of oil	during instruction & operation	100%	within site (2ha)	fugitive dust from wind erosion of disturbed soil
) water	sewage lischarge	during operation	high	nearby down-gradient water bodies slightly impacted	some treatment probable
	spills	during instruction & operation	high	nearby down-gradient water bodies	oil/fuel spills due to improper storage and handling
	discharge from domestic waste	during instruction & operation	dependent on procedures used for sewage treatment & disposal	nearby down-gradient water bodies	improper procedures used
:) land	spills of fuels & oils	during operation	high	within camp area	mishandling of petroleum products
	erosion	during operation & after abandonment	high	within site	vegetation cleared allows for erosion
1) vegetation	spills of fuels & hazardous materials	during operation	high	localized to spill area	accumulation of contaminants in vegetation

'Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
	deposition from wind erosion	during operation & abandonment	high	localized to near camp	
) Anxiety	air transportation	during construction & operation	low-moderate	in vicinity of airstrip or lake	wildlife stress & alienation
	ground transportation	during construction and operation	low	at campsite	wildlife stress & alienation
	Instruction & operation of camp	during construction & operation	low	approximately 3 km radius of camp	wildlife stress & alienation
	human presence	during construction & operation	low-moderate	within camp site	wildlife stress & alienation
	accidental fires	during construction & operation	low	in immediate vicinity of camp	put out immediately
l) Impairment of Normal Behaviour	instruction of camp	during construction & operation	moderate during construction	minor	blockage of migratory movement
5) Direct Mortality	garbage disposal and client hunting	during operation	high	killing of trash animals	some of camp's clients are hunters

4.9 Generic Footprint for a Community

The six communities located in the Slave Geological Province range in size from Yellowknife with a population of 16,060 to Umingmaktok with a population of 80. Except for Yellowknife the primary economic activities of the communities are hunting, fishing and trapping. As the populations increase each community require more land for building houses, roads, water lines and other community infrastructure. The generic impacts from these developments are given in Table 4.8.

Table 4.8: Generic impacts for a community.

Mechanism	Activity & pathway	Time scale	Probability y	Magnitude	Assumptions
Decreased Quantity of Habitat (short term & long term changes):					
) water	increased usage	permanent	100%	depends on community size	water licence required
	parts of water bodies filled in	permanent	100 %	minor streams will be lost	necessary for establishing stable surface
	water sprayed on road surface	summers	high	all major dirt roads	water required for dust control
)) land	laying gravel on ground surface	permanent	100%	all gravel roads	gravel required for road construction
	used for buildings & roads	permanent	100 %	depends on speed of expansion	clearing necessary for construction
	construction of borrow pits	permanent	100 %	5% of land area	for crushing and stockpiling road gravel and permafrost berms
:/d) vegetations/ prey	vegetation removed	permanent	1 00 %	as required	land not available for vegetation
	small mammals killed	during construction & operation	high	continuing losses	vehicular traffic primarily responsible
2. Decreased Quality of Habitat					
a) air quality	emissions from equipment and vehicles	permanent	100%	localized	gasoline and diesel -powered equipment used
	fugitive dust	permanent	100 %	localized	dust spread for short duration
b) water	salt contamination from CaCl	permanent	high	down-stream water bodies affected	CaCl used for dust control

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
	sedimentation in water-courses	continuous	high	down-stream water bodies affected	erosion of fill around Culverts
	hazardous waste spills	continuous	high	site specific	improper disposal/ storage of equipment fuel, etc.
	sewage effluent discharge	permanent	varies depending on treatment	downstream water bodies affected	communities growing with growing population
land	increased access to wilderness	during operation	100%	50 km radius	community accesses wilderness for recreation, development
	permafrost degradation	several years	low	certain building lots	damage to permafrost layer
	fuel/oil spill	during occupation	high	site specific	accidents in handling fuel and oil
vegetation	diversity of species changes	permanent	high	over area of community	new plants introduced by inhabitants
	damaged vegetation from vehicular traffic	permanent	high	within I 5 km of community	skidoos & 4-wheel drive vehicles used
) Anxiety	encroachment on habitat	permanent	100 %	in immediate vicinity of community	mammals move away
	sensory disturbances	life of community	high	varies with species	
	blockage of migration routes	permanent	moderate	specific to species	community blocks migration route
	attraction to community	permanent	high	can affect some species up to 20 km away	improper treatment of garbage or waste
	withdrawal from area	permanent	high	specific to species	intermittent high traffic and/or hunting pressure
	feeding	permanent	high	specific to species	old food source lost new focal sources found
	range abandonment	permanent	high	dependent on size of community	continuous traffic and/o hunting pressures
	blockage of fish spawning routes	permanent	moderate	dependent on number of streams blocked	improperly placed culverts or diverted streams

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
	barrier to dispersal movements of small mammals	permanent	low'	specific 10 species	raised road surface and vehicular traffic
	impaired territorial boundaries (birds)	permanent	moderate	specific to species	
	range extension of some birds	permanent	high	specific to species	
	roads, bridges, buildings, cutbanks and culverts provide nesting sites	life of community	high	specific to species	bridges, cutbanks and culverts arc used in construction
	attraction of birds to roads for grit, salt and mud	life of community	high	specific to species	
) Direct Mortality	access allows increased hunting, fishing and trapping	permanent	1 00%	can be controlled by game laws	access to wilderness is increased (hunt ing, etc./ development opportunities)
	small mammals destroyed by large equipment	during instruction & occupancy	high	not large	heavy machinery required for construction
	vegetation destroyed by gravel overlay	during construction & occupancy	100%	on cleared surface	gravel required for buildings and roads
	large and small mammals and birds killed	during instruction & occupancy	high	can be controlled by game laws	animal/vehicle collisions and hunting pressures

4.1Q- Generic Footprint for Tourism

Tourism activity will increase in the Slave Geological Province as a result of the development of an all-weather road. Road access is a primary catalyst for tourism development. Lodges may be built along a road and from the lodge other wilderness areas may become more accessible. Tourism development also provides employment opportunities for northerners which in turn provides increased capital for more equipment, such as skidoos, to access hunting, fishing, and trapping areas. The generic impacts from tourism are given in Table 4.9.

Table 4.9: Generic impacts for tourism.

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
Decreased Quantity of Habitat (short term& long term changes):					
water	increased usage	permanent	1 00%	minor	small camp used only in summer
	displacement for buildings & roads	permanent	100 %	specific area	clearing necessary for construction
d) vegetation/ prey	vegetation removed	permanent	100 %	as required	land not available for vegetation
	small mammals killed	during instruction	high		clearing required
. Decreased Quality of Habitat					
) air quality	emissions from equipment and vehicles	permanent	100 %	localized	gasoline and diesel -powered equipment used
	fugitive dust	permanent	100 %	localized	dust spread for short duration
ı) water	salt contamination from CaCl	permanent	high	down-stream water bodies affected	CaCl used for dust control
	hazardous waste spills		high	site specific	improper disposal/ storage of equipment fuel, etc.
	sewage effluent discharge	permanent	varies depending on treatment	downstream water bodies affected	communities growing with growing population
c) land	increased access to wilderness	permanent			damage to peat layer
	fuel/oil spill				accidents in handling fuel and oil

Mechanism	Activity & pathway	Time scale	Probability	Magnitude	Assumptions
) vegetation	diversity of species changes				
	damaged vegetation from vehicular traffic	permanent			
) Anxiety	encroachment on habitat	permanent	100 %	in immediate vicinity	human activity increased
	sensory disturbances	permanent	high		
	blockage of migration routes	permanent	moderate	specific to species	road traverses migration route
	attraction 10 camp	permanent	high	can affect some species up to 20 km away	improper treatment of garbage or waste
	withdrawal from area	permanent	high		intermittent high traffic and/or hunting pressures
	feeding		high		
	blockage of fish spawning routes			dependant on number of streams blocked	improperly placed culverts
	barrier to dispersal movements of small mammals	permanent	low		raised road surface and vehicular traffic
i) Direct Mortality	access allows increased hunting, fishing and trapping	permanent	I 00%		access to wilderness is increased (hunting, etc./ development opportunities)

5.0 Cumulative Environmental Effect (CEE) Framework

The assessment of cumulative environmental effects is a complex process that can be dealt with by breaking it down into a number of steps. Some of these steps are common to any well conducted EIA while others are specific to CEE assessment. Most of the component parts already have been discussed separately; this chapter deals with how to combine them in a manner that allows the assessor to evaluate the potential for cumulative environmental effects.

Table 5.1 describes each step briefly. Section 5.1 elaborates on each step. Figure 5.1 illustrates the process. Section 5.2 provides an example of how this framework might be applied to evaluating the potential for cumulative environmental effects from industrial and other developments in the SGP.

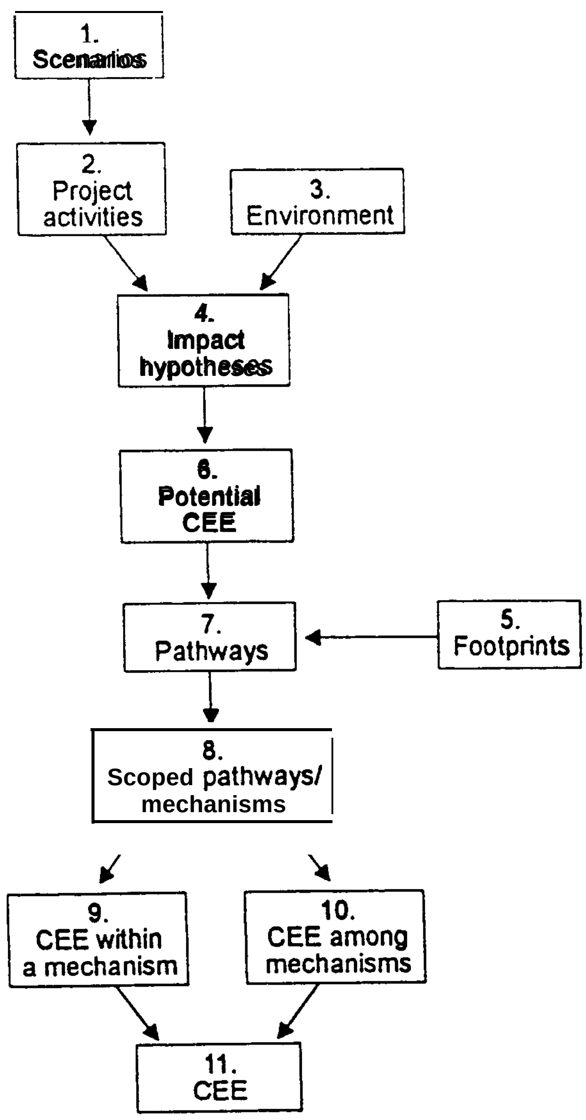

Figure 5.1: Outline of CEE assessment framework.

Table 5.1: Cumulative environmental effects framework.

Step Name	Description
1 Describe development scenarios	
2 Describe project activities	As in EIA
3 Identify VECS	As in EIA
4 Develop impact hypotheses	As in EIA
5 Describe footprint of proposed development	
6. Identify potential CEES	List potential CEES of concern based on impact hypotheses.
7 Record pathways	Tabulate all the pathways (for all the activities) that result in the effects identified in Step 5.
8 Scope and analyse pathways	Integrate footprint data with pathways to establish whether the pathways recorded in Step 7 have potential to act cumulatively i.e. do they operate in same spatial or temporal horizon? Are they potentially additive? Eliminate pathways that are not potentially cumulative. Output represents the potentially additive cumulative effects.
9 Evaluate potential for CEES within same or similar pathways	Apply professional judgement to results of Step 8 to evaluate whether similar pathways/ mechanisms that may be additive are likely to be significant.
10 Evaluate potential for CEES among different pathways	Apply professional judgement to results of Step 8 and 9 to evaluate whether different pathways and /or potential intermediate effects are likely to interact. Output represents the potentially synergistic CEEs.
11 Combine CEES	Combine CEES from Steps 9 and 10.

5.1 About the Steps

Step 1 Establish the development scenarios (Chapter 3). What combination of developments, and what magnitude of events are being evaluated.

Step 2 Describe the development in terms of the specific activities associated with each type of development: i.e. a mining operation involves construction, tailings and waste rock disposal, atmospheric waste emissions, etc.

Step 3 Describe the environmental setting. At this step the biota, vegetation, soil, water and atmospheric renditions are characterized. Is the project area in the tundra or taiga? What Valued Ecosystem Components (VECs) are of concern?

Step-4 Identify possible impacts of the proposed activities on the environment. A common method of doing this is to develop impact hypotheses. Appendix B describes this method briefly and provides examples of some impact hypotheses diagrams for the Slave Geological Province. Table 5.2 indicates the range of impact hypotheses that might be needed. Input from specialists is needed to ensure that hypotheses are plausible. Trivial hypotheses can not be eliminated yet because, unlike conventional EIA, there is not enough site specific information at this stage.

Steps 2 to 4 are common to any well conducted EIA. Steps 5 to 9 are unique to analysing for CEE.

Step 5 Determine over what range of space or time the impacts of each type of activity are observed. In other words, what are the environmental footprints of the proposed development activities? For example, a project that produced gaseous emissions may have an atmospheric footprint that extends hundreds of kilometres downwind. Footprints reflect the observed environmental impacts after mitigation has been applied. Environmental footprints have been described more filly in Chapter 4 and Appendix C.

Step 6 Identify which of the effects or impacts in the impact hypotheses are of potential concern for each VEC. At a technical level this will also involve specifying the assessment indicators and ecological indicators (see Everitt, 1992 for a discussion). In practical terms it means also agreeing on how to measure an effect. For example, if the effect of the concern is a loss of quality of caribou habitat, an assessment endpoint might be the nutritional status of the caribou.

The focus is shifted from the development and all the potential impacts it might have to the VEC and to the specific effects of potential concern and to the range of mechanisms that give rise to those effects. At this point it is important that the impact hypotheses (Step 4) are reviewed for consistent language i.e. effects such as reproductive failure and mechanisms such as habitat loss should be described using the same terminology in all impact hypotheses so that when the next step, Step 7, is carried out, all the pathways involving a particular mechanism, such as loss of habitat, are readily recognized.

Step 7 Record all the pathways that involve each single mechanism and VEC (e.g. habitat loss for caribou) from all the different impact hypotheses for all the activities of all the projects. This step is primarily a matter of tabulating all the pathways for each mechanism identified in Step 6. Table 5.3 is an example.

Step 8 Combine the footprint data (Step 5) with the pathways tabulated in Step 7 and the geographical and spatial realities for each VEC. At this point in the analysis trivial hypotheses, ones that do not leave a footprint, will be eliminated, Consider the feasibility of cumulative effects occuring between pathways that have not been eliminated. For example, will the footprint for the damage to vegetation hypothesis overlap with the caribou range? Will habitat loss due to a mine coincide spatially or temporally with increased hunting from a community so as to be additive in effect, or are the two activities so separate that the caribou will experience the habitat loss and the increased hunting as completely isolated mechanisms? If a particular pathway is isolated from others, in terms of its potential to cause a CEE, it can be eliminated at this step. The output of this step will be to identify in space and time the points of probable convergence of effects. This step is based on a thorough evaluation of temporal and geographical overlaps, and requires technical EIA skills.

Step 9 Evaluate the potential for significant cumulative environmental effects within each set of similar mechanisms from all activities. At this point expert judgement is brought to bear, for example, on whether the projected loss of many small areas of habitat across the caribou's range as a result of all the projected activities is likely to be significant to the caribou population.

Step 10 Evaluate the potential for significant cumulative environmental effects between mechanisms from all activities. As with Step 9, that assessment starts with looking at temporal and/or spatial overlaps, but it differs from Step 9 in that it looks at overlaps between mechanisms. For example, it looks at whether caribou that have been weakened by habitat loss are more vulnerable to hunting mortality. It requires expert analysis by a specialist in the particular VEC being examined to evaluate the significance of potential synergies.

Step 11 Combine all the cumulative effects identified in Steps 9 and 10 to generate a comprehensive assessment of the cumulative effects from all mechanisms. Unlike Steps 9 and 10, which rely heavily on professional judgement, this step is a more mechanical process of ensureing that all the effects identified in Steps 9 and 10 are accounted for.

Table 5.2: Overview of Impact Hypotheses for Slave Geological Province.

Project Types	Caribou	Musk Oxen	Grizzlies	Peregrine	Curlew	Air	Fresh Water	Grayling	Charr	Vegetation	Wilderness	Other
1. Mineral Exploration	1-Car	1-M	1-Gri		1-Cur	1-A	1-FW	1-GL	1-Ch	-V	3	0
2. Mine Development	2-Car	2-M	2-Gri	2-P	2-Cur	2-A	2-FW	2-GL	2-Ch	2-V	2-W	2-O
3. Mine Operations	3-Car	3-M	3-Gri		3-Cur	3-A	3-FW	3-GL	3-Ch	3-V	3-3	3-O
4. Abandoned Mines	4-Car	4-M	4-Gri	4-P	4-Cur	4-A	4-FW	4-GL	4-Ch	4-V	4-W	4-O
W	[illegible]	M	[illegible]	[illegible]	[illegible]	[illegible]	5-FW	5-GL	5-Ch	5-V	5-W	5-O
6. Hydroelectric De	6-Car	6-M	6-Gri	6-P	6-Cur	6-A	6-FW	6-GL	6-Ch	6-V	6-W	6-O
7. Road Development - W r/Al W	7-Car	7-M	7-Gri	7-P	7-Cur	7-A	7-FW	7-GL	7-Ch	7-V	7-W	7-O
8. Port Development	-Car	8-M	8-Gri	8-P	8-Cur	[illegible]	8-FW	8-GL	8-Ch	8-V	8-W	8-O
9. Communities *	9-Car	9-M	9-Gri	[illegible]	9-Cur	9-A	9-FW	9-GL	9-Ch	9-V	9-W	9-O
AP		10-M	10-Gri			10-A	10-FW	10-GL	10-Ch	10-V	03	0-O
Climate Change *	11-Car	11-M	[illegible]	[illegible]	[illegible]	[illegible]	-FW	[illegible]	11-Ch	11-V	3	0
12. Other	12-Car	12-M	12-Gri	12-P	12-Cur	12-A	12-FW	12-GL	12-Ch	12-V	12-W	12-O

[light shading] Impact hypothesis diagrams are provided in Chapter 5.

