

An evaluation of health impact assessment in Canada
using four case studies from the mining industry

by

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ABSTRACT

In Canada, health impact assessment is part of the Integrated Environmental Assessment framework. This thesis addresses previously expressed concerns regarding a lack of health impact assessment in Integrated Assessment frameworks and examines how thoroughly human health has been taken into consideration in the environmental assessments that have been conducted for new mining developments in Canada. Using an evidence-based policy analysis approach, four case study environmental assessments that have been reviewed by public panel under full or partial responsibility of the federal government of Canada were examined retrospectively and discussed in context of the recently published Canadian Handbook on Health Impact Assessment. Information regarding the case studies was gathered primarily from formal environmental assessment documentation. State of knowledge was identified from a review of health science literature. The performance of health impact assessment was assessed by comparing scope of health impacts considered during each environmental assessment with the state of knowledge. The impact of the consideration of health impacts on the governments' final decision was evaluated by comparing the scope of health impacts considered in the panel report and those in the government(s') reports. These comparisons were facilitated using a tool, developed as part of this work, which integrates attributes of mining lifecycle, impact pathway, and determinant of health categories to provide a visual and informative snapshot of the scope of human health impacts.

The results indicate that environmental assessments have been predominantly concerned with effects of direct and ecosystem mediated exposures to chemicals on affected communities and have had an impact at the decision-making phase. The limited use of scientific knowledge regarding other environmental hazards or occupational and social health factors are found to be a product of the unique processes which have resulted from the ambiguous legislation and scoping exercises of the past. In conclusion, while the Canadian Handbook on Health Impact Assessment has considerable potential to improve upon past practices, the increasing development of confidential Impact and Benefits Agreements (IBAs) between proponents and communities may negatively impact the further development and effectiveness of health impact assessment of mining operations in the long term.

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LIST OF ABBREVIATIONS

CEAA 1995	Canadian Environmental Assessment Act 1995
CEOH	Federal, Provincial, Territorial Committee on Environmental and Occupational Health
EARP	Environmental Assessment Review Process
EARPGO 1984	Environmental Assessment Review Process Guidelines Order 1984
NEPA 1969	US National Environmental Protection Act 1969
IBA	Impact and Benefits Agreement

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1. INTRODUCTION

Health impact assessment (HIA) is a process established in governmental policy that is used at the planning stage of a development project to assess the potential effects of the proposed project on public health. In a 4-step process, which includes a provision for public participation, potentially significant impacts are first identified and then assessed with respect to significance and acceptability. The results of the assessment are presented to a decision-maker, thereby allowing a rational public policy decision to be made (Andrews, 1988).

Since its formal inception in the USA in 1969, health impact assessment has been integrated within the Environmental Assessment framework and entrenched in the environmental protection sector of governance in many jurisdictions. This sector has traditionally been primarily concerned with the natural environment. Following the perception that human health was a neglected component of environmental assessment processes, studies that systematically assessed the level of consideration of human health in environmental assessments validated this perspective. Institutional challenges that have affected the procedures that are followed in environmental assessments and knowledge-based challenges have routinely influenced the consideration of impacts to human health. However, following developments in the public health sector that have led to a better understanding of non-medical determinants of health, further studies that have been carried out both internationally and in Canada have continued to conclude that human health concerns are a neglected component of the environmental assessment process.

In 1999, Health Canada published the Canadian Handbook on Health Impact Assessment¹ (Health Canada, 1999a; Health Canada, 1999b; Health Canada, 1999c) as part of a Federal, Provincial, Territorial process (Spiegel & Yassi, 1997). This handbook was developed to promote the concepts of health impact assessment to the different participants in the environmental assessment process in Canada in order to ensure that the potential impacts of development projects on human health would be adequately assessed.

¹ Subsequently, the Canadian Handbook on Health Impact Assessment was released as four volumes

The mining industry is just one of the sectors of economic development addressed by the Canadian Handbook on Health Impact Assessment and has been chosen as the focus of the thesis for two reasons. Firstly, mining is a prominent industry in Canada where its increasingly remote developments are often subject to environmental assessments. Concerns have been raised in the past regarding the attention given to human health (Young, 1997) in these assessments. From a policy perspective, it is appropriate to ask if the objective of a health impact assessment framework, to address impacts on human health, has the potential to be met. Secondly, the mining industry has also experienced the emergence of voluntary but confidential Impact and Benefits Agreements (IBAs), which compensate local aboriginal land-users for impacts to be caused by a mining development. IBAs are exclusive to the mine developer and affected communities and do not involve the government as an informed party. Since the objectives of the governmental Environmental Assessment framework include addressing the impacts and the overall acceptability of a project, the effectiveness of the governmental framework is brought into question.