[dark shading] Impact hypothesis diagrams are provided in Appendix

* Other phenomena that result from human activity

** LRTAP = long range transport of airborne pollutants

5.2 Example

The following example will illustrate how the steps of the CEE framework can be applied to a scenario that includes three associated new developments: an all weather road, a new mining operation and an associated community. This example is at the extreme edge of probability fo rhte foreseeable future. The location that has been arbitrarily selected is somewhere in the tundra, north of Yellowknife. The VEC being studied is caribou. The outcomes and conclusions described for each step are fictitious. The intent is to illustrate how the framework can be used, not to suggest what the outcome of the analysis will be.

Step 1 Describe scenario	The True North Company has decided to develop a mine at a previously undeveloped site 300 km northeast of Yellowknife. The development is one of three similar mines proposed for the area, and it is decided that these can all be served by the construction of a permanent community for 3,000 people (half aboriginal and half non-aboriginal) and 400 km of all weather road. The road will lead from Yellowknife to Aurora, the site of the new mines. Each mine will be an open pit mine that will process 10,000 tonnes per day and will employ 400 permanent workers.
Step 2 Describe project activities	The developments will involve a) construction and maintenance of a townsite and infrastructure for 3,000: lots and buildings, roads, sewage and water treatment, airstrip, fuel storage, etc.; b) the construction, operation, and decommissioning after 25 years of three mines, including the open pit, water supply, waste rock piles, tailings, the mills, and fuel storage facilities; and c) the road that will access the community will follow the route of an existing winter road for 250 km, then extend for an additional 150 km. Truck traffic carrying materials to the community is expected to average 15 trucks a day. Aggregate for road construction is available along the route.
Step 3 Describe the environment/VECs	The proposed townsite and mine are located in tundra. Water is abundant, two separate drainage basins occur in the area and several unconnected lakes are under consideration as water supplies and mine waste disposal areas respectively. The fish resources are not noteworthy. The area supports productive and abundant sedge meadows (10% of the area) where the caribou congregate on their way to their spring calving grounds. Indigenous hunters report that 4,000 animals from the Bathhurst caribou herd move through the area each spring. The fall migration through the area is less predictable. No other VECS have been identified.
Step 4 Develop impact hypotheses	The developments may impact on caribou in the following ways (see Figures 5.3 -5.7 for detailed impact hypotheses): • The road may destroy valuable habitat, increase hunting pressure all along its route, serve as a barrier to migration or otherwise disturb the animals; and vehicle accidents may lead to fuel spills, collisions with animals, and fires. • The community will displace caribou from its traditional habitat; the noise and disruption may result in the animals avoiding the area, with the loss of use of additional habitat. The residents will increase hunting mortality. • The mine will displace caribou from previously used habitat the noise and disruption may result in the animals avoiding the area, with the loss of additional habitat Air emissions from the mine may affect vegetation as a result of unavoidably high sulphide content. Mine tailings may cause acid rock drainage that might seep throughout the soil, given the weak drainage in the area. Accidents may cause additional contamination of habitat. When abandoned the mines may leave behind toxic materials or improperly reclaimed areas that result in contamination of water or vegetation, or physical hazards.

Step 5 Apply footprints *Even with the best available technology, some residual impact of development is inevitable.*	Applying footprints gives us a much more realistic pictue of the likely impacts of each development if undertaken individually. The following example uses details from the footprint of a mine (Chapter 4) and partial footprints for the road and community (Appendix C). Where no data are available, artifical estimates have been used (i.e for hunting). • The road will occupy an area 20 meters wide and 400 km long Dust and noise may extend the zone of influence to ¼ km in width, for a total area of 100 square kilometers. Accidental spills could be contained to an area within this zone except where it crosses the major rivers, where spills could result in contamination extending several kilometers downstream. Between 200 and 300 hunters may be attracted into the area from Yellowknife and other immunities per year. • The mines will each occupy an area of 0.14 km^2. Five lakes will be affected with a total area of 2 km^2, with downstream effects disappearing after 2 km on each of three systems. (Total = 6 km of river). The effect of acid precipitation on local vegetation will extend less than 4 km downwind; heavy metals or other contaminants would be undetectable in lichens beyond the property boundaries. • The community, including the adjacent zone of disturbance for wildlife, will occupy an area of 3 km^2. A minimum of 1,200 residents would hunt; 600 aboriginal and 600 others. Because of the lack of trees and the nature of the watertable and permafrost, wild fires are unlikely. Spills of toxic materials would be localized within the townsite. The most environmentally damaging accident that is likely is a fire at one of the fuel storage facilities in the area,
Step 6 Identify effects that are of concern for each VEC	The impacts of greatest concern for caribou were loss of vegetation, contamination or pollution of their habitat, increased disturbances that would disrupt their ability to survive, direct mortality from hunting, and behavioral changes, such as interference with their migration patterns. The discussions and workshops that resulted in this consensus also dealt with how these effects would be measured (i.e. what indicators would be used), and the level of each that would be used to determine significance.
Step 7 Record pathways within each mechanism	See Table 5.3.

Table 5.3: Pathways for major mechanisms that may affect caribou. Numbers refer to pathways identified on impact hypotheses diagrams for mining, roads and communities, Figures 5.3 to 5.7.

Quantity of habitat (loss of vegetation)	Quality of habitat (contamination and pollution)	Sensory disturbance	Mortality (direct only)	Impairment of behaviour
Mine Construction				
2-car #1 2-car #2 2-car #13a 2-car #13b 2-car #5 2-car #9 2-car #18	2-car #16a 2-car #16b 2-car #13a 2-car #13b 2-car #18	2-car #18	2-car #18	
Mine Operation (waste disposal only)				
3-car #5 3-car #6 3-car #7 3-car #5, 6 cont.	3-car #5 3-car #6 3-car #7		3-car #13 3-car #14 3-car #15	
Mine Abandonment				
	4-car #1 4-car #3		4-car #10	
Roads (construction and use)				
7-car #5 7-car #6	7-car #4 7-car #7	7-car #3	7-car #1 7-car #2	7-car #8
Community				
9-car #1	9-car #15	9-car #4	9-car #3	9-car #5

Step 8 Scope and analyst pathways	The effects most likely to haven cumulative effect on the caribou arc those that result from habitat loss (quality and quantity) and increased mortality. No(c, this assumes that the evidence from the Dempster 1 lighway that caribou are not particularly vulnerable to behavioural disturbances also applies to the Bathurst herd. The proposed configuration of mines and community is in a line that runs from Aurora Lake towards the southeast for approximately 5 km. (see Figure 5 2). The effect maybe a line of occupied land approximately 5 km long that the animals may have to move around during their spring migration. The existence of a long I&eat the north end of the line of development will effectively block passage around the northern end of the line, further impounding the reduced accessibility of land northeast of (behind) the line. The prevaling wind directions may extend the zone of impact another 2 km to the southeast. Thus many of the pathways that involve habitat loss have the potential to act cumulatively in space: the amount of habitat effectively lost may be greater than simple addition of areas would suggest. Pathways involving hunting mortality would all be directed against the same herd. [t would be spread out along the road and throughout the season, with 70% of the hunting taking place during one month in the spring, within 20 km of town Hunting by miners would already be accounted for under community hunting, and can be eliminated from further consideration. That leaves hunting generated by the road and from the community. It has the potential to be more than simply additive: a community at the end of a road may attract more out-of-region hunters than a road that serves the mines alone would. The mortality associated with abandonment can be eliminated from consideration as a cumulative effect: it would occur at a time when hunting mortality would be reduced.
Step 9 Evaluate potential CEE within a mechanism	Loss of habitat consists of small parcels of land along the 400 km of road, but might compound rapidly in the area near the mine and town because of the possible linear effect. One major consideration is whether the loss of sedge meadows would be significant. Given that the proposed town is located on an area of prime sedge meadow at the outflow of Aurora Lake, and that the quantity and quality of sedge meadow deteriorates as you move southeast away from the lake, would the animals find enough alternative habitat to meet their nutritional needs, especially in the spring when females require high quality food in order to reproduce successfully? Are there other areas for them to use along their route? Expertise about caribou is required to evaluate this. Local indigenous hunters report that animals seem to prefer this area; it is a funnel through which they move every the spring. It is unclear how significant the increases in hunting mortality might be. Three factors would affect the extent to which hunting might cumulate. The first is the numbers of hunters that each project contributes, and their level of activity. The second is the duration of exposure: how long the caribou are along the road or near the community. The third is how the existence of the community might affect the numbers of hunters drawn to the area.
Step 10 Evaluate potential CEE between mechanisms	Two possible integrations that might exist between mechanisms are evaluated by caribou specialists (which might include traditional aspects). The first is whether the animals will be more vulnerable to hunting because they are weakened as a result of hunger. It is realized that animals hunted along the road from the south will not yet have experienced the loss of habitat. The second consideration is whether females that have been exposed to both the stress of increased hunting and the loss of sedge meadows will bear fewer calves. If so, at what level does a reduction in productivity become significant?

This example provides a simplified version of how selected mechanisms could be evaluated for CEE using the framework.

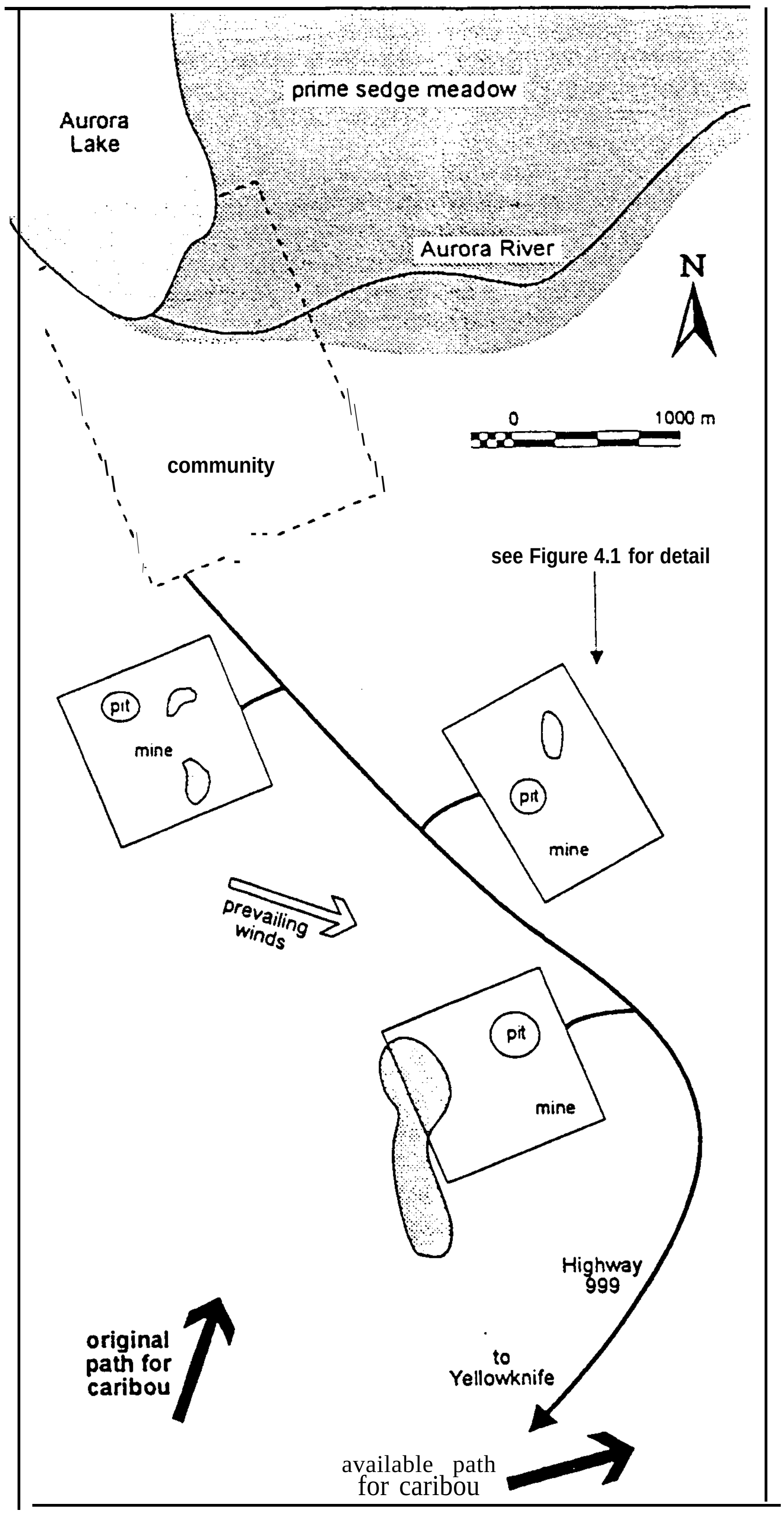

Figure 5.2: Example of a development scenario.

1-car Effects of mineral exploration on caribou

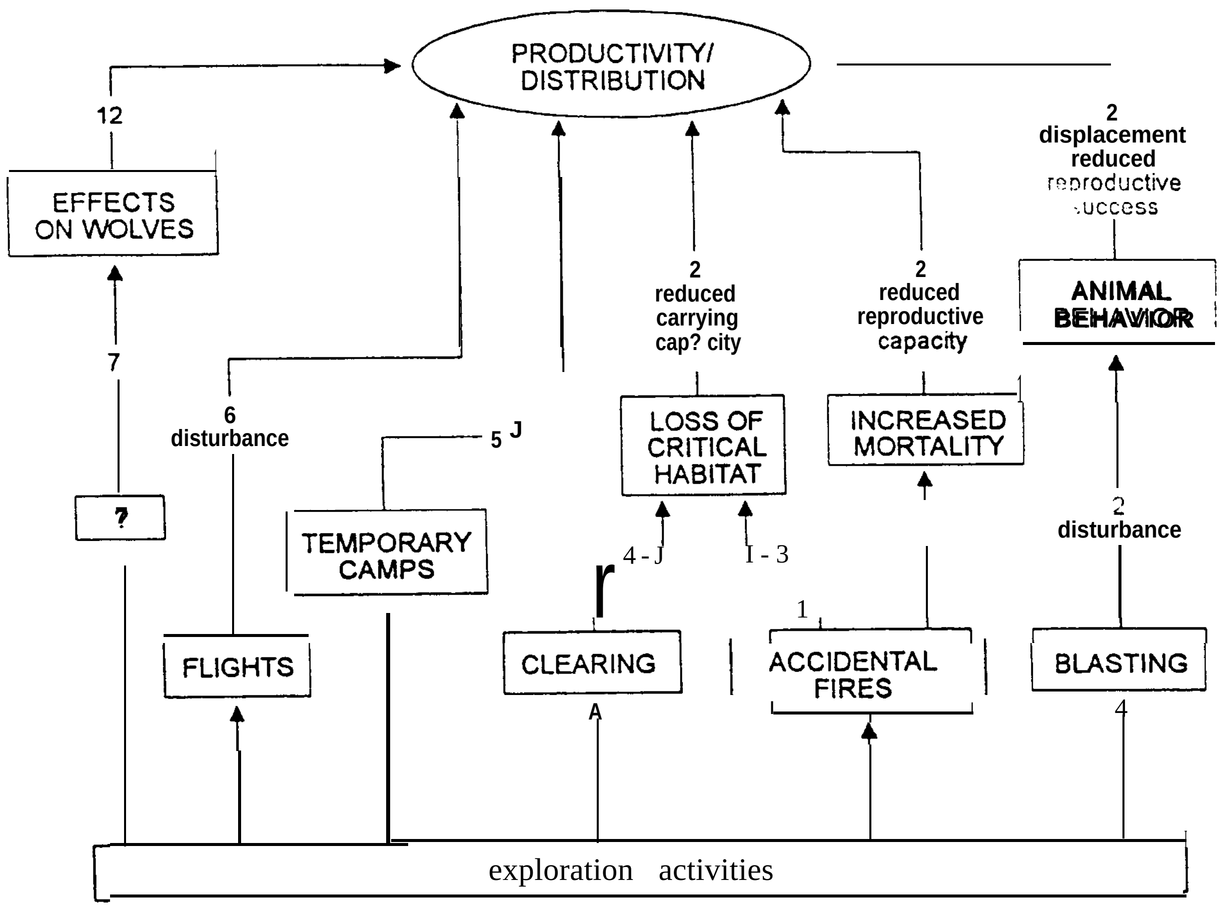

Figure 5.3: Impact Hypothesis 1-caribou. Mineral exploration on caribou.

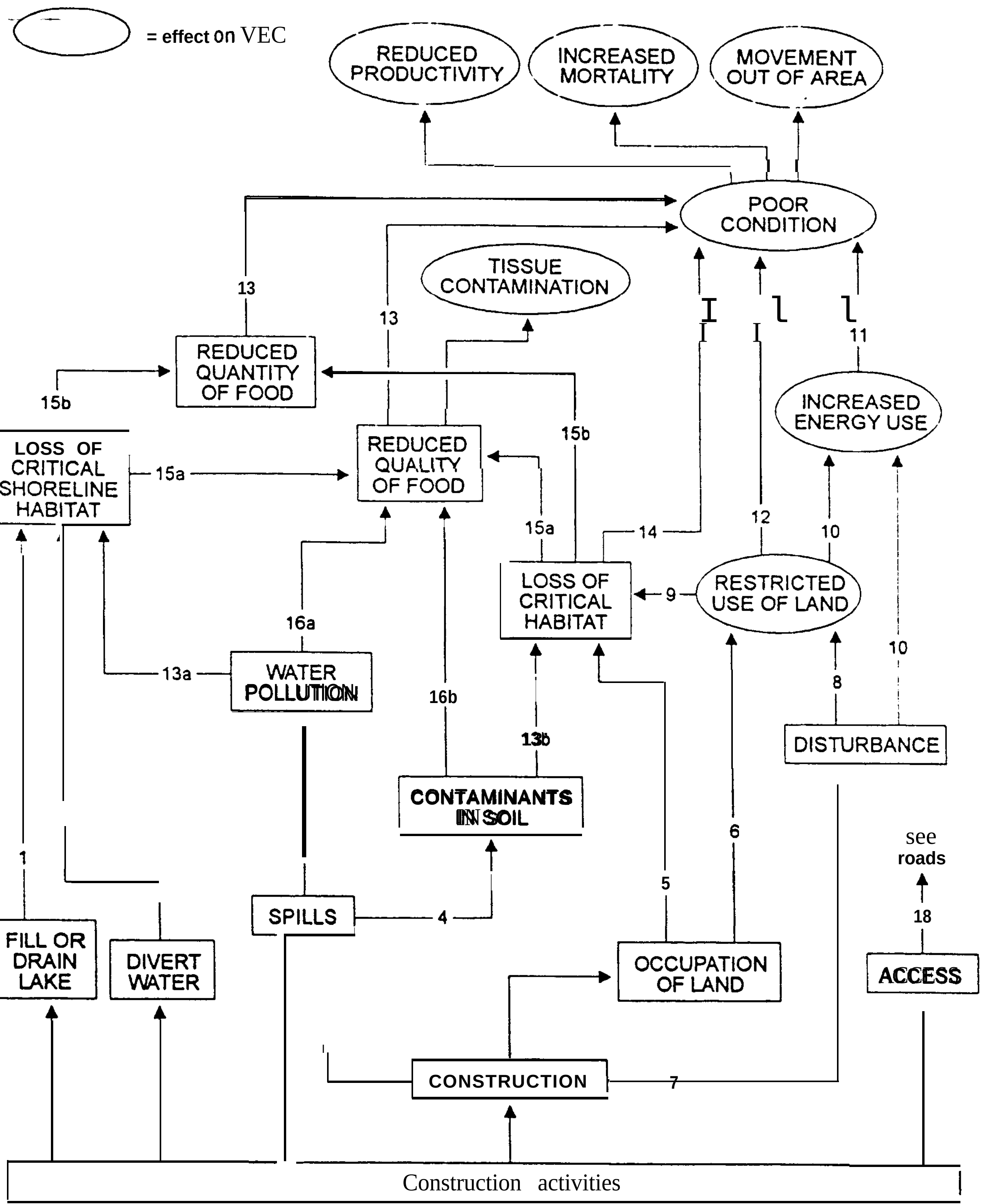

Figure 5.4: Impact Hypothesis 2-caribou. Mine construction on caribou.

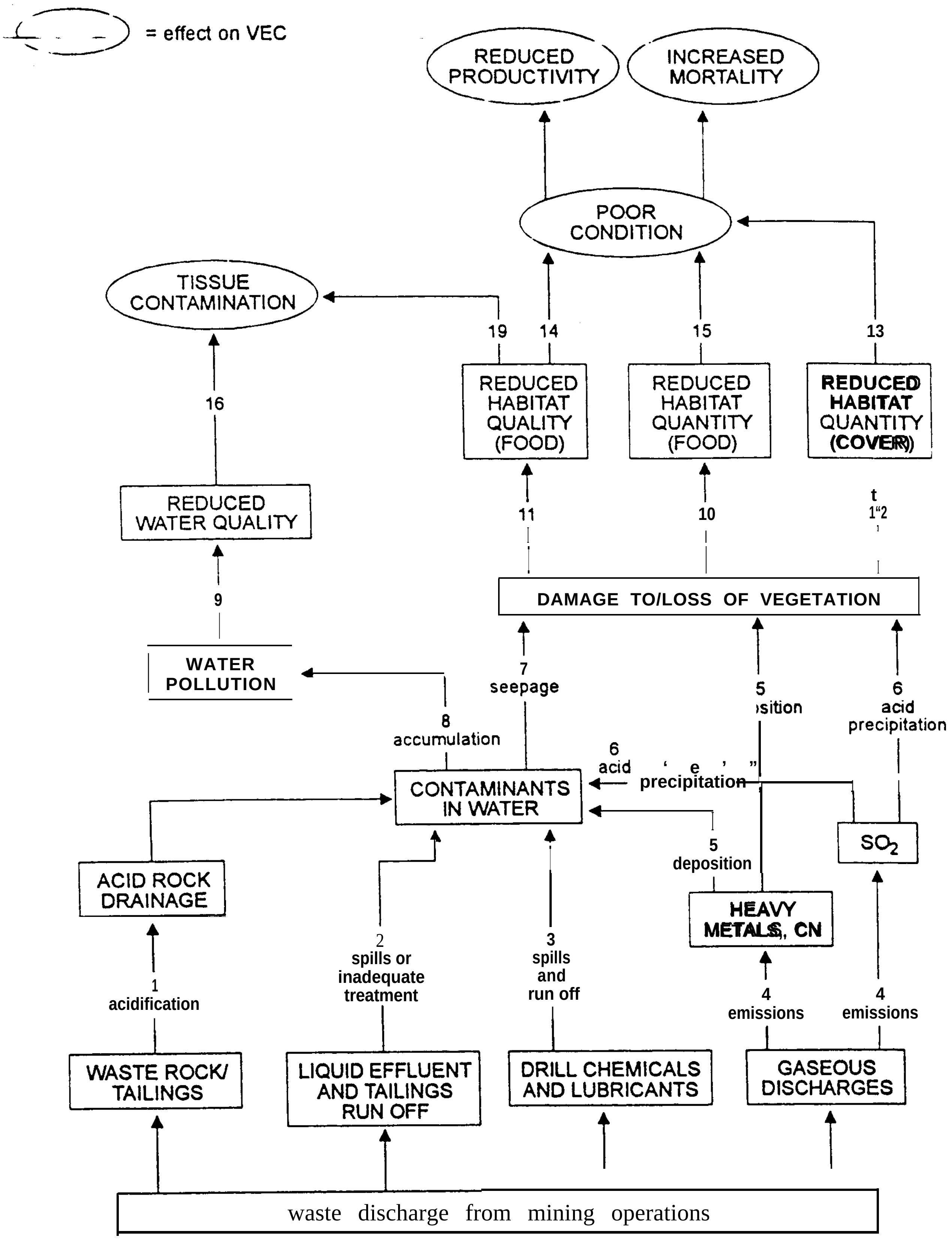

Figure 5.5: Impact Hypothesis 3-caribou. Waste discharges from mining operations on caribou.

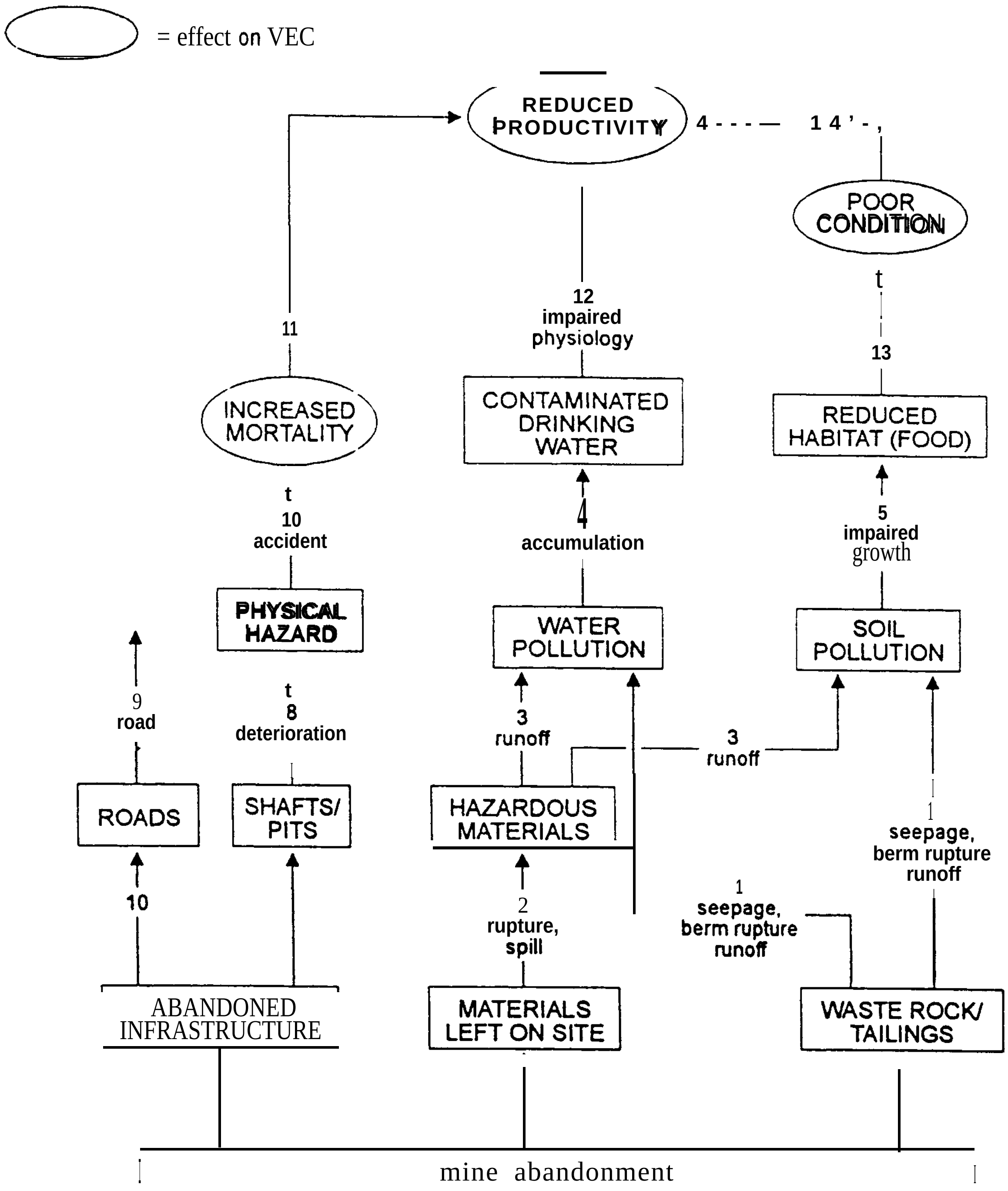

Figure 5.6: Impact Hypothesis 4-caribou. Mine abandonment on caribou.

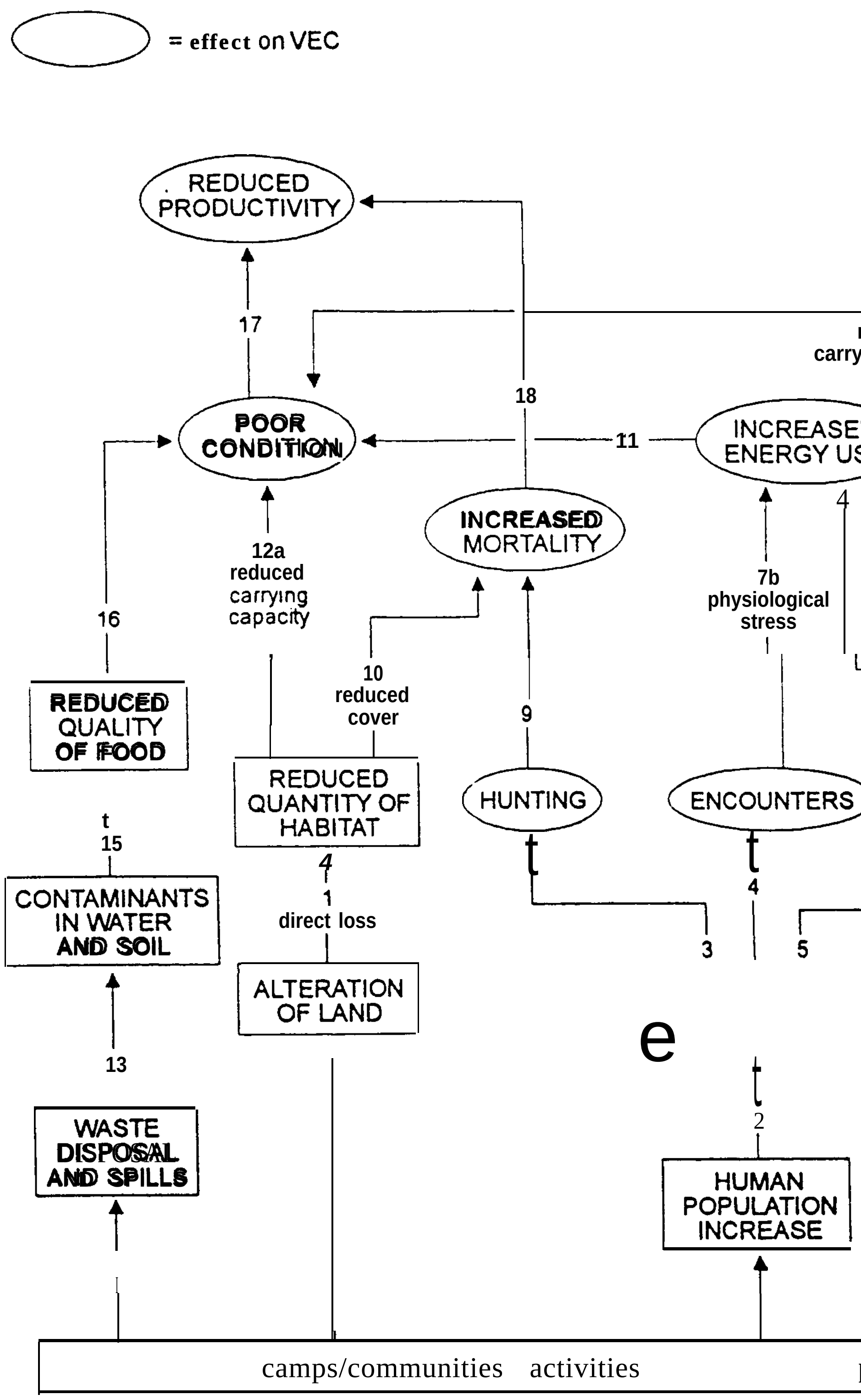

Figure 5.8: Impact Hypothesis 9-caribou. Camp/community on caribou.

hypotheses can be examined by experts, reformulated as needed, and those of no significance be discarded.

6.6 Implementation

Before the framework that we have developed can effectively become part of routine environmental management processes in the N. W. T., there are a number of important steps that should be undertaken including:

1 subjecting the proposed framework to a rigorous scientific and stakeholder review process to ensure its soundness and acceptability;

2 examining the nearly 50 pieces of legislation that currently apply to mining operations to determine what changes, if any, are required in order for the framework to be effectively implemented in this region of Canada; and

3 determining who is responsible for various aspects of the implementation. With the rapidly evolving institutional arrangements in the north, significant shifts may take place in the years ahead in the approach to, policies for, and management systems for enabling cumulative environmental effects analysis in this part of Canada. This prospect makes it all the more important that the parties collaborate in developing a common framework and agree to submit it to testing under applied conditions.

6.7 Adaptive Approaches

The framework outlines a process for evaluating potential CEE that incorporates all the basic elements. However the emphasis given to each step may vary with the entity applying it. The Working Group may decide to expand or collapse certain steps. For example, Step 6 might be broken down into a series of steps relating to environmental components. Alternatively, steps might be inserted that specifically call for the input of Traditional Ecological Knowledge (which we did not deal with explicitly). Once users are familiar with the basic elements of the framework there may be opportunities to adapt them to particular management and decision-making contexts.

7.0 Glossary[1]

This glossary provides the definition and/or meaning for some of the technical terms used in this report and in the assessment of CEE.

abiotic: Characterizes the nonliving parts of an *ecosystem*, consisting of all physical elements, such as wind. temperature. and amount of light, and nonliving materials, such as water, soil, and air, that influence the living organisms.

abundance: The number of individuals of a *species* in any *given* area. Abundance and *distribution* provide valuable information about *populations*, and when measured over time, can also provide valuable information about the status of *species at risk*.

aquatic: Pertains to freshwater *ecosystems.*

bioaccumulation: General term describing a process by which chemical substances are ingested and retained by organisms, either from the *environment* directly or through consumption of food containing the chemicals. See also *biomagnification*.

bioconcentration: See *biomagnification*.

biodiversity (biological diversity): The variety of life on Earth. It refers to all animals, plants, and microorganisms in terrestrial, freshwater, and refine *ecosystems*. It includes three levels: genetic, species, and ecosystem diversity. It emphasizes the complex relationships among all living things on Earth.

biomagnification: Cumulative increase in the concentration of a substance in successively higher levels of a *food web*. See *also bioaccumulation*.

biota: Collectively, the living organisms in a given *ecosystem*, including bacteria and other *microorganisms*, plants, and animals.

community: In ecological terms, a community is a collection of *populations* of plants, animals and other organisms that interact with one another, forming a living system with its own composition, structure and functions. The breeding bird communities of Banff National Park were identified based on characteristic combinations of bird *species* and vegetation types.

contamination: Introduction of any foreign, undesirable physical, chemical, or biological substance into an *ecosystem.* Does not imply an effect (see *pollution*). Usually refers to introduction of human-made substances.

cumulative effects: Cumulative impacts are caused by the aggregate of past, present, and reasonably foreseeable future actions. Impacts of a proposed action on a given resource must include present and future impacts that will occur when added to the impacts that have already taken place in the past. Such impacts must also be added to effects (past, present, future) caused by actions taken by other entities, insofar as they also cumulatively impact the same specific resource.

distribution: The location of individuals of a *species* at any given time. Abundance and distribution provide valuable information about *populations*, and when measured over time, can also provide valuable information about the status of *species at risk.*

ecological footprint: There is no singular, authoritative, and widely held definition of this term. In its most common use, this term refers to the land and water area which is needed to exclusively provide the natural resources and services needed by a specified human population, and to assimilate the wastes it generates, using prevailing technology. Note that the phrase "appropriate carrying capacity" is often used interchangeably with ecological footprint.