The Canadian Handbook on Health Impact Assessment (Health Canada, 1999a; 1999b; 1999c) is a relatively new tool to guide both the health impact assessment process and the ultimate decisions made regarding newly proposed projects that are subject to the environmental assessment process. The effectiveness of the guidance in the handbook with respect to the health impact assessment of proposed mining projects now and in the future is unknown. In this respect, two questions emerge: a) To what extent have human health impacts from mining operations been comprehensively considered in environment assessments of mining operations in Canada in the past; and b) Will adherence to the Canadian Handbook on Health Impact Assessment (Health Canada, 1999a; 1999b; 1999c) likely ensure the adequate health impact assessment of proposed mining projects in the future? The overall objective of this thesis is to address the first of these questions. Implications of the findings with respect to the second question are addressed in the discussion. Specifically, the thesis looks retrospectively at four case studies of proposed mining projects that have been reviewed by federal or joint federal-provincial public panels to evaluate the performance of the environmental assessment processes with respect to

the consideration of impacts on human health. State of knowledge is used to measure the performance of the process.

A systematic methodology for the analysis of the case studies was devised for this study and involved the development of a tool to evaluate the scope of health factors considered in an environmental assessment. The *Health Impact Assessment Scope Evaluation Tool* examines the extent to which the project phase, impact pathway (Spiegel & Yassi, 1997), broad determinants of health (Federal, Provincial and Territorial Advisory Committee on Population Health, 1994) and physical or social environment impact type have been considered in a health impact assessment. Impacts in the physical environment impact categories are also classified by exposure environment and hazard type. Such complexity has not been previously achieved in other studies that have evaluated the consideration of health impacts. These attributes are linked through the development of a *Map of human health impact relationships of a mining project*, integrating these attributes together under the DPSEEA (Driving force, Pressure, State, Exposure, Effect and Action) framework (Kjellstrom & Corvalan, 1995) developed by the World Health Organization, to represent the relationship between a mining project and human health.

2. STUDY GOAL, OBJECTIVES AND RESEARCH QUESTIONS

2.1 Study goal

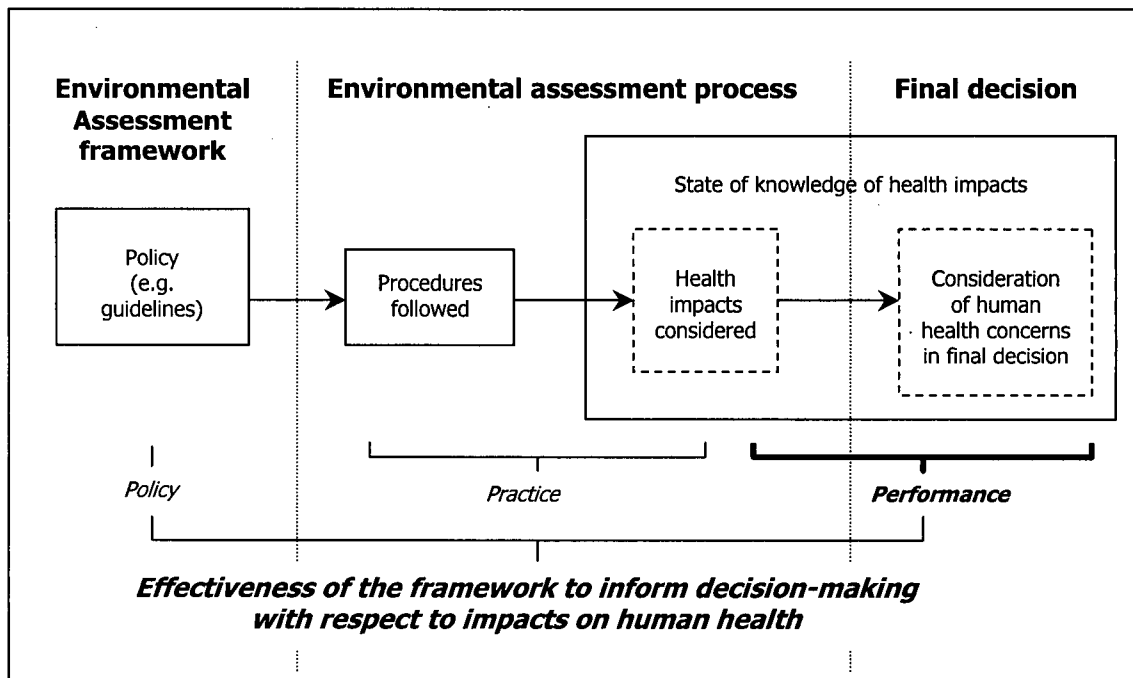
The overall goal of this study is to evaluate the potential for effective health impact assessment of proposed mining projects in Canada by looking retrospectively at past project assessments. The study will contribute information to enable informed decisions to be made with respect to the environmental assessment of mining projects in order for significant impacts of proposed mining projects on human health to be adequately assessed in the future. A secondary goal was to contribute a tool that will facilitate comprehensive consideration of health factors either during or after an environmental assessment of mining projects. Policy makers, environmental assessment practitioners, the mining industry and the general public are all intended users of the results from this study.