[1] Note: Words in italics are defined or explained elsewhere in the Glossary.

ecoregion: For land areas, *ecosystem* units defined in the ecological land classification system for Canada. It is a hierarchical system, with ecozones being the largest units. These are sub-divided into progressively smaller units based upon similarities or dissimilarities in ecological characteristics, such as climate, soil or water properties, and *wildlife*. Each ecozone is subdivided into ecoprovinces, each ecoprovince into ecoregions, and each ecoregion into ecodistricts. The Bow Valley is comprised of four ecoregions: montane, tower subalpine, upper subalpine, and alpine.

ecosystem: An integrated and harmonious association of living organisms and their nonliving *environment* functioning within a defined physical location. The root words of ecosystem are "eeo," a derivative of the Greek term for house or home, and "system," which addresses the relationships and connections between the biological and physical parts. Ecosystems are composed of air, land, water, and living organisms, including humans.

effluent: A liquid waste material that is a by-product of human activity (e.g. liquid industrial discharge or sewage), which may be discharged into ecosystems.

environment: The components of the Earth, including air, land, and water, all layers of the atmosphere, all organic and inorganic matter and living organisms, and the interacting natural systems that include all of these components. Everything that surrounds and affects or influences an organism or a group of organisms; it includes both living and nonliving components as well as both natural and human-built elements.

fish stock: In fisheries science an exploited fish population is termed a stock, synonymous with population.

flooding: A natural or human-induced occurrence in which normally dry land is inundated by water. Seasonal flooding is important to the health of some species of plants and animals.

flow disruptions: Changes to the natural flow of a river or water level of lake due to human actions (e.g. dams).

groundwater: Water occurring below the ground surface which may supply water to wells and springs. Groundwater occupies pores, cavities, cracks, and other spaces in bedrock and unconsolidated surface materials.

habitat: The place or type of site where plant, animal, or microorganism *populations* naturally occur. The concept of habitat includes the particular characteristic of that place, such as climate and the availability of water and other life requisites (e.g. soil nutrients for plants and suitable food and shelter for animals), which make it especially well suited to meet the life-cycle needs of the particular *wildlife.*

hazardous waste: Waste that poses a risk to human or ecological health and requires special disposal techniques to make it harmless or less dangerous.

indicator: A measure that, tracked over time, provides information on trends in the condition of a phenomenon and has significance extending beyond that associated with the properties of the statistic itself. See also *environmental indicator.*

infrastructure: The basic installations, facilities and services on which the continuance and growth of a community depends such as transportation networks, utilities, housing and social services.

inorganic compounds: Compounds not containing a combination of carbon/hydrogen/oxygen as in living things. See also *organic compounds.*

leaching Washing out of soluble substances by water passing down through soil. Leaching occurs when more water falls on the soil than is lost by evaporation from the surface. Rainwater running through the soil dissolves mineral *nutrients* and other substances and carries them via *groundwater* into water bodies. The leaching of mercury and other heavy metals into water supplies is believed to be a serious consequence of *acid deposition.*

monitoring: The process of checking, observing, or keeping track of something for a specified period of time or at specified intervals.

natural resource: Any naturally-occurring feature or process which can be economically made use of by humans. Such entities are not considered resources by their mere presence alone until they are required and used by humans. As knowledge and technology expand and social objectives change, so too do the number of resources.

non-point source: Source of *pollution* in which *pollutants* arc discharged over a widespread area or from a number of small inputs rather than Gom distinct, identifiable sources. Examples include eroding crop lands, *urban* and suburban lands, and logged forest lands. See also *point source,*

nutrient: Any element or compound that an organism must Lake in from its *environment* because it cannot produce it or cannot produce it as fast as it needs it. As *pollutants*, any substance or group of substances (e.g. phosphorus or nitrogen) that. if added to water in sufficient quantities, provides nourishment that promotes the growth of aquatic vegetation in those waters to such densities as to degrade or alter or form part of a process of degradation or alteration of the quality of those waters to an extent that is detrimental to their use by any plant or animal, including humans. An example would be *eutrophication* of a lake).

organic compounds: Compounds based on carbon, and also containing hydrogen, with or without oxygen, nitrogen, or other elements. Organic originally meant "of plant or animal origin" and it is still sometimes used in this way. For example, "organic waste" can mean food scraps, manure. sewage, leaves, etc.; "organic fertilizer" can mean manure; "organic deposits" can mean peat or other plant material in soil; "organic *nutrients*" can mean nutrients derived from decayed plant material. However, now that organic compounds are routinely created by people, the word "organic" is also used to refer to synthetic organic compounds as in "organic *pollution*" (which can include *toxic* human-made organic compounds). See *organochlorine compounds.*

permafrost: Perennially frozen layer in the soil, found in alpine, arctic, and antarctic regions.

persistent: Refers to chemical compounds, such as many *organochlorine compounds,* that do not break down easily in *ecosystems.*

point source: A source of *pollution* that is distinct and identifiable. Includes smokestacks and outfall pipes from industrial plants and municipal sewage treatment plants. See also *non-point source.*

pollution: The release by humans, directly or indirectly, of substances or energy into ecosystems, that results or is likely to result in such deleterious effects as to harm living resources and life, be hazardous to human health, hinder human activities, or impair the quality of the ecological resources, and reduce amenities.

population: A group of organisms of the same *species living* within a specified region.

renewable resource: *Natural resource (e.g. tree biomass,* fresh water, fish) whose supply can essentially never be exhausted, usually because it is continuously produced. (N.B. Natural or human-induced happenings can change this status. For example, passenger pigeons were once a renewable resource.)

salmonid: A fish of the Salmonidae family, which includes soft-finned fish such as salmon, trout and whitefish.

solid waste: Discarded materials which are those with insufficient liquid content to be free-flowtig but may include hazardous and special wastes which may be liquid but that require specialized handling and disposal to render them safe.

species: A group of related individuals with a common hereditary morphology, chromosomic number and structure, physiological characteristics, and way of life, separated from neighboring groups by a barrier that is generally sexual in nature—i.e. members of different species do not normally interbreed, and if they do, the progeny are sterile.

toxic: Pertains to any substance if it is entering or may enter the *environment* in a quantity or concentration or under conditions having or that may have an immediate or long-term effect on the environment [including living organisms within it] or instituting or that may constitute a danger to human life or health.

traditional ecological knowledge (TEK): The knowledge base acquired by indigenous and local peoples over many hundreds of years through direct contact with the *environment.* This knowledge can include an intimate and detailed knowledge of plants, animals, and natural phenomena, the development and use of appropriate technologies for hunting, fishing, tapping, agriculture, and forestry, and a holistic knowledge or "world view"' which parallels the scientific discipline of ecology. In some cases, TEK has been shown to be "old wives' tales," and in other cases conditions may have changed significantly since the information was collected. See also *indigenous ecological and environmental knowledge*.

vertebrates: Animals (birds, mammals, amphibians, reptiles) that have a vertebral column, or backbone.

water quality: The quality of water as defined by variables such as oxygen dissolved in the water, suspended solids, bacteria, toxic chemicals and nutrients such as phosphorus and nitrates.

wetland: Land that has the water table at, near, or above the land surface or that is saturated for a long enough time to promote wetland or *aquatic* processes, and various kinds of biological activity that are adapted to the wet *environment.* Includes fen, bog. swamp, marsh, and shallow open water.

wildlife: Pertains to all nondomesticated, living organisms and defined in the Wildlife Policy for Canada. It includes not only the vertebrate animals (mammals, birds, fish, amphibians, and reptiles), but also invertebrate animals, vascular plants, algae, fungi, bacteria, and all other wild living organisms.

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Appendix A - Known Mineral Deposits In the Slave Geological Province that May Someday be Developed

Deposit	Location	Reserves (millions of tonnes)	Grade	Source
;oala Lake	)0 km NE of Yellowknife I° 25'N 10° W	135	liamonds I ct/t	3HP, 1994
.ac de Gras	30 km NE of Yellowknife I° 20'N 10° W	n/a	liamonds =4.5 ct/t	NM, 240495
Arcadia	oronation Gulf Coast - 7° 42.4'N 11° 23.0'W	0,78	gold 6.2 g/t	DIAND, 1993
Boston	) km E of Bathurst Inlet 7° 37'N)6° 2 1'W	n/a	gold	DIAND, 1995
Butterfly	5 km SE of Lupin Mine 3°36.5' 10"47.0	0.13	gold 14.2 g/t	DIAND, 1993
Cass	10 km NE of Yellowknife 4° 20'N 15° 16'W	2.7	gold 8.23 g/t	S.N.W.T.
Damoti Lake	00 km N of Yellowknife 4° 10'N 15" 5'W	n/a	old	NM, 270295
George Lake	lackett River area - ,3054' 07°25'	3.1	old 12 g/t	NM. 150393
Goose Lake/Boot Lake	;E of George Lake ;5° 33'N 06°30'W	n/a	old	DIAND, 1995
Mahe	30 krn NE Yellowknife 52° 57'N 13°19'	0.5	gold 5.9@	G. N.W.T.
Nicholas Lake	90 km NNE of Yellowknife 63 °14.7'N 1 13"44.7'W	0.65	gold 16.1 g/t	DIAND, 1995
Pistol Lake	20 km W of Bathurst Inlet 67°3'N 108"47W	0.5	gold 13.92 g/t	G. N.W.T.
Tundra	240 km NE of Yellowknife 64° 6.7'N 111° 16.3'W	15.5	gold 6.5 g/t	G.N.W.T., 1995

Deposit	Location	Reserves (millions of tonnes)	Grade	Source
urner Lake	185 km NE of Lupin 67° 13'N 108°56'	1.2	gold 5.35 g/t	G. N.W.T.
flu	90 km S of Coronation Gulf- 66° 55'N 110° 48.0'W	>1.0	gold 18 g/t	N. W. T. CM, I 993 p2
iondor	60 km east of Izok Lake 65° 33.7'N 111° 48.0'W	7.3	zinc 4.8% lead 0.4% copper 0.2% silver 46 g/t	NM,091291 CMH92, p240
Iackett River	SW of Bathurst Inlet 65° 55.9N 108° 27.5W	21	zinc 5.0% lead .8% copper 0.4% gold 4.4 g/t silver 150 g/t	DIAND, 1993
High Lake D Zone	50 km S of Coronation Gulf 67° 22.8'N 110° 51.3'W	4.1	zinc 4.2 % copper 2.5% silver 29.6 g/t	Aber, 1993
High Lake AB Zone	50 km S of Coronation Gulf 67" 22.8'N 110" 51.3'W	3.2	copper 5.5% zinc 1.1% silver 18.2 g/t gold 2.3 g/t	Aber, 1993 DIAND, 1983 p32
Hood River #10	80 km N of Izok Lake 66°03.6' 1 12" 45.3'	1.2	zinc 4.40/0 copper 4.1 % silver 27 g/t gold 0.7 g/t	CMH92 p240
Hood ~V~#41	*80 km N* of Izok Lake 66°03.6 *I 12°45.3'*	*0.9*	zinc 3.20/0 copper 1.40/0 silver 12 g/t	CMH92, p240
Hood River#41 A	80 km N of Izok Lake 66°03.6' 112°45.3'	1.1	zinc 3.3% copper 2.4% silver 16 g/t	CMH92, p240
Izok Lake	265 km S of Coppermine 65° 37.8'N 112° 47.8'W	12.3 probable, plus 1.3 possible	zinc 14.6% copper 2.50/0 lead 1.6% silver 77.7 g/t	NM, 100593 p1
Musk	South of Bathurst Inlet 65° 19.3'N 107° 36.0'W	0.34	zinc 10.0% lead 1.4% copper 1.2% silver 343 g/t	DIAND, 1993
sunrise	115 km ENE of Yellowknife 62° 55'N 1 12* 22'W	1.8	zinc 8.9% lead 4.2% silver 405 g/t gold 1 g/t	DIAND, 1993

Deposit	Location	Reserves (millions of tonnes)	Grade	Source
Yava	SW of Bathurst Inlet 65° 36.2'N 107 °56.0 'W	1 - 2	zinc 3% lead 0.5% copper 0.5% silver 102.8 g/t gold 2.0 g/t	DIAND, 1993
Thor Lake	100 km ESE of Yellowknife 62° 6.9'N 112° 35.6'W	70	rare earths	DIAND, 1993

- The following sources can be found in the reference section (Section B).

Aber	- Aber press release, ! 993
BHP	- BHP Diamonds Inc. Project Description Report
CMH	- Canadian Mines Handbook, year and page
DIAND	- Department of Indian Affairs and Northern Development
G. N.W.T.	- Energy Mines and Petroleum Resources, pers. comm.
NM	- The Northern Miner - refers to date of publication
N. W.T.CM	- N. W.T. Chamber of Mines

Appendix B - impact Hypotheses

One commonly used methodology for predicting the impact of development activities is an approach referred to as Impact Hypothesis.

Under this approach a series of hypotheses (unproven statements assumed for the purpose of argument) are generated to include all of the cause-effect relationships that are theoretically possible between the activities and the WCS that are being evaluated. Typically these take the form of a series of active statements and a diagram that illustrates them.

e.g. Dredging will result in sediment being released into the stream.

Expertise is then used to answer three questions about each hypothesis:

1. Do we know enough about this relationship as it applies in this case to predict whether it is likely to occur?

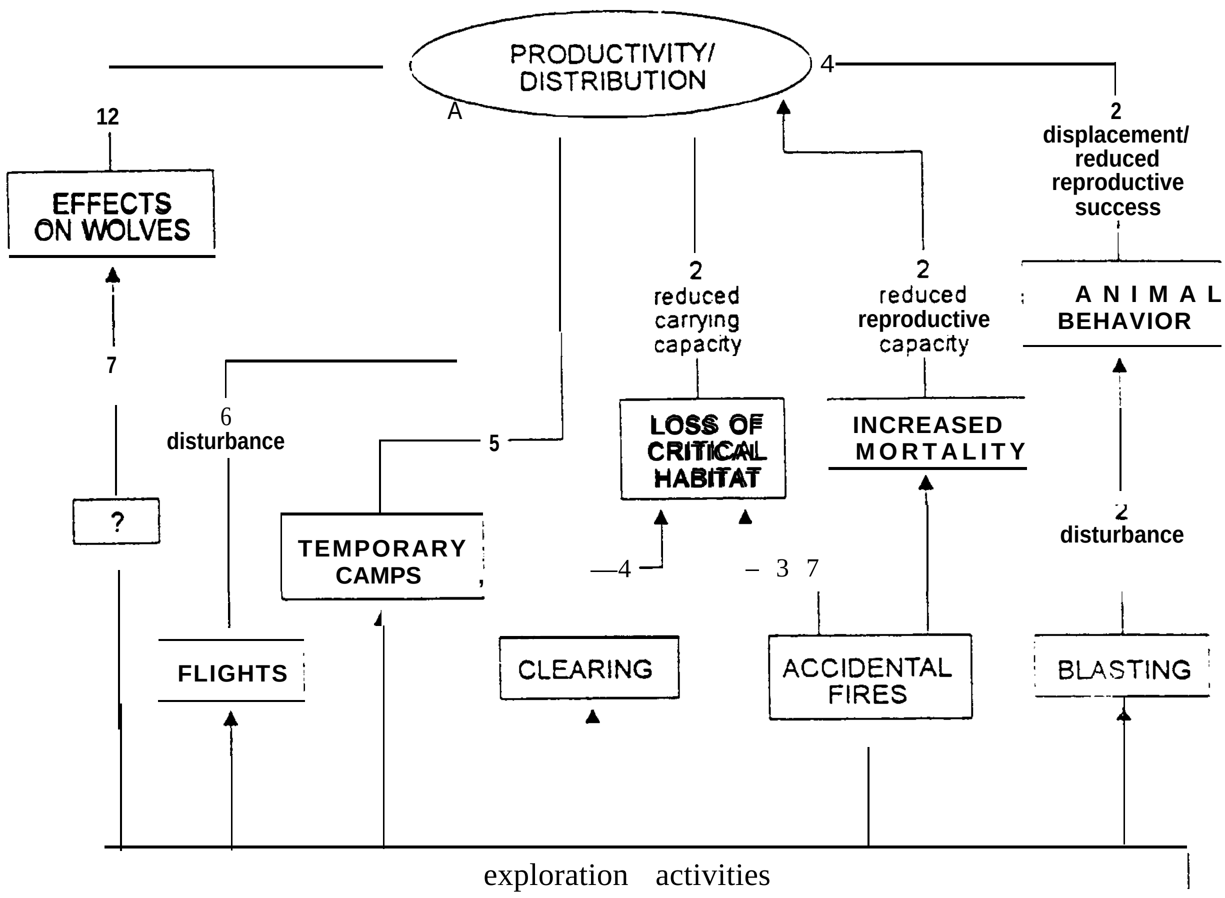
2. If yes, is it likely to occur?