2.2 Development of research questions

In order to address this overall goal it was important to examine the concept of effective health impact assessment. Some important concepts have been explained succinctly by Sadler (1996). Sadler (1996) outlined the general concept that environmental assessment policy influences environmental assessment practice and that, in turn, influences the performance of the process. In terms of this study, this implies that the procedures followed in the process will influence the consideration of impacts on human health. However, it is apparent that the state of knowledge will also influence the scope of assessment of impacts on human health, and this can be used as a measure of performance. Examining the procedures that led to the consideration of impacts to human health will provide insights into past challenges and current needs. Sadler (1996) also explained that the effectiveness of the process can be measured in terms of the performance of the process itself and maybe more appropriately in terms of the overall objective to inform decision-making, suggesting that influence of the consideration of health impacts on the final decision should be examined in addition to the quality of the consideration of impacts on human health within the environmental assessment process. Examining this concept of influence will indicate if health impact assessment is utilized as a decision-making tool in the health impact assessment of mining operations in Canada.

These concepts are grouped together in an influence diagram in figure 2.1 below and illustrate the conceptual framework for the four research questions used in this study.

Figure 2.1. Influence diagram showing the conceptual framework for an evaluation of health impact assessment



Based on this conceptual framework, the following four research questions were addressed in this thesis:

Research Question 1: What procedures have been followed to identify potential significant impacts to human health in the environmental assessment of mining projects?

Research Question 2: What health impacts have been considered during the environmental assessment of mining projects?

Research Question 3: What is the evidence that the health impacts considered during past environmental assessments of mining projects have been consistent with the state of knowledge?

Research Question 4: What is the evidence that the consideration of health impacts has had an impact on the governments' final decision?

2.3 Specific objectives

In order to answer these four research questions the following specific objectives were identified:

- a) Identify the procedures followed that affected the consideration of impacts on human health during each phase of the environmental assessment process during the environmental assessments of mining projects in the past, using four case studies;
- b) Develop a tool to examine the scope of human health impacts of mining projects;
- c) Determine scope of impacts to human health considered in environmental assessments of proposed mining projects in the past using this tool;
- d) Establish state of knowledge regarding human health impacts of mining projects in the past by extending Stephens and Ahern's (2001) literature review using the PubMed health science database;
- e) Determine if the scope of health impacts considered in environmental assessments of mining projects in the past were indicative of the state of knowledge, by integrating the results from (c) above with evidence of state of knowledge at time of those environmental assessments in the past;
- f) Determine to which extent human health concerns have been incorporated in the ultimate decision by establishing the scope of consideration of impacts on human health evident in the decision document using the tool developed in (b) and comparing this to the scope of health impacts considered in the panel report from (c);
- g) Identify and discuss procedural challenges in health impact assessment processes in the past by critically analyzing the overall performance of health impact assessment processes in the case studies and;
- h) Discuss the potential for the Canadian Handbook on Health Impact Assessment to address past omissions in the consideration of health impacts that were identified in (g)

3. LITERATURE REVIEW: HEALTH IMPACT ASSESSMENT AND ENVIRONMENTAL ASSESSMENT

3.1 Global development of Health Impact Assessment

3.1.1 Introduction

The formal environmental assessment process, which includes a health impact assessment component, was initiated in the US in the environmental sector of governance. The development of environmental assessment internationally has also occurred in this sector, which is principally concerned with the natural environment. In addition to institutional challenges that may have prevented human health concerns from being considered in environmental assessments of development projects there is evidence to suggest that a lack of knowledge may also have contributed to a lack of consideration of these concerns. Nevertheless, health impact assessment as a component of environmental assessment has been promoted on an international scale. There have also been advancements in the conceptual framework regarding non-medical determinants of health in the public health sector and technological developments in health impact assessment procedures. These developments are discussed below.

Terminology used in this and consequent sections needs to be addressed here. The term *Environmental Assessment*² is a general term that covers the spectrum of Impact Assessment frameworks that includes concerns for the natural environment. Sometimes the term *Integrated Environmental Assessment* is used when there is an explicit recognition of a human health component. However, the terms *Environmental Assessment* and *Integrated Environmental Assessment* are often used interchangeably. In this study the term *Integrated Environmental Assessment* is only used where I have determined this distinction to be important in relating information from the literature. Cumulative effects are those effects created in conjunction with other projects. Determinants of health include the physical and social environments.

² Use of capital letters (e.g. Environmental Assessment) denotes the formal framework, whereas absence of capital letters denotes process (e.g. environmental assessment process)

3.1.2 Environmental Assessment and the emergence of the Health Impact Assessment

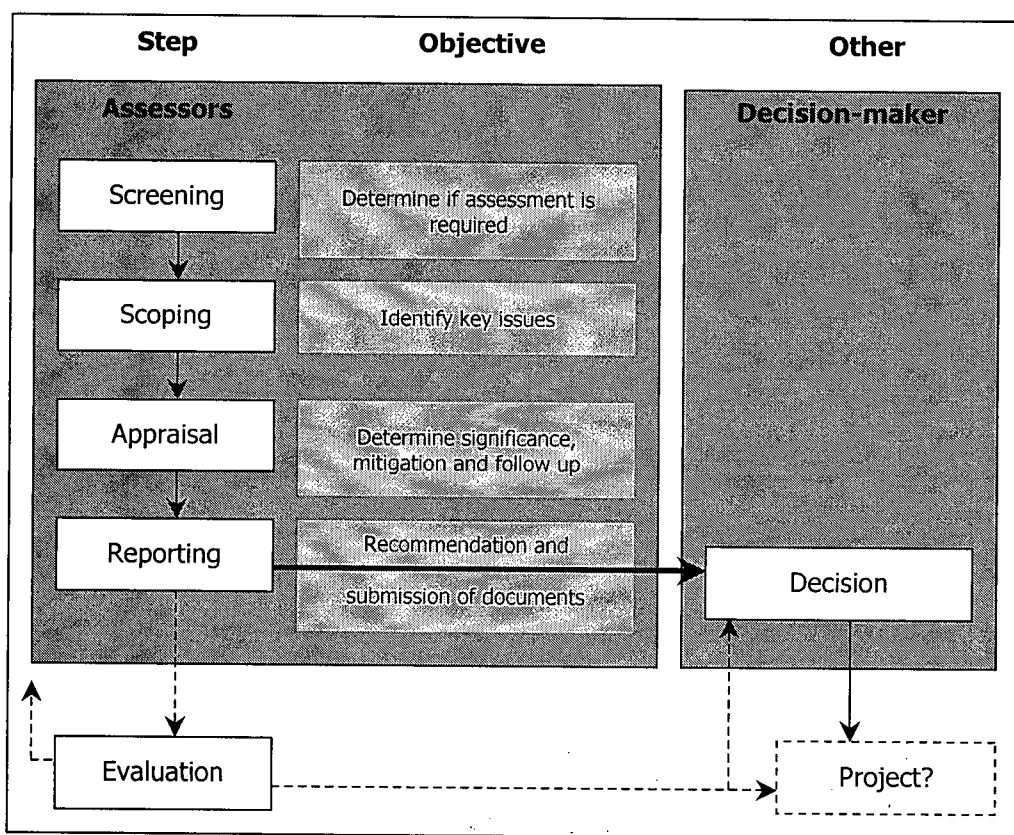
The 1969 US National Environmental Policy Act (NEPA 1969) was the first Environmental Assessment framework to be formally established in governmental legislation worldwide. NEPA 1969 was developed in response to the controversy surrounding the adverse effects on human health and the natural environment that were occurring as a result of the unregulated emissions of industrial developments that were increased in the period of rapid industrial growth that had followed World War I (Cashmore, 2004; O'Riordan & Sewell, 1981; Petts, 1999). One commonly recognized example of the public outcry that occurred at this time is Rachel Carson's book *Silent Spring* (Carson, 1962) that focused on the impact of agricultural pesticides on nearby communities.

The objectives of 1969 US National Environmental Policy Act (NEPA 1969) were aimed at ensuring that development projects with potentially unacceptable outcomes were prevented by interventions at the planning stage and ensuring benefits to the health and well-being of humans as well as the natural environment. A 5-step process was established within the 1969 US National Environmental Policy Act (NEPA 1969) and enabled knowledge of how impacts caused by economic developments might affect human health to be used in conjunction with value judgements, to determine the acceptability of a project (Sadler, 1996). Andrews (1988) indicates that this transparent process provides the information required to make a rational public policy decision that will be acceptable to the general public.