3. If yes, is it likely to be significant?

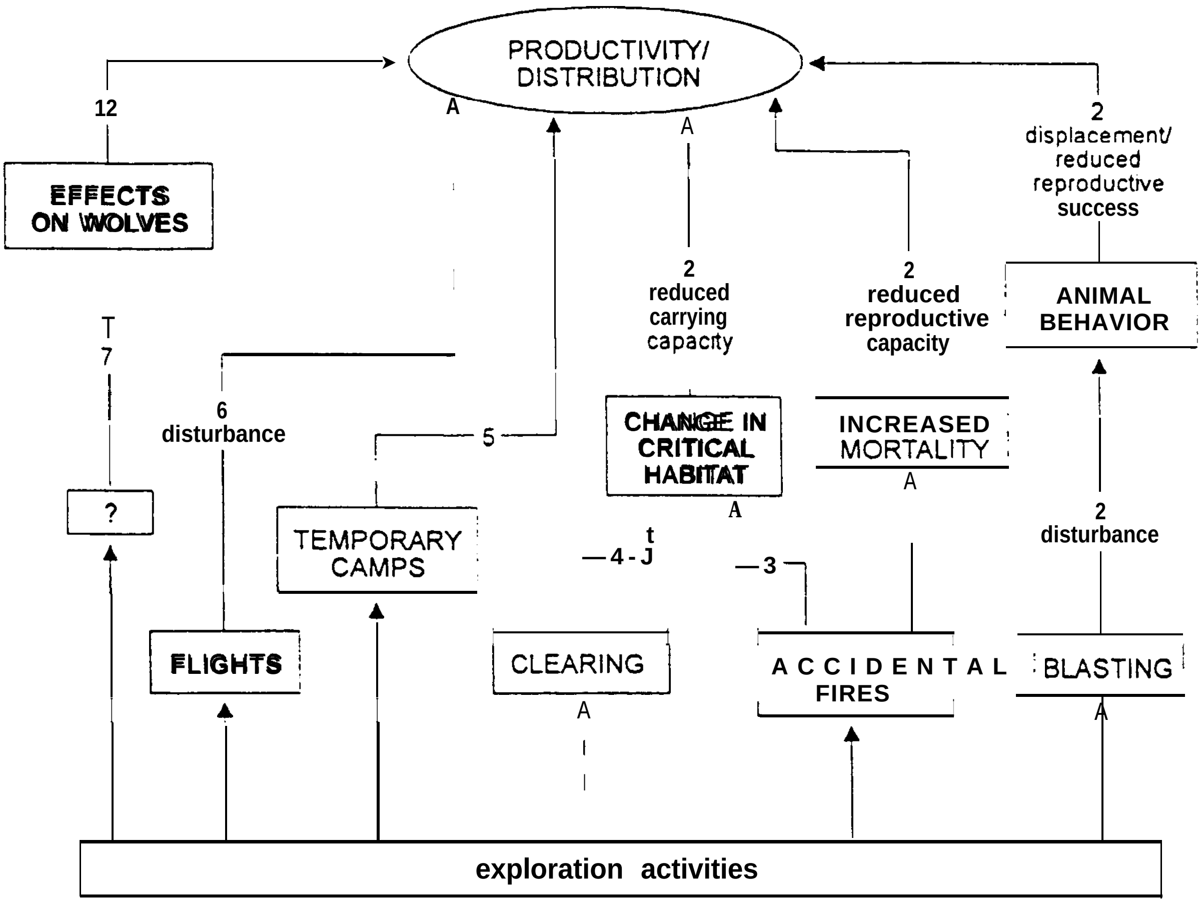
Studies will be designed and/or analysis focused on a much smaller range of potential impacts depending on the answers to these questions.

The following diagrams represent some of the impact hypotheses that might be developed for the SGP.

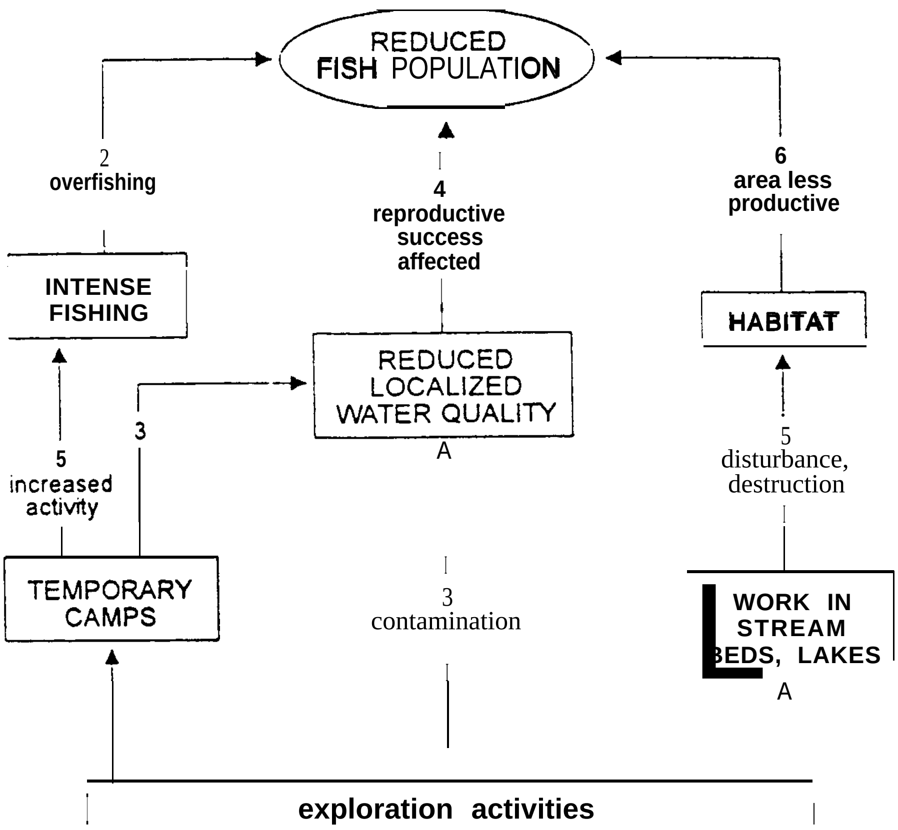
1-m **Effects of** mineral exploration on musk oxen



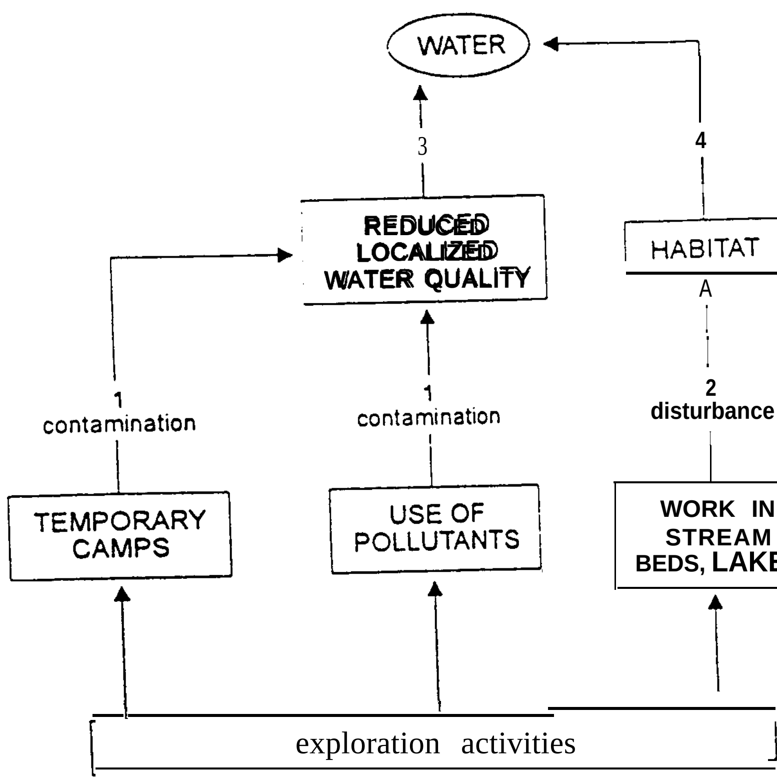
1 -gri **Effects of mineral exploration on grizzlies**



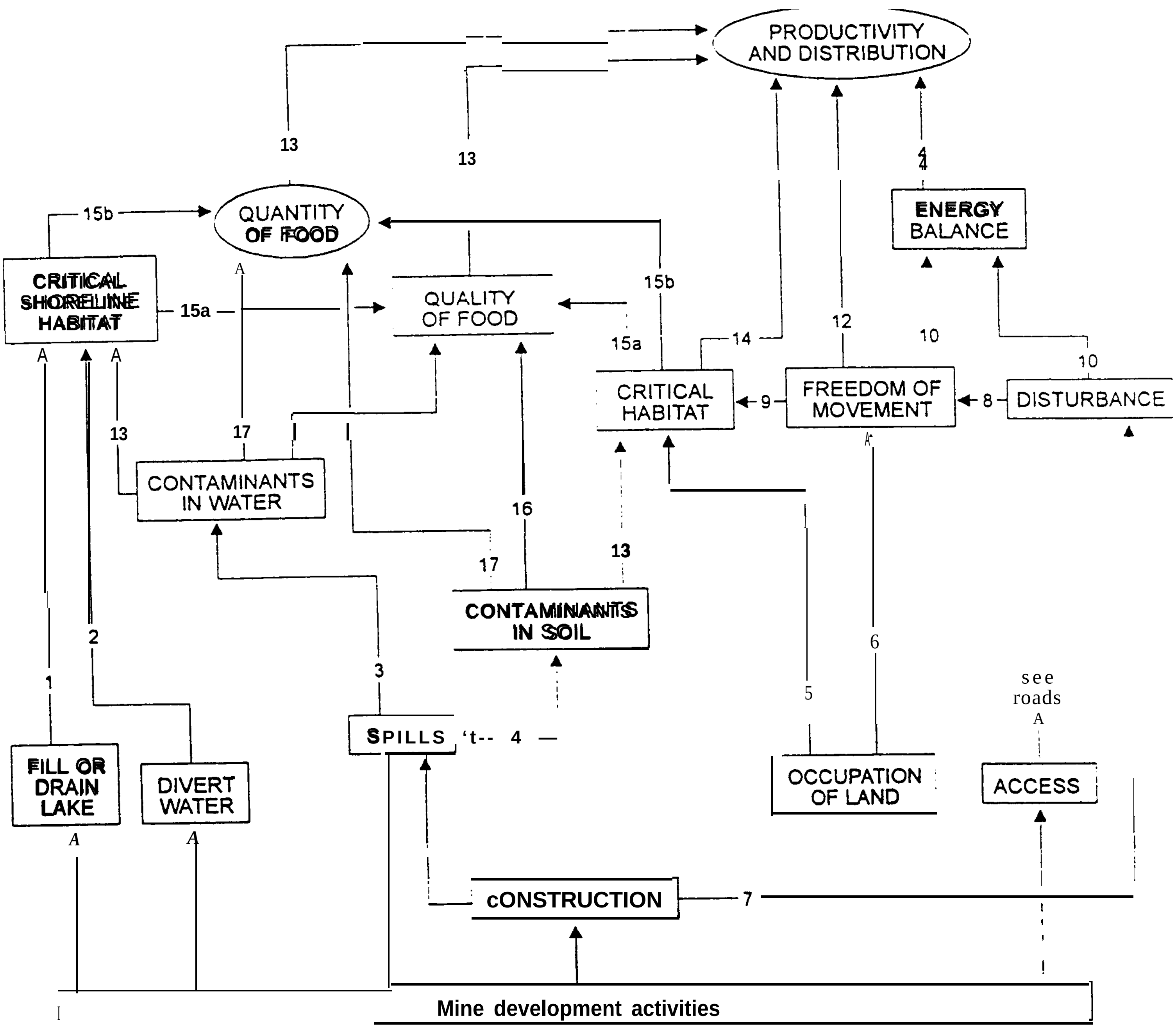
1-gl Effects of mineral exploration on grayling, lake trout



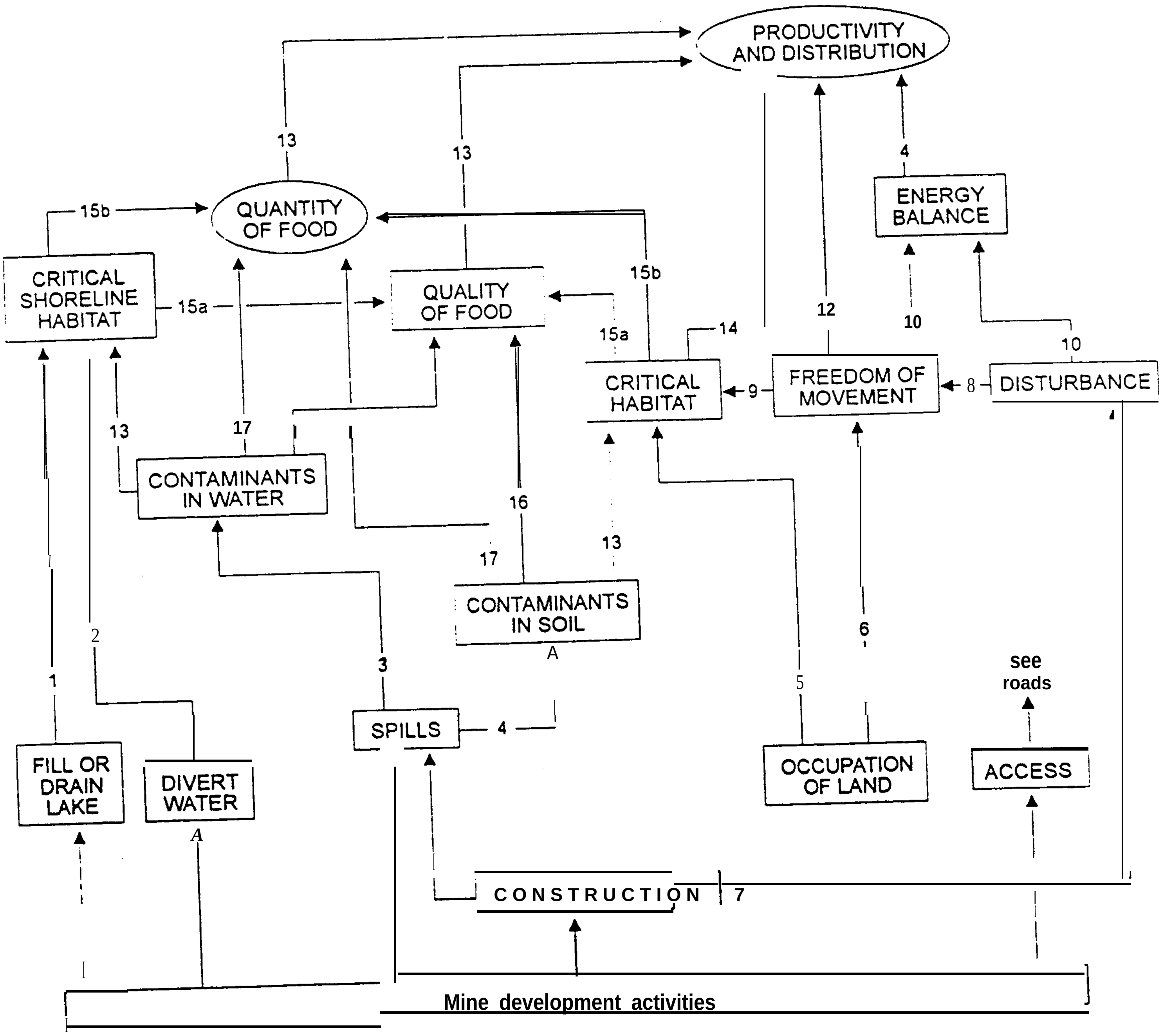
1-fw Effects **of mineral exploration on fresh water**



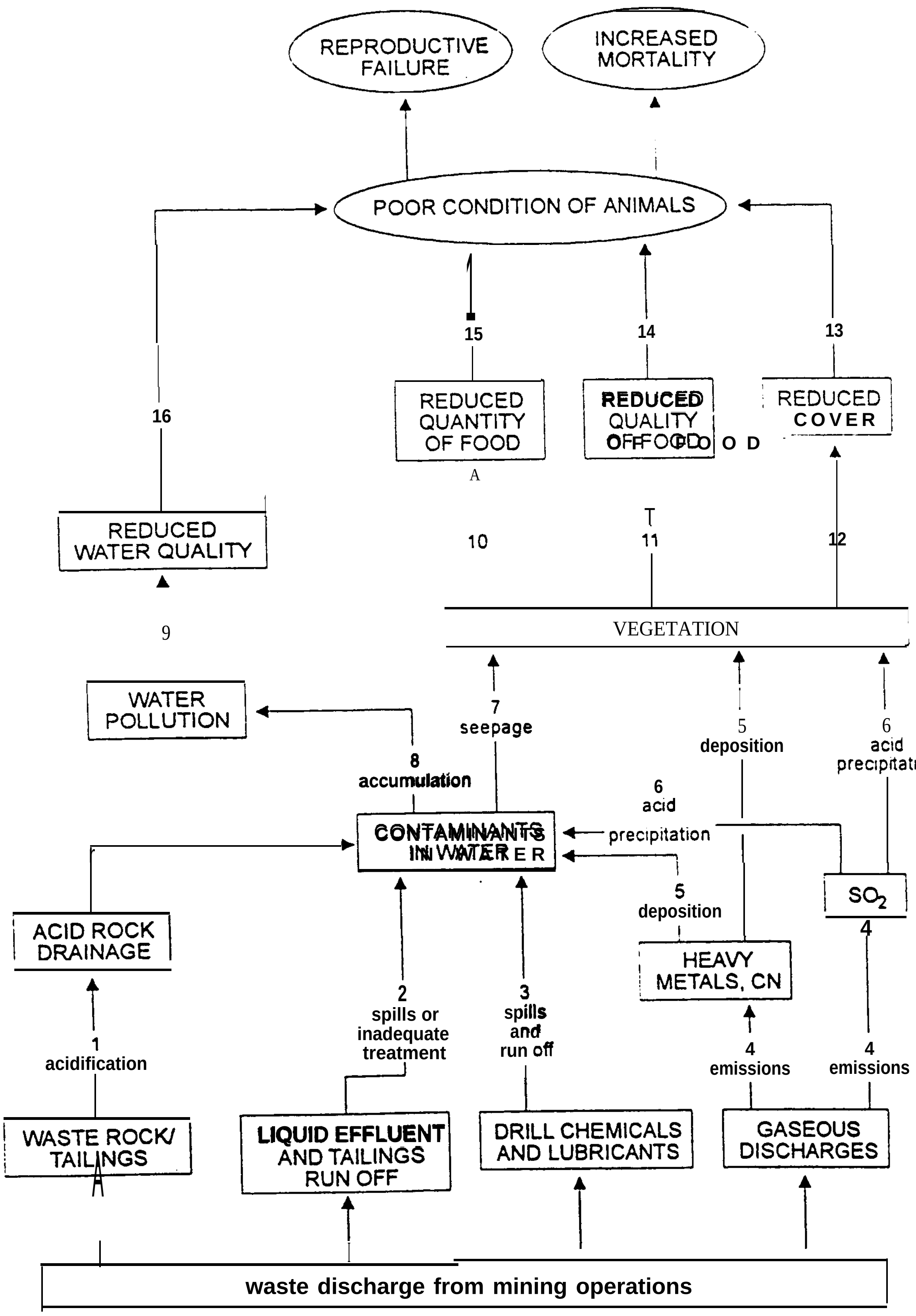
2-m Effects **of mine development on musk oxen**