Since its inception, the general process has remained unchanged. The World Health Organization (2005b) has summarized a simple 5-step generic model of the health impact assessment process as including the following: 1) screening, 2) scoping, 3) appraisal and 4) reporting and 5) evaluation. Each of these five steps is associated with certain activities. Under NEPA 1969, in the screening phase, projects that may cause potential significant effects are selected for further assessment. Projects with the potential for significant effects on the natural environment or human health could be selected here. Then, in the scoping phase, key issues to be examined in the appraisal phase are identified (Ugoretz, 2001). In the appraisal phase, these key issues are examined to identify any potentially significant

effects. In the event that any significant and unacceptable effects are identified, potential mitigation measures that could be incorporated into the project to reduce the likelihood of adverse effects are considered. Follow-up measures are also developed at this stage. At the end of the appraisal, the findings from the appraisal stage and any recommendations are reported to a final decision-maker. An evaluation phase occurs during and after the subsequent development of a project. A flowchart of the 5-step health impact assessment process described here is illustrated in figure 3.1 below:

Figure 3.1. Flowchart illustrating the generic health impact assessment process within the Environmental Assessment decision-making framework*



*Adapted from World Health Organization (2005b) and Health Canada (1999a)

Several procedures were established for the health impact assessment component of the integrated environmental assessment process under NEPA 1969. For instance, the World Health Organization's definition of human health: "a state of complete physical, mental and social well-being and not merely the absence of disease" (World Health Organization, 1948) was established as the working definition of human health. The need to assess short-term, long-term and cumulative effects (Go, 1987) of various

alternatives (Ugoretz, 2001) was also established. Under NEPA 1969, the health impact assessment process used only scientifically based methods (e.g. risk assessment) (Ugoretz, 2001), although Cashmore (2004) observed this changed over time to incorporate more subjective methodologies. Public participation was incorporated as a feature of the process, which provided for a transparent process.

Wathern (1988) identified Canada, Australia and Colombia as three early legislated environmental assessment frameworks that were institutionalized in the early 1970s following the NEPA 1969 precedent. Other examples followed in the 1980s. Those identified by Wathern (1988) include the Netherlands, Japan and the European Community (EC) that adopted legislated environmental assessment frameworks in 1981, 1984 and 1985 respectively.

It is evident that the environmental assessment process had become entrenched in the domain of environmental governance (Arquiaga, Canter, & Nelson, 1992; Giroult, 1988) that was, and maybe still is, predominantly concerned with impacts on the natural environment. Gibson (2002) alludes to a pressure that existed in the early days of the development of environmental assessment that succeeded in gaining the natural environment as a focus of environmental assessment, at least in Canada. Insights into the large amount of public pressure in the early 1970s that accompanied the first Earth Day in USA, which if only by name, appears focused on ecological concerns, are provided by Lewis (1990), the founder of Earth Day, and gives credence to Gibson's statement.

3.1.3 Developments in environmental assessment and the challenges to assess human health

Developments in the understanding of human health and its determinants occurred in the public health sector separately and concurrently to the development of the environmental assessment process and were able to contribute to the development of the health impact assessment process.

In 1974, the first of these developments, The Lalonde report, formally titled, "A New Perspective on the Health of Canadians. A working document", (Lalonde, 1974) from Canada marked a global watershed in

explicitly identifying non-medical influences on health.³ Within this new climate of public health awareness, the World Health Organization had sought to strengthen the consideration of human health in environmental assessment framework worldwide and, in 1982, gained sanction from the World Health Assembly (1982) who endorsed the use of integrated environmental assessment processes in Environmental Assessment frameworks (Health Canada, 1999c).

In the late 1980s, in articles that addressed the consideration of environmental health issues in environmental assessments, both Giroult (1988) and Martin (1986) made opening statements that concern for human health had become a neglected component of the Environmental Assessment framework worldwide. However, the first evidence of a systematic study that evaluated the consideration of human health in environmental assessment processes is that by the World Health Organization (Centre for Environmental Management and Planning, 1986) in 1986, which was described by both Go (1987) and Giroult (1988). Of 13 Environmental Assessments of chemical industry projects, only one was found to have an explicit consideration to human health in the documentation that was examined for the study. The study was therefore able to validate those general statements that had been made previously. Later, in similarly designed studies, Canter (1990), and Arquiga, Canter and Nelson (1992) would also conclude that the consideration of human health had been lacking in the USA. The methods used in these studies are outlined later in section 3.2.3.