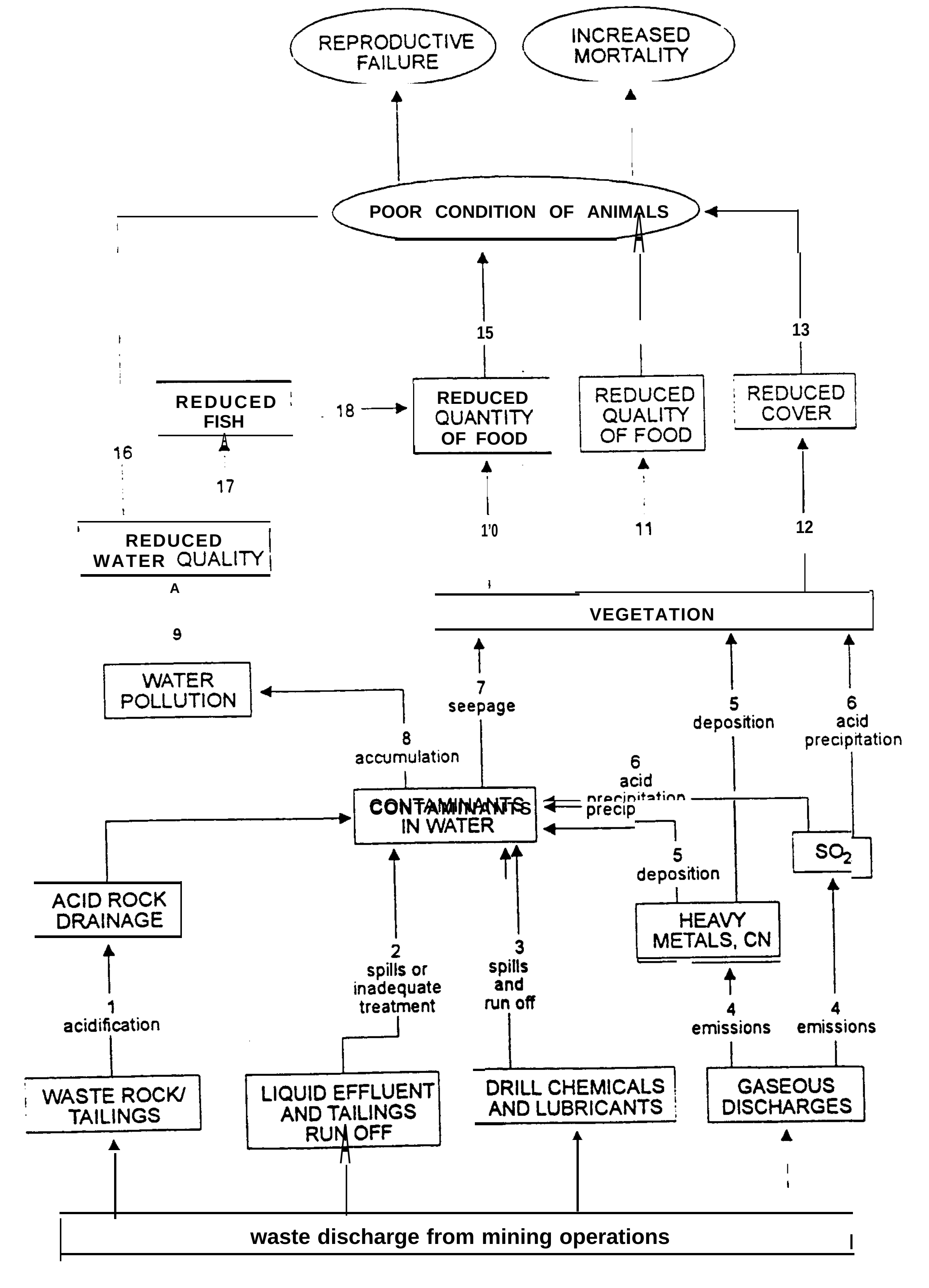
2-gri Effects of mine development on grizzlies



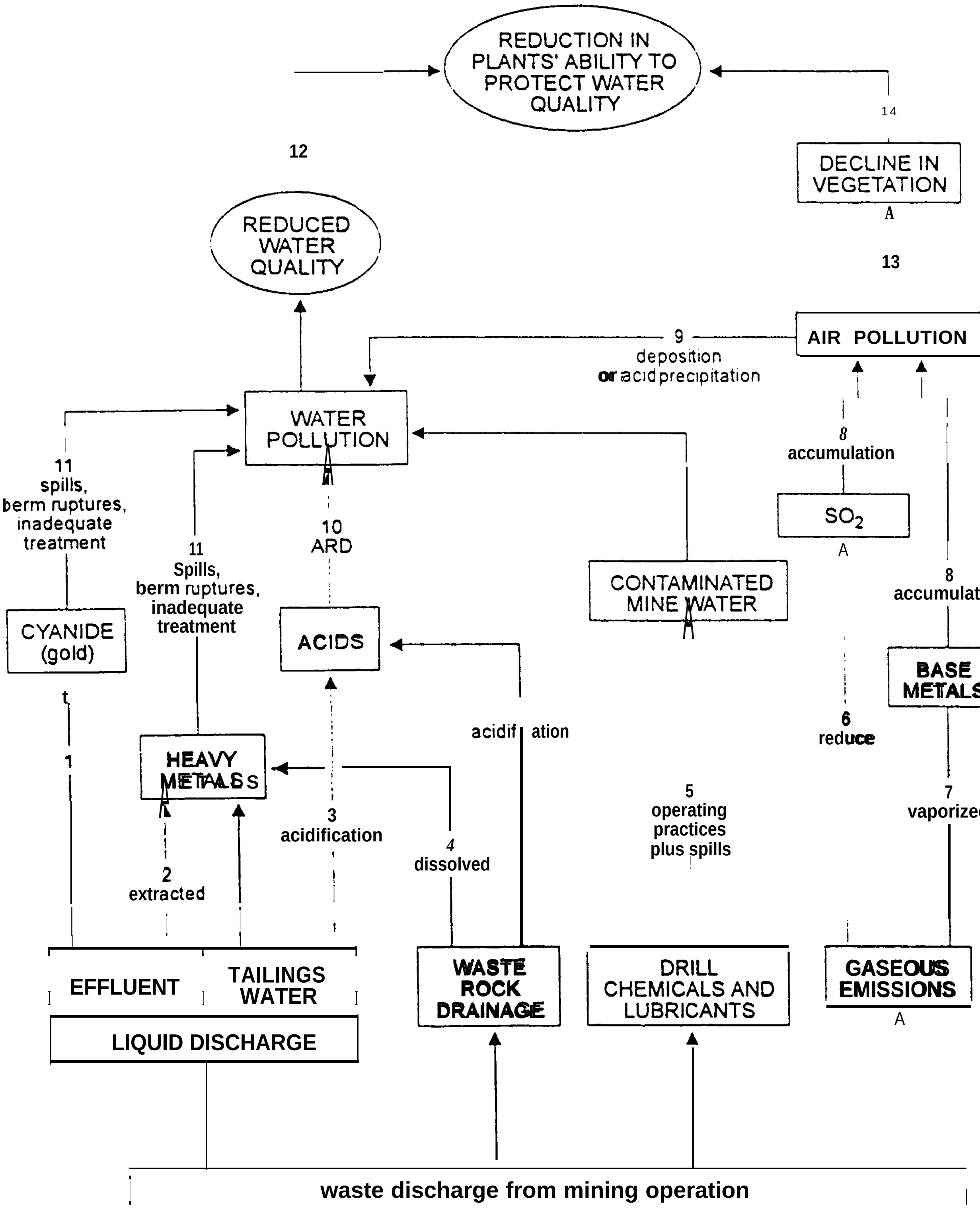
3-m Effects of waste discharges from mining operations on on musk oxen



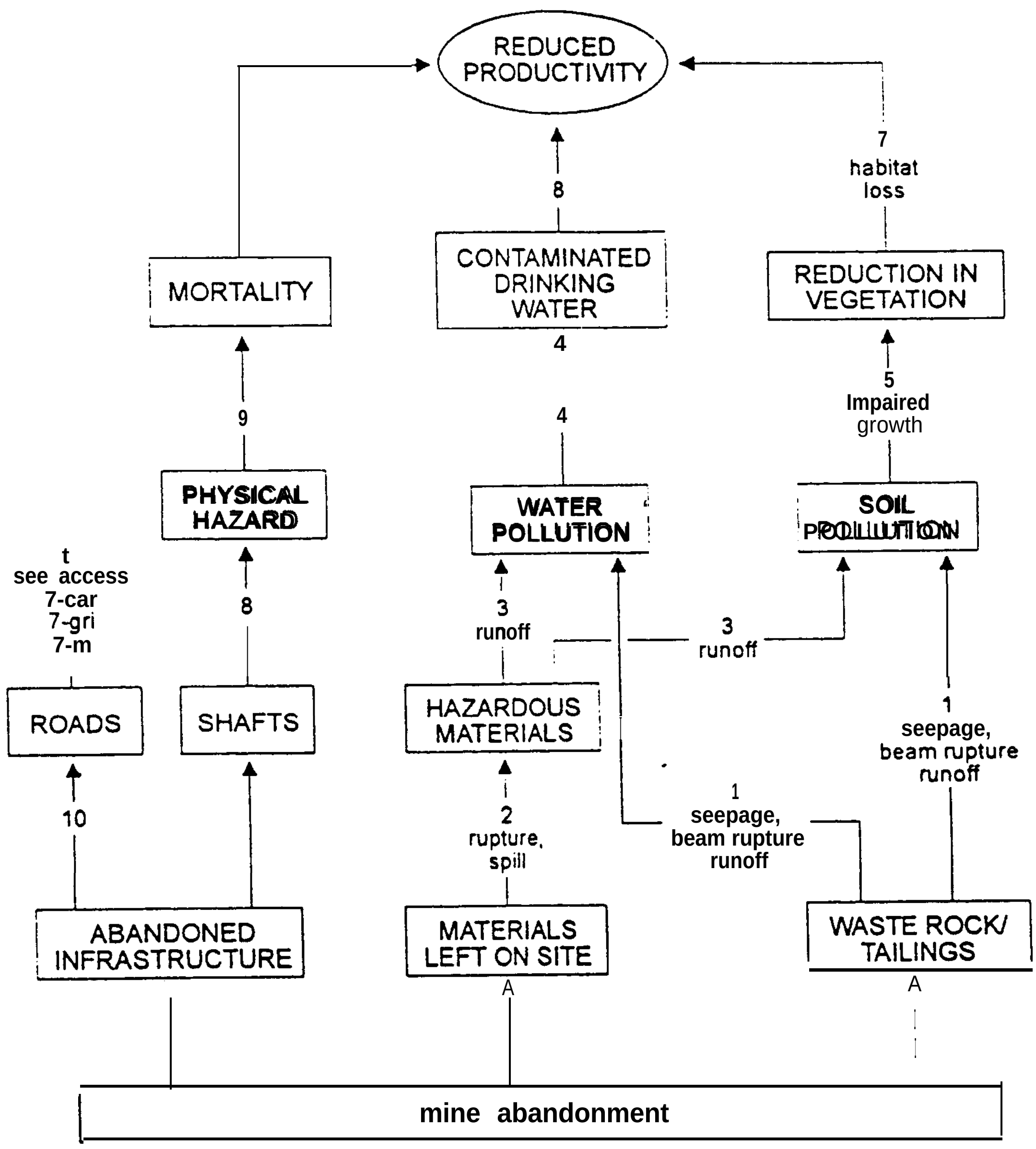
3-gri **Effects of waste discharges from mining operations on on grizzlies**



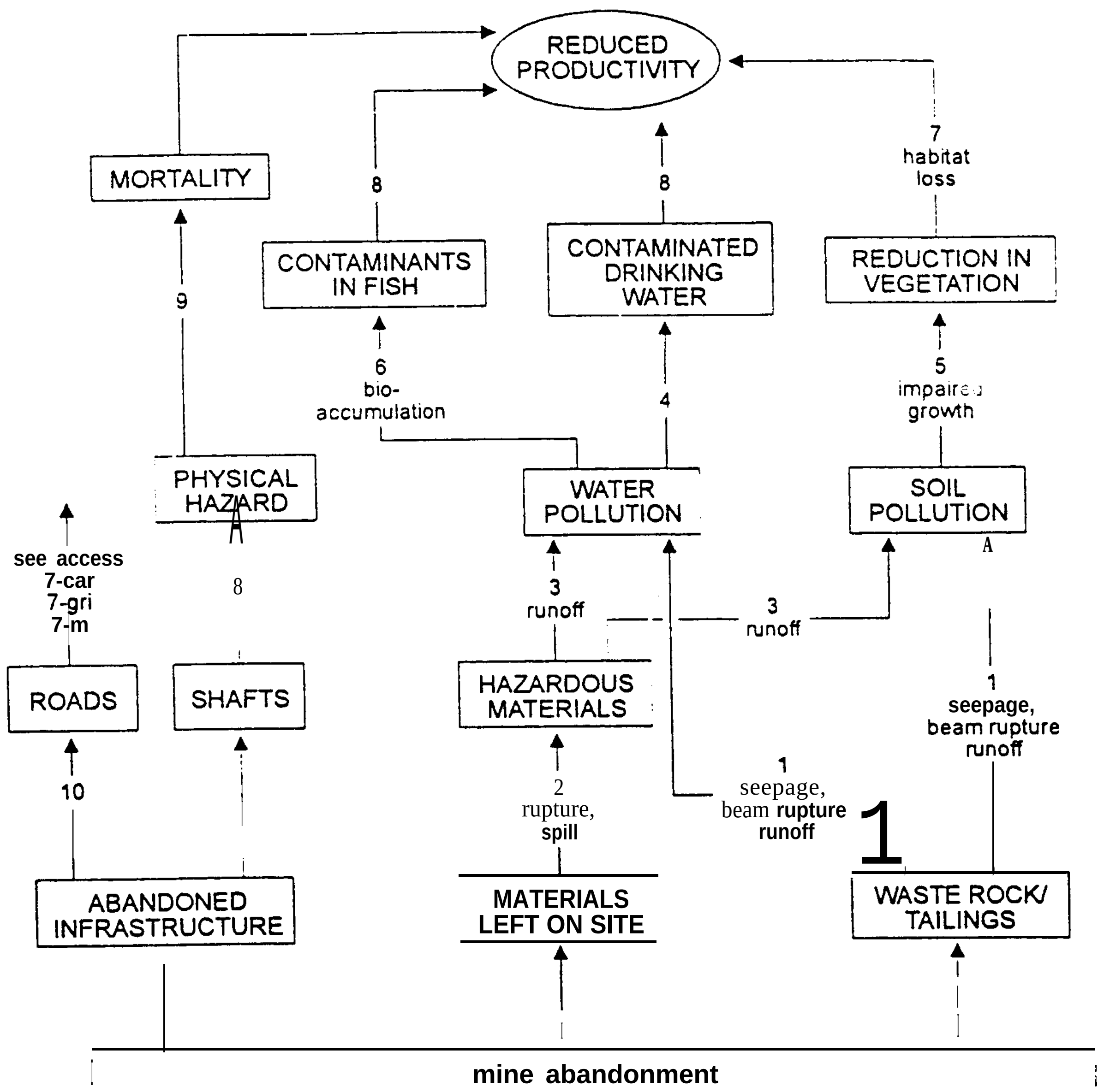
3-fw Effects of waste discharges from mining operations on fresh water



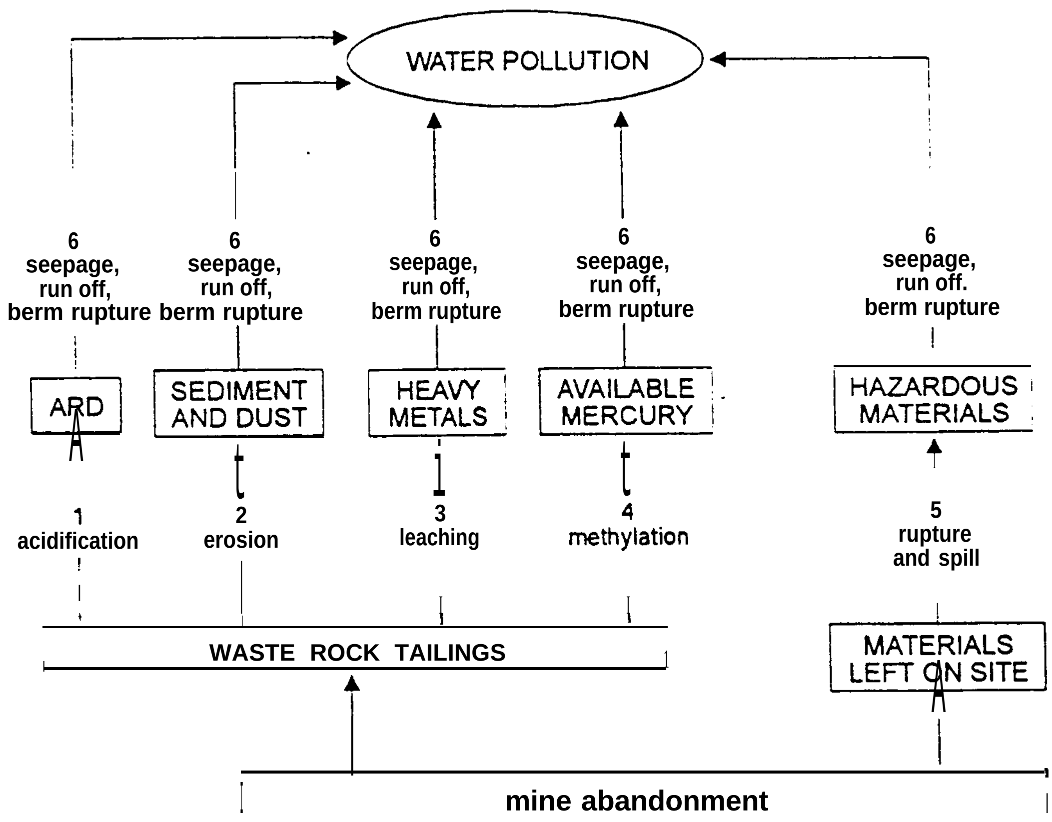
4-m Effects of mine abandonment on musk oxen



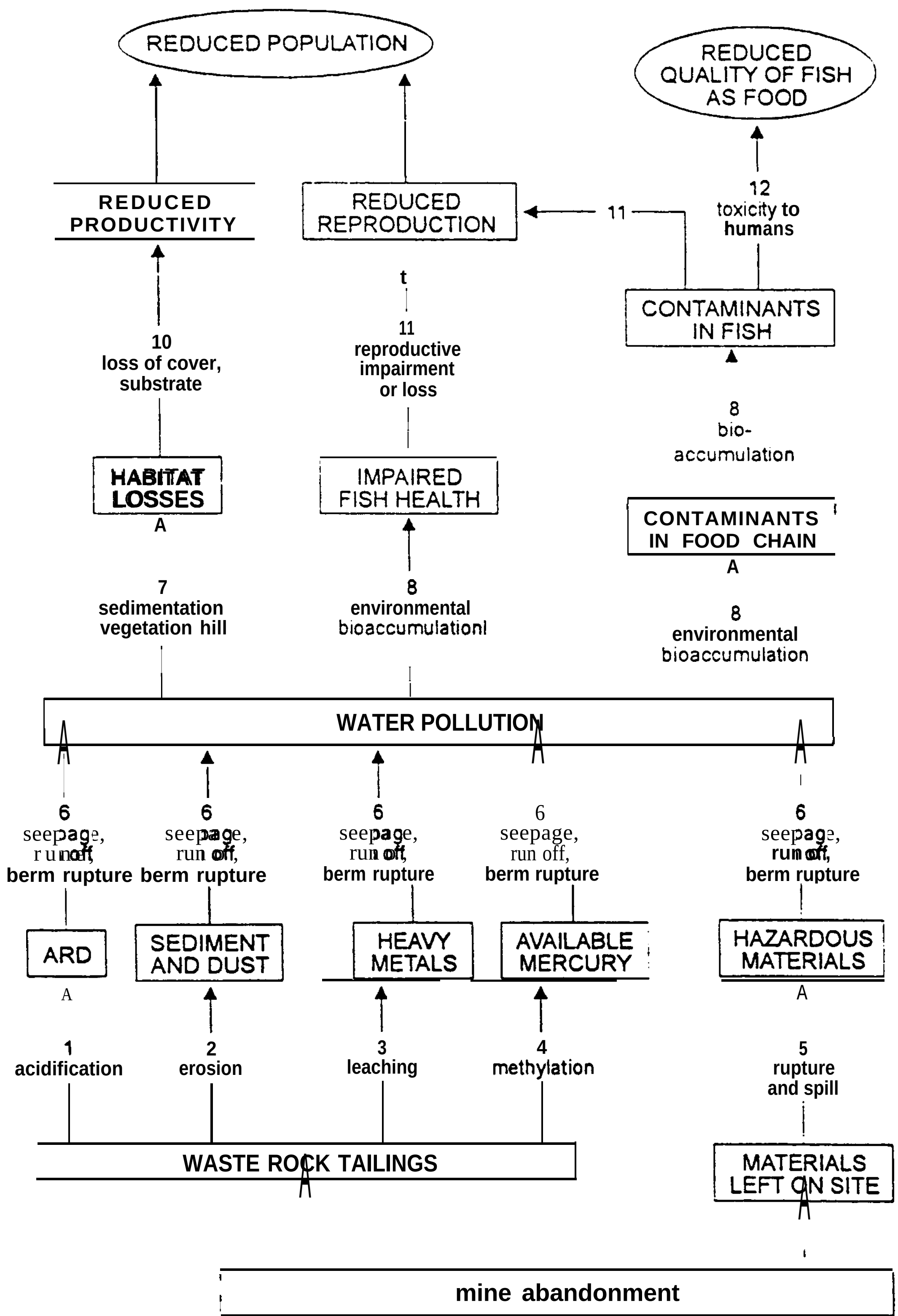
4-gri **Effects of mine abandonment on grizzlies**



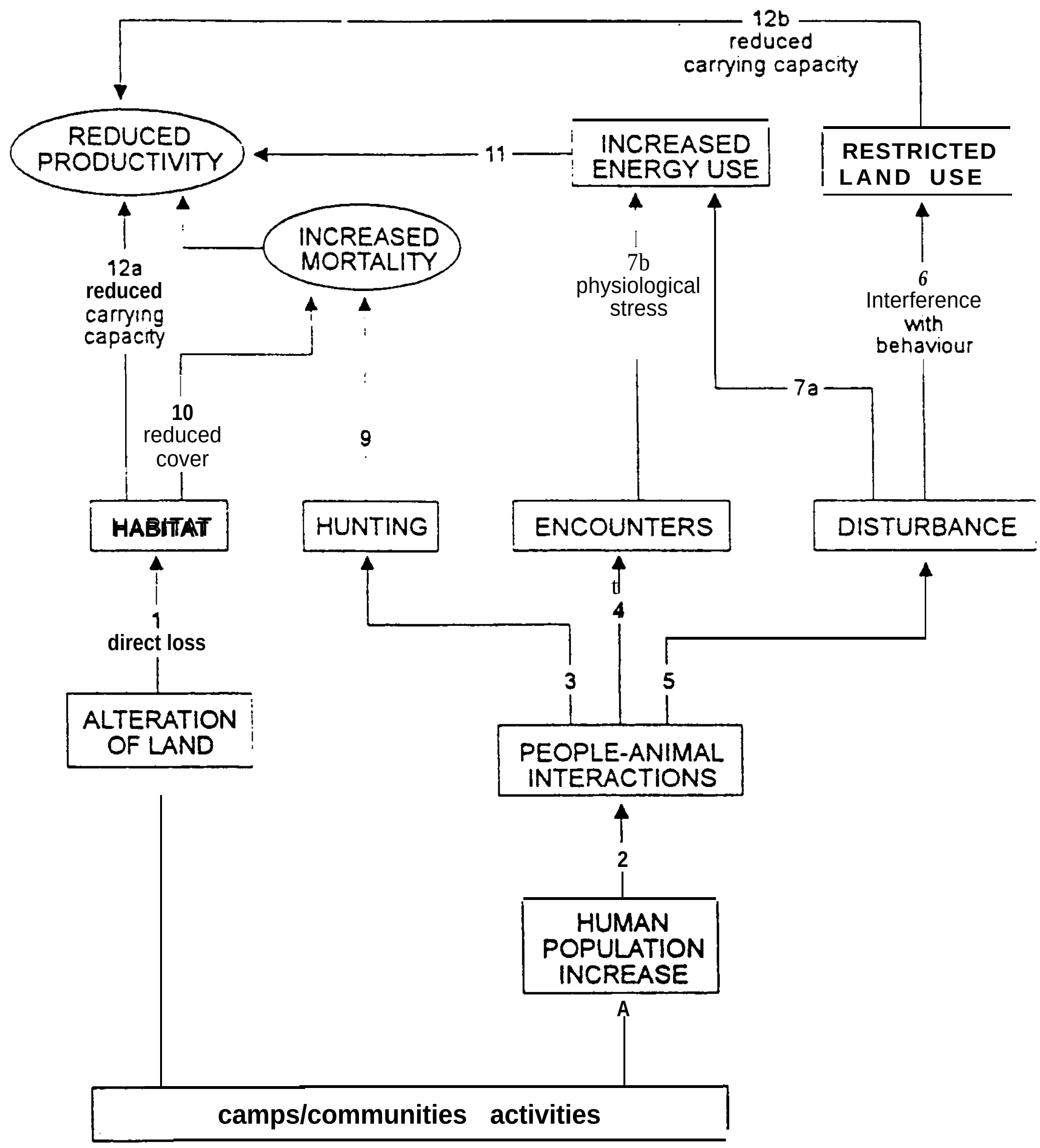
4-fw Effects of mine abandonment on fresh water



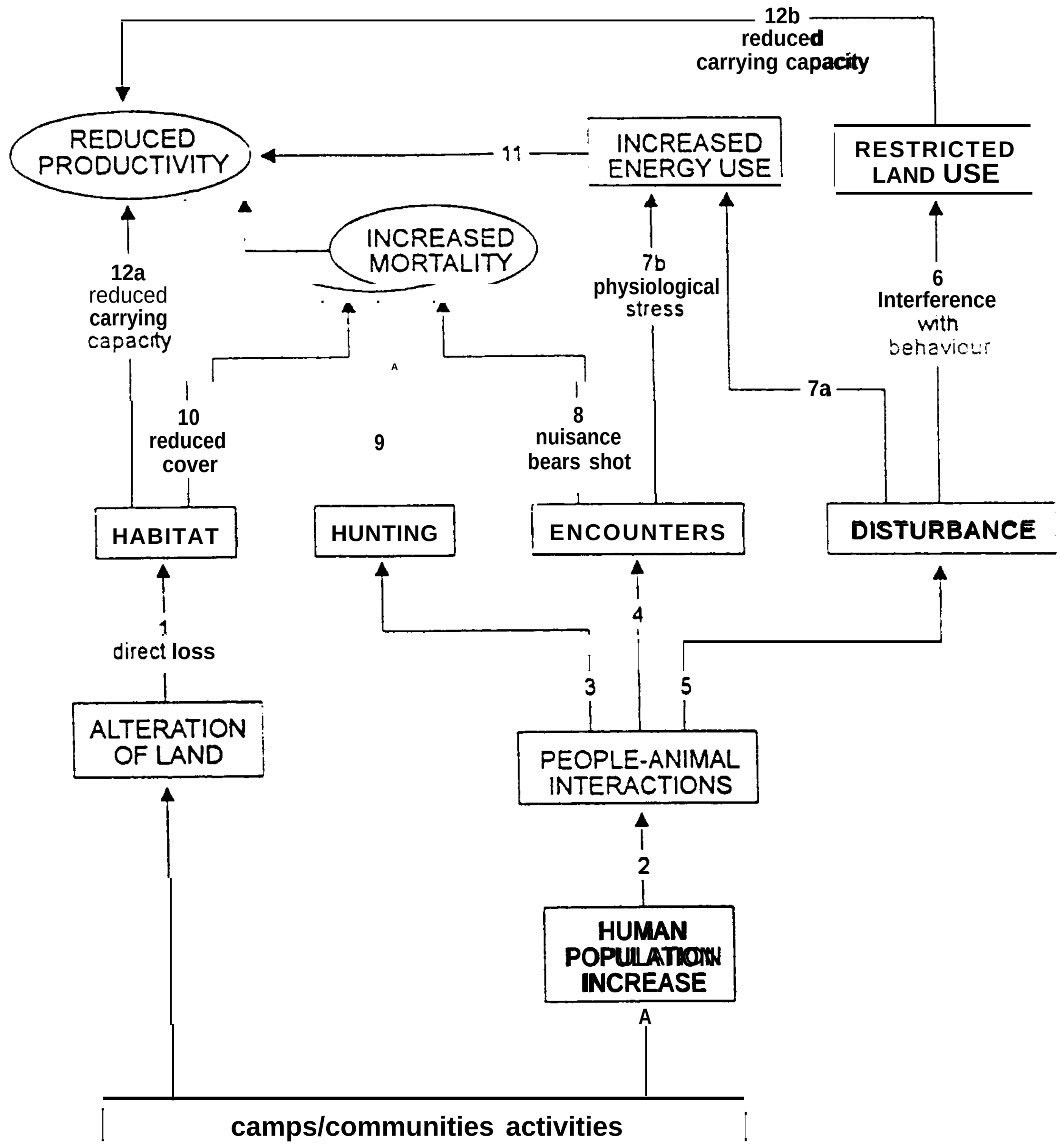
4-gl Effects of mine abandonment on grayling



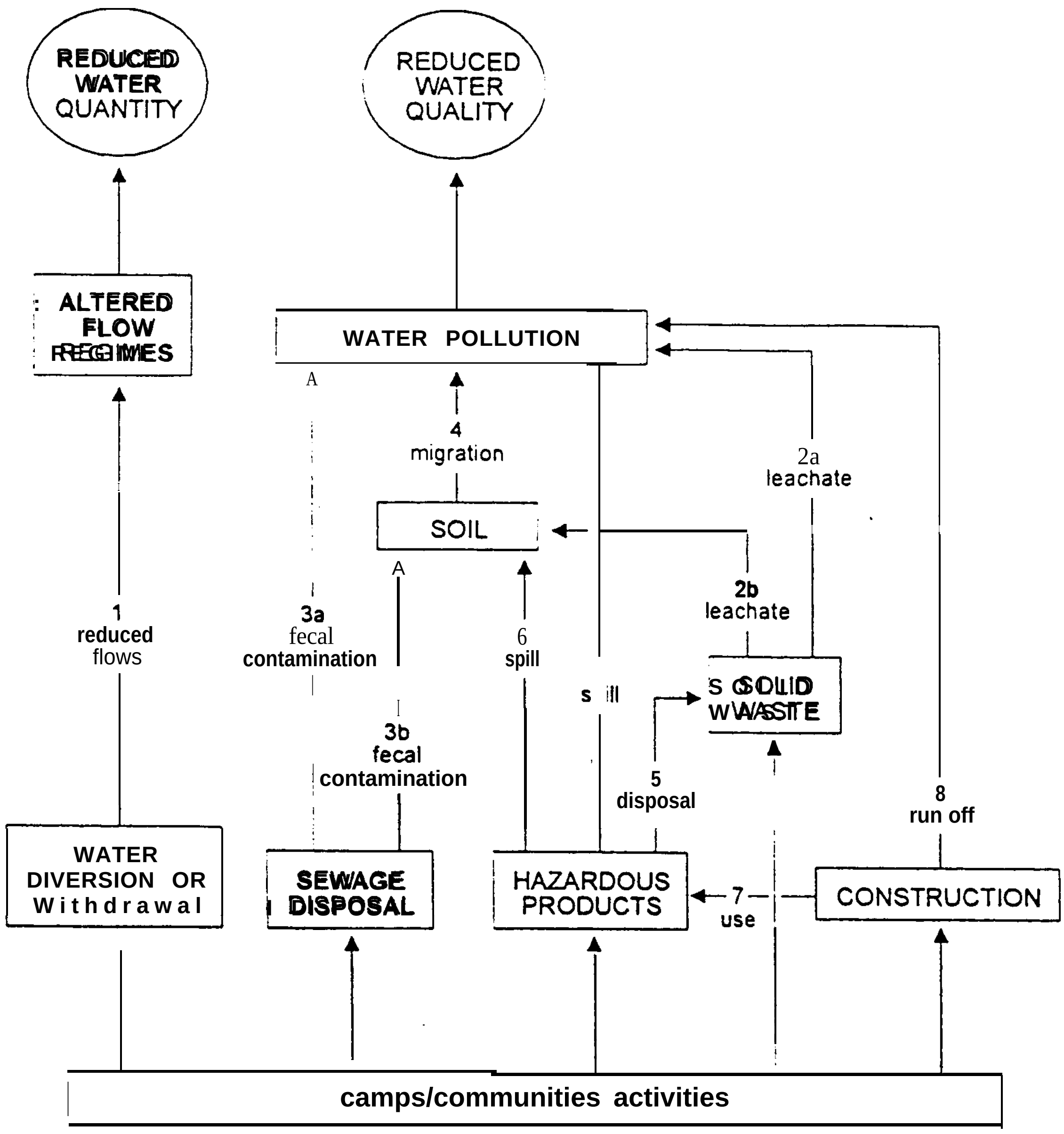
9-m **Effects of camp/community on musk oxen**