Giroult (1988) identified three challenges with respect to effective health impact assessment at this time: 1) the development of the environmental assessment process and procedures by ecologists, which may not have been conducive to the assessment of impacts on human health; 2) lack of knowledge regarding human health impacts; and 3) the tendency for government authorities to treat health data as confidential. Also at this time, in a critical assessment of the effectiveness of environmental assessment to address human health, Go (1987) suggested that perceptions of the environmental impact assessment study team and the permitting authorities were the determining factors in the procedures

³ Economic, cultural, and physical environments are examples of non-medical determinants of health.

that are followed in an assessment, and therefore, in the outcome of the process. Andrews (1988) also pointed out environmental assessments may be carried out under conditions of conflict of interest as the government agency that is responsible for an environmental assessment of an industrial project often has economic growth of that sector as a primary mandate.

Meanwhile, developments in the concepts of non-medical determinants of health had continued in the public health sector and on an international level, with the Ottawa Charter for Health Promotion (World Health Organization, 1986) including these concepts in a new framework for health promotion. Davis and Sadler (1997) observed that the relationship between the biophysical environment and human health had been recognized internationally at this point.

It appears that as a result of these developments in the public health sectors, organizations that were perhaps more oriented towards a concern for human health sector had continued to develop, and promote, through publication, an environmental assessment process in which the consideration of human health is an explicit component. In their review of international literature on health impact assessment, Davis and Sadler (1997) identified several examples of impact assessment processes that were described either as integrated environmental assessment or health impact assessment processes worldwide in the period succeeding the World Health Assembly (1982) endorsement in 1982. Examples that were published from international organizations between 1985 and 1995 include those from the World Health Organization (Sloan, 1993; World Health Organization, 1985; World Health Organization, 1989) World Health Organization Regional Office for Europe [e.g. Giroult (1988), World Health Organization (e.g. (Turnbull, 1992))], World Bank (e.g. Listorti (1991)), Asian Development Bank for Asia-Pacific Region (Asian Development Bank, 1992) and Commonwealth Secretariat (e.g. Slooff (1995))].

The inclusion of explicit concern for human health in the environmental assessment process was promoted in another opportunity in 1992, when the World Health Organization highlighted the importance of Health Impact Assessment in Agenda 21 (United Nations Environmental Program, 1992),

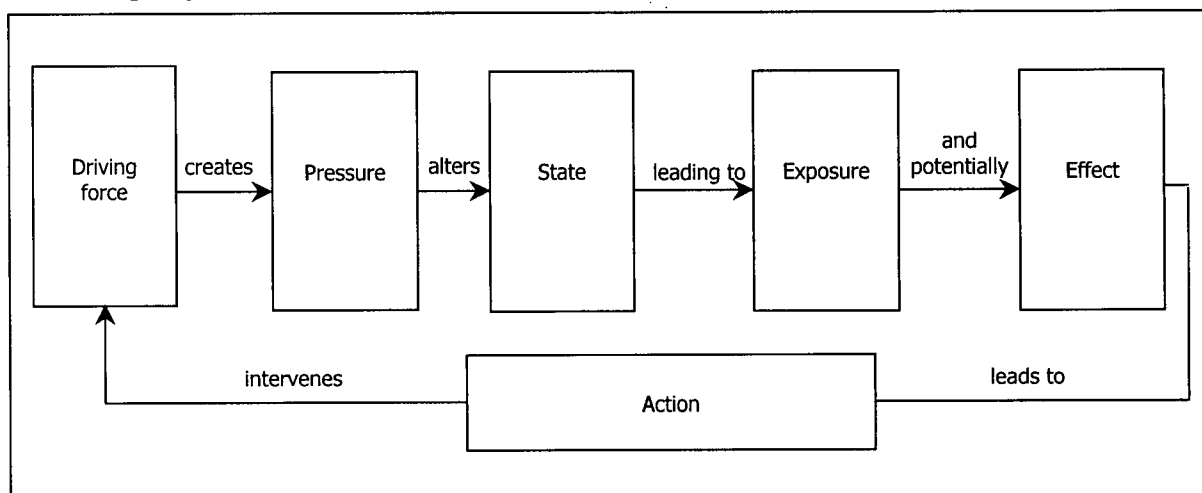
which was prepared for the 1992 United Nations Conference on Environment and Development. Earlier, the publication of the Bruntland report (World Commission on Environment and Development, 1987), which called for sustainable economic development, and was central to the 1992 UN Conference on Environment and Development (United Nations Environmental Program, 1992), also highlighted the need to consider the impact of industrial developments on public health.

3.1.4 Technological developments in health impact assessment

During this time, there had also been developments in the technological tools that could be used in the explicit assessment of impacts from industrial developments on human health. Sadler (1996) reported that one of the first tools to make a contribution to health impact assessment was a health and environment cause-effect (Pressure-State-Response) framework published in 1993 by the Organisation for Economic Cooperation and Development. In this early framework, "Pressure" is analogous to the mining development, "State" refers to the change in state of the environment and "Response" refers to a health outcome or effect.

The same year, the DPSEEA (Driving force, Pressure, State, Exposure, Effect and Action) framework, a classification system for environmental health indicators (Kjellstrom & Corvalan, 1995) that linked the various impact types to health effects in humans was also published. The DPSEEA impact chain is illustrated in Figure 3.2 on the following page. The following example illustrates the DPSEEA framework with respect to the mining industry: the market price of lead (driving force) may lead to the smelting of lead ore (pressure) that may result in significant environmental emissions (state) of lead dust in air (exposure) may lead to lead poisoning (effect) in community members and therefore should be mitigated (action). Later, the DPSEEA framework was supplemented by the MEME (Multiple Exposures Multiple Effects) framework (World Health Organization, 2005a) that draws attention to the multiple effects on human health that a collection of multiple exposures can cause.

Figure 3.2. DPSEEA (Driving force, Pressure, State, Exposure, Effect and Action) framework showing impact chain*



*Adapted from Kjellstrom and Corvalan (1995)

Up until the mid 1990s, the development of health impact assessment appears to have been largely limited to the governmental domain. The earliest evidence of academic contribution to the field identified in the literature review for this study is an article by Ewan, Young, Bryant and Calvert (1993) from the University of Wollongong regarding the integrated environmental assessment process in Australia, which was identified by Sadler (1995) in a review of health impact assessment literature. Other academic work at this time includes the collaborative effort (Spiegel, 2004) of the Canadian Handbook on Health Impact Assessment (Health Canada, 1999a; 1999b; 1999c) and an article by Spiegel and Yassi (1997) that illustrated how indicators could be developed for use in health impact assessment. The framework presented by Spiegel and Yassi (1997) established four impact pathways through which development projects could affect human health. These four impact pathways are presented in Table 3.1 on the following page.

Table 3.1. The four categories of health impacts of mining developments as explained by Spiegel and Yassi (1997)

Pathway 1	Environmental Contaminant (exposure) Human exposure to radiation, toxic chemicals, noise, workplace safety and health hazards leading to an increased risk of cancer or other chronic diseases, including effects to 2 nd generation, among workers and local residents
Pathway 2	Ecosystem mediated effects Human exposure to toxic substances through changes in the ecosystem, potentially increasing body burden of contaminants in those affected
Pathway 3	Employment and Income Effects Effects such as improved wages, rotational employment, prolonged separation from spouse and children, mobility associated with direct participation of individuals employed at the mine and their immediate family
Pathway 4	General Community Impacts Impacts such as increased industrial activities that lead to increased employment and overall income that contribute to the overall impact of the whole community, not just the mine employees and their families

Other tools that are specific to health impact assessment include the Canadian Handbook on Health Impact Assessment (Health Canada, 1999a; 1999b; 1999c), which is discussed later in section 3.3.6 and procedural guidelines for health impact assessment that are summarized in a website coordinated by the World Health Organization (2005b).

3.1.5 Challenges to achieve the consideration of human health concerns in environmental assessment processes

During this period there had been further advancements in the public health sector regarding non-medical determinants of health. Work in this field led eventually led to the establishment of the Determinants of Health model (Evans & Stoddart, 2003), which has been articulated in Canada by the Federal, Provincial and Territorial Advisory Committee on Population Health (ACPH), in 1994 (Federal, Provincial and Territorial Advisory Committee on Population Health, 1994).

With these conceptual advancements and technological development in health impact assessment, one may expect that the consideration of human health concerns would have improved over time. However, recent studies have not been able to confirm this. For example, the British Medical Association (1998) found evidence of concern for human health to be omitted from 28 of the 39 Environmental Impact Statements it had reviewed. However, it should be noted that the UK environmental assessment framework is not explicit in requiring a health component in assessments. That said, in 2000,

Steinemann (2000) carried out a study in the USA of projects where there was a requirement to consider impacts to human health and found 26 of 42 Environmental Impact Statements, which were selected due to the potential for significant impacts to human health, were lacking any explicit mention of human health. Steinemann (2000) reported only one of the 16 that did mention human health, included more than one general statement related to human health.

In addition to these studies outlined above that have evaluated the human health component of environmental assessments, there have been numerous other studies, reviews and articles that have taken indirect approaches to the subject but have also identified some of the challenges faced in achieving the consideration of human health in an environmental assessment process. These have predominantly involved critical analyses of Environmental Assessment frameworks or procedures used the environmental assessment processes.