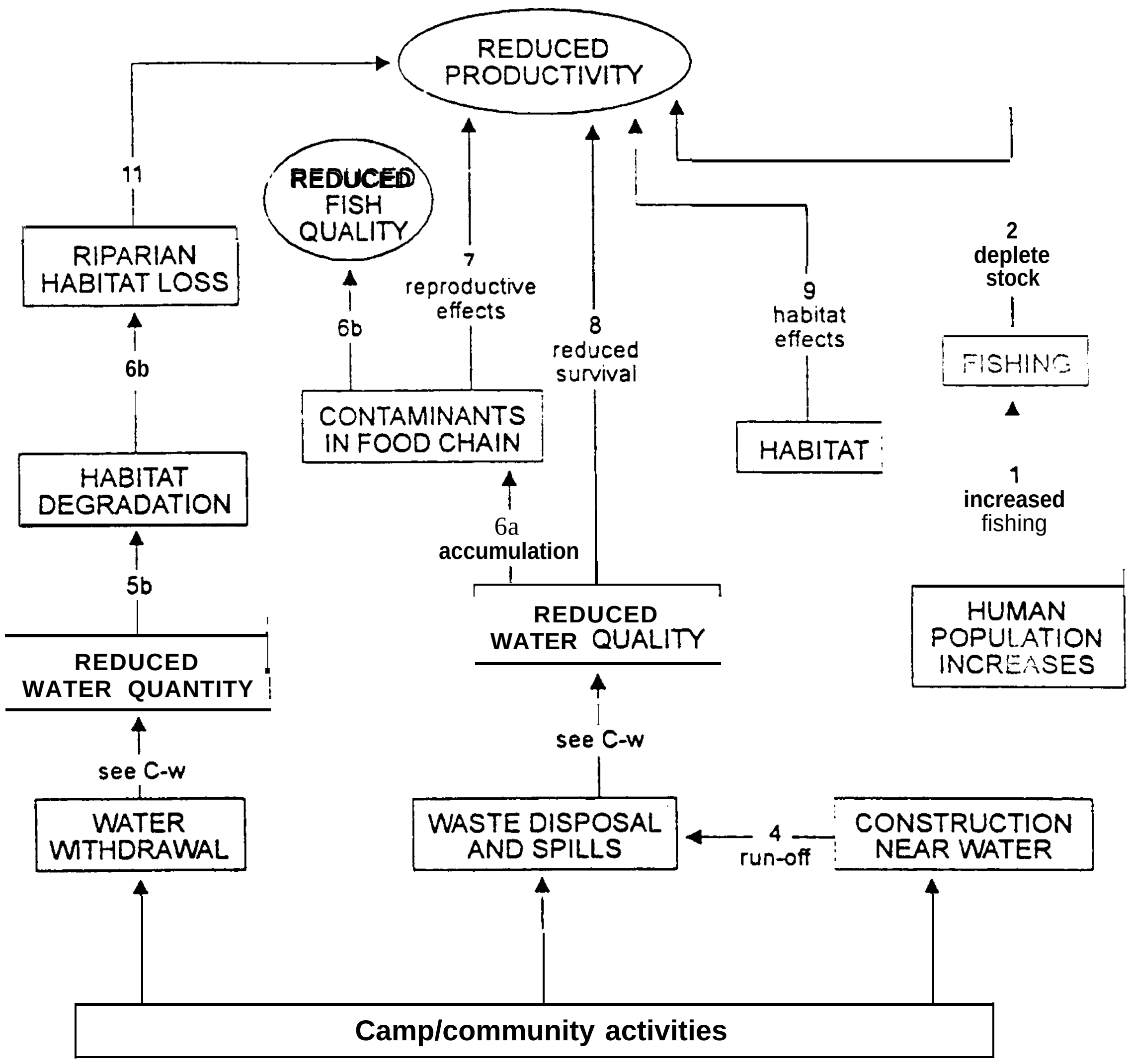
9-gri Effects of camp/community on grizzlies



9-fw Effects of camps/communities on fresh water



9-gl **Effects of camp/community on grayling, lake trout**



Appendix C - Physical Footprints

For this assignment, estimated and actual physical area] footprints of past, current and potential activities in the Slave Geological Province (SGP), Northwest Territories have been determined. This information can help in describing generic footprints as well as in developing a preliminary cumulative environmental effects framework,

Footprints of Abandoned Mines

Twenty-one abandoned mines have been identified in the SGP (Table C. 1). Twelve of these have a known physical footprint ranging from 6,000 m^2 to 500,000 m^2 and averaging 25,000 m^2 . This physical footprint includes access roads, mine railways, airstrips, site facilities, mine workings and waste disposal sites. The environmental footprint or the areal extent of impact of these mines in some cases is much greater than the physical footprint. For example, the most significant in terms of known environmental degradation is the Discovery mine. At this site, the continuing erosion of tailings is resulting in ongoing mercury contamination of Giaque Lake sediments and the fish in Giaque Lake are sufficiently contaminated with mercury to render them unsafe for human consumption. Giaque Lake has an area of 20 km^2.

Footprints of Presently Operating Mines

In 1994 there were six active mines within the Slave Province (Table C.2). They are all gold properties—Colomac, Miramar Con, Royal Oak Giant, Lupin and Trerninco Ptarmigan and Mon mines. The total leased area is 24 million m^2 or 24 km^2 . The environmental footprint of these properties is also likely to be far greater than the leased area. For instance, the sulphur dioxide gases from roaster stack emissions from the Royal Oak Giant Yellowknife Mine have negatively impacted vegetation up to 5 km from the mine site (G. N. W. T., 1993). As well, arsenic contamination from Yellowknife gold mines extends to the waters of Back and Yellowknife bays of Great Slave Lake and also nearby smaller lakes around Yellowknife.

Footprints of Exploration Camps and Development Projects

Table 3.1 reveals that between 30 and 83 mineral exploration camps were located in the SGP in the years 1990 to 1995. Some of these camps would be too small to require a land use permit (used by two people for less than 100 person days). Most of the camps would be regulated by land use regulations and would average under 1 ha (10,000 m^2) in size. Land use regulations require operators to remove all evidence of the camp upon completion of their project. Therefore the residual footprint from those camps would be negligible.

Successful grass roots exploration projects lead to drilling programs and advanced development projects.

The three most advanced mineral development projects in the SGP are the BHP Dia Met proposed diamond mine at Lac de Gras which is currently under review by an environmental assessment panel; the Inmet Corporation's Izok Project, a zinc, copper and lead deposit for which a comprehensive corporation's environmental evaluation study has been completed; and the Nicholas Lake Project, a joint gold mining venture by Athabasca Gold and Chevron Minerals.

There is also an extensive exploration program currently underway by Kennecott Canada and Aber Resources at Lac de Gras which may lead to another diamond development. This mineral property is 30 km southeast of the BHP Dia Met development. The physical footprint of the current exploration effort is 5 ha.

Table C. 3 provides physical footprints for a number of operations for the BHP Dia Met, Izok, Kennecott and Nicholas Lake projects.

Footprints of Outfitters in the SGP

There are currently nine outfitters (Table C.4) with 23 camps operating in the SGP. The average size of a camp is 2 ha which is the parcel size allocated by DIAND. This amount only encompasses the size of the outfitter's permanent camp and does not include their hunting/fishing zones which may be as large as 240,000 ha.

Footprints of Hydroelectric Facilities

The only hydroelectric facilities operating in the SGP are the four dam structures on the Snare River system operated by N.W.T. Power Corp., and the Bluefish hydro site on the Yellowknife River operated by Miramar Con. The Dogrib Power Corp. is currently constructing another hydro facility, the Snare Cascades, upriver of the existing dam structures on the Snare River.

In Table C.5, the physical footprints of the Snare system and the drainage area impacted is provided. The transmission lines from the Snare site to Yellowknife and Rae-Edzo provide the majority of the physical footprint.

In Table C.6, the physical footprints of active and abandoned transmission lines in the SGP is provided. The total physical footprint is 22.2 km^2.

Footprints of Winter and All-weather Roads

The major roads, all-weather and winter in the SGP, are listed in Table C.7. These roadways have a total physical footprint of about 20 million m^2 or 2,000 ha, three quarters of which are from winter roads.

Spills of petroleum products are known to occur both on all-weather and winter roads. Data concerning average spills over twelve years on two roads in the SGP, the Lupin Winter Road and the Ingram Trail (all-weather road), are presented in Table C.8.

Air Transportation

Records on actual air traffic in the air space above SGP are not readily available. Table C.9 provides a summary of traffic in certain communities, a float-plane base, and a mine. Approximately 100,000

_-flights were recorded for 1994. The **number of helicopter** hours flown to service mines and mine exploration camps has been estimated to be 7,500 hours/month (Table C. 10).

Footprints from Aircraft

Aircraft have a variable effect on wildlife depending on the altitude and type of aircraft as well as the species and activity of the animal. Calef, (1976) found that barren ground caribou exhibited strong escape responses to aircraft flying below 60m but that these responses became milder with increasing altitude of the aircraft so that at 1 SO m there were very mild responses. These responses were **typical** for caribou in spring and fall migrations, however, during calving and early winter, panic responses were exhibited by a greater percentage of caribou when aircraft flew at all altitudes below **150** m. Helicopters have less of an effect on caribou than fixed wing aircraft (Calef, 1976) ,however, some studies reveal that this is not so for other species (Ward and Stehn, 1990).

Panic responses, or the startle effect, may increase stress levels in all animals by affecting physiology, reproductive success and habitat use (CEAA, **1995).** In research conducted concerning low level flights in Labrador, CEAA found that waterfowl exhibited flushing and avoidance behaviour in response to aircraft noise. Raptorial birds (eagles, falcons, etc.), show an increase in mortality of eggs and young, energetic stress and changes in habitat use patterns. Clearly, there are tangible effects of aircraft on wildlife, however, long term effects of continued exposure are as yet unknown.

Footprints of Communities

In the SGP there are seven communities having a total leased area of 53,876 ha as recorded by the Department of Municipal and Community Affairs of the Government of the Northwest Territories. The leased area for each community is presented in Table C. 11. The footprint of the communities is much larger than its physical size as the air pollution and noise from the community flows downwind for several kilometres from each community.

Table C. 1: Physical footprints of some abandoned mines in the Slave Geological Province.

Abandoned Mines (Year of closure)	**Other** Names	Roads/Airstrips	Site Facilities/ Operations	Waste Disposal Sites	**Total** Estimated Land Use Area
iscovery[1] (1969)	Bruce-Avis, Winter Lake	I ,840 m* (est.) irstrip	7,500 m² (est) buildings	30,000 m² (est.) ilings ,300 m² (est.) solid aste	500,000 m²
[ope Bay' (1975)	Roberts Lake	,600 m² (est.) ad	2,100 m² (est.) buildings	, I 00 m² (est.) ilings ,600 m* (est.) aste rock	00 m²
undmark[2] (1949)	Thompson-Lundmark	umerous roads, ize unknown o airstrip	120,000 m (est.) buildings	5,000 m² (est.) ilings ,900 ml (est.) soli aste	0,000 m²
almita[3] (1959)	Salerno Group	0,000 m²	n.a.	.a.	a.
undra Gold[3] (1987	Taurcanis, Bulldog	onnecting mine ites	n.a	.a.	a.
tarmigan [7]	Jack, Lilly Groups	1,850 m² (est.) oad	2,400 m² (est.)	,028 m² (est.) waste dump settling pond	,300 m²
Ruth[2] (1987)		,000 m² (est.) road airstrip on esker (size unknown)	800 m* (est.)	,700 m² tailings	500 m²
Beaulieu[2] (1948)	Norma, Brandy	3,900 m² (est.) access road	6,900 m² (est.)	2,000 m² tailings	2,800 m²
Bullmoose[2,4,9] (198	Terra Mines	1,530 m airstrip 67 km ice road	58,000 m² buildin 6,300 m² (est.) tank farm	tailings 70,000 m²	20,000 m²
Hidden Lake* (1 969)	Raggetty Ass	11 km winter road 220,000 m²(est.)[6]	8,000 m² (est.) buildings	ailings <400 m²	50,000 m²
Liten[2] (1 967)	Old Parr	no airstrip, 5,000 m² road	276 m² (est.)	946 m² (est.) tailings	,000 ml
West Bay* (1948)	Blackridge, DAF Group	500 m road, 160 m railway, 6600 m² total[5] 6,600 m²	2,500 m² (est.) buildings	6,500 m² (est) tailing 550 m² (est) solid waste	6,150 m²
Peg Tantalum[2] (1 964)		5 km winter road no airstrip	84,000 m² (est.) buildings	1,000 m² (est.) tailings	5,000 m
Pensive Yellowknife[2] (1947)		no airstrip	18 m² shaft surface area, building size unknown	n.a.	.a.

Abandoned Mines (Year of closure)	Other Names	Roads/Airstrips	Site Facilities/ Operations	Waste Disposal Sites	Total Estimated Land Use Area
De Steffany[2] (1954)	Best Bet, Moose	3,000 m (est.) all-weather roads 30000 m* (est.)[5] no airstrip	26,000 m^2 (est.) buildings	n.a.	56,000 m^2

Note: [1] All-Can Engineering & Surveys (1993b)
[2] Acres (1993)
[3] EdHomby(1995). Indian and Northern Affairs Canada (personal correspondence)
[4] Northwest Territories Water Board (1985)
[5] assuming all-weather road or railway 10 m wide
[6] assuming winter road 20 m wide
[7] Treminco Resources (1988)
[8] not including ice road
[9] Nicholas (1985)
[10] Reid Crowther (1993)

Table C.2: Presently operating mines,

Presently Operating Mines	Roads and Airstrips	Site Facilities and Operations	Waste Disposal Sites	Area of Surface Lease
Colomac	357,367 m^2	132,857 m’	1,140,000 m^2	120 ha
Miramar Con	n/a	n/a	n/a	351 ha
Royal Oak Giant	n/a	n/a	n/a	590 ha
Lupin	94,946 m’	55,625 ma	550,000 m^2	1,233 ha
Treminco Ptarmigan/Tom	12,110 m^2	4,794 m^2	184,943 m^2	200 ha

Table C.3: Advanced mineral development projects,

Projects	Roads and Airstrips	Plant or Camp Site	Waste Rock Sites	Tailings	Total Surface Lease
Aber Kennecott	120,000 m^2 (actual)	29,400 m* (actual)	12,500 m^2 (actual)	n/a	5 ha (actual)
BHP Dia Met	1,147,500 m^2 (proposed)	= 3,000,000 m' (proposed)	396,425 m^2	424 ha	n/a (projected area 73 km^2)
Izok	3,000,000 m' (proposed)	200,000 m^2 (proposed)	*4,160,000* m^2 (proposed)	37 ha (proposed)	4,428 ha (proposed)
Nicholas Lake	300 m^2 (actual)	26,800 m^2 (actual)	95,625 m^1 (actual)	n/a (actual)	12.3 ha (actual)

Table C.4: Outfitters in the Slave Geological Province.

Adventure Northwest
Arctic Safaris
Aurora Camp Caribou
Burnside HTA/Tundra Camps
Cadieux's Caribou Pass
Camp Ekwo
PeterSons' Point Lake Camp
True North Safaris
Webb Outfitting (N. W. T.) (Qaivvik Ltd.)

Total Number of Camps= 23
Average Size = 2 ha

Table C.5: Hydroelectric and related infrastructure in the Slave Geological Province.

Hydroelectric 'Facilities	Roads, Transmission line Corridors and Airstrips	Site Facilities and Operations	Flooded Area	Total Area
Miramar Con Hydro	n/a	n/a	n/a	n/a
Snare Hydro	19,451,000 m^2	13,794 m^2	50,000 m^1	19,514,794 m^2

Table C.6: Physical footprints of hydroelectric transmission lines.

	Transmission Line	Length (km)	Area (km*)
Active	Snare to Yellowknife	140	9 8
	Snare to Rae	105.2	7.4
	Bluefish to Yellowknife	approx. 33	2.3
Not Active	Bluefish to Thompson - Lundmark	43	0.86
	Bluefish to Discovery	62	1.2
	Snare to Rayrock	34.2	0.68

Table **C.7:** Roads in the Slave Geological Province.

Roads	Length (km)	Width (m) (including right of way)	Area of Road (m^2)
Rae Lakes Winter Road	194	12	2,328,000
Yellowknife to Rae	97	20	1,940,000
Yellowknife Access	1.2	20	24,000
Ingraham Trail	72	20	1,440,000
Colomac Winter Road	157	20 (average width)	13,140,000
Lupin Winter Road	567	20 (average width)	11,340,000
Total Road Area: 20,212,000 m^2			

Table C.8: Spills on two roads in the Slave Geological Province (averages over 12 years from 1983-1994).

Road	Type of Spill	Number per Year	Volume (l) per Year
Ingraham Trail	fuel/oil	1.2	11,656 (approx.)[1]
Lupin Winter Road	fuel/oil	1.2	3,199 (approx.)[2]

[1] 93% of spills have known volumes.
[2] 64% of spills have known volumes.

Table C.9: Air transportation in the Slave Geological Province.

Community Name	Number of Flights (1994)
Dettah	0
Rae Edzo	n/a
Snare Lake	228 (approx.)
Bathurst Inlet	>100
Yellowknife	83,281
Yellowknife Float Plane Bases	15,000 (approx.)
Lupin Mine	2,936

Table C. 10: Helicopters operating in the Slave Geological Province for the mineral industry.

Number of Helicopters	Number of Hours of Operation
50 (approx.)	7,500/month (approx.)[1]

[1] These figures are rough estimates based on information gathered from one helicopter company which operates in the area

Table C.11: Surface lease areas of communities in the Slave Geological Province.

Community Name	Approximate Area (ha)
Snare Lake (Wekweti)	150
Dettah (T'ereheda)	700
Yellowknife	13,555
Rae Edzo	4,410
Bathurst Inlet (Umingmoktok)	3,010
TOTAL	21,825