In a review of health impact assessment literature, I (McCaig, 2005) proposed that these challenges can be grouped into two categories: *institutional challenges* that occur as a result of the implementation of a process and *knowledge-based challenges*.

Institutional challenges that have been identified more recently include: unclear regulation (Davies & Sadler, 1997; Gibson, 2002); a lack of recommendations regarding concerns for human health used in the decision-making stage, (Gibson, 2002); and a perception among many environmental assessment practitioners that environment assessment is a scientific process and not a political process, which may prevent health concerns that are not yet identified as causal to be excluded from an assessment (Beattie, 1995; Wilkins, 2003). Echoing earlier concerns by Go (1987), Gibson (2002) also noted the lack of health professionals at the scoping stage. Steinemann (2000) observed a tendency for impacts to human health to be addressed indirectly through environmental regulation and reported that a project developer's fear of liability if potential health impacts are acknowledged is also a factor. Since the environmental assessment process lies in the governmental domain, this latter conclusion suggests

developers may be able to influence these processes. In fact, developer driven environmental assessments have been cited as shortcomings in articles relating to the assessment of mining projects [e.g. (Canadian Institute of Resources Law, 1997)].

With respect to *knowledge-based challenges*, recently Steinemann (2000) noted the lack of knowledge regarding cause and effect mechanisms of impacts through the physical environment and the underdeveloped state of methodologies available for use in the process, which echoed the conclusions made by Giroult (1988) and Martin (1986) in the late 1980s (see section 3.1.3), illustrating the lack of development in this area.

I (McCaig, 2005) identified four main areas of *knowledge-based challenges*: equity and knowledge of risk; data acquisition; assessment tools; and analysis or synthesis of results. A fifth area could be general knowledge-based challenges, for example, the general lack of research and development outside of procedural analyses and lack of insights generated from real case studies as identified by Davis and Sadler (1997). Examples of challenges in the *equity and knowledge of risk* category include the lack of scientific information regarding specific determinants of health and on a general level, lack of knowledge regarding consistencies between different economic developments and lack of knowledge regarding the incorporation of traditional knowledge (Health Canada, 1999a). Examples of challenges in the *data acquisition* category include lack of indicators of community, social and psychological health and well-being and lack of baseline information at the community level (Davis and Sadler, 1997). With respect to the *assessment tools* category, I (McCaig, 2005) identified a challenge to identify adequate tools or to adapt currently inadequate tools for effective health impact assessment. Challenges in the *analysis or synthesis of results* category include the judgment of significance, which is particularly difficult in cases where traditional knowledge is used (Health Canada, 1999a).

3.1.6 Other insights

Curtis and Epp (Curtis & Epp, 1999) observed a gradual shift in the objectives of Environmental Assessment frameworks from the mitigation of adverse effects to achieving sustainable development

that has occurred in the period succeeding the publication of the Bruntland report (World Commission on Environment and Development, 1987). Perhaps more insightful is the emergence of other impact frameworks that have adapted the NEPA 1969 framework and process for the assessment of specific foci that have continued to develop concurrently to the integrated environmental impact assessment framework (Sadler, 1995) and Pope, Annandale and Morrison-Saunders (2004). These are the Environmental Impact Assessment, Sustainability Assessment and Health Impact Assessment frameworks, which are concerned with only the natural environment, sustainable (socio-economic) development and public health respectively. In countries where this has occurred, there has essentially been a split of the frameworks and therefore the consideration of impacts on the natural environment and impacts on human health. This raises the possibility that the impacts on human health are either small or not valued in comparison to those on the natural environment or the assessment of human health is too challenged. Alternatively, as Gibson (2002) suggested, the inclusion of human health may not be wanted due to a fear of possible detracting from ecological concerns.

3.2 Measuring effectiveness of health impact assessment

3.2.1 Introduction

The effectiveness of impact assessment process can be defined in many ways. Fundamentally, effectiveness can be measured in terms of the process itself but also in terms of the outcome, that is, at the decision-making stage. In this context, the relationship between the procedures followed in the process, the consideration of impacts on human health, and the influence of this on the decision are explored here.

Methods that have been used in previous studies to measure the level and scope of consideration of impacts on human health are also described in this section. These are principally empirical studies that have involved an examination of documentation produced from the environmental assessment of proposed projects.

Care should be taken when interpreting the term *Environmental Impact Statement* as their characteristics differ between countries. For instance, in the USA, Environmental Impact Statements are the complete archived record of the assessment process that is presented to the decision-maker, whereas in Canada, this term has been used to describe a study submitted by the developer in the appraisal phase. Persons carrying out the assessment on behalf of the government are referred to as *environmental assessment practitioners* (Health Canada, 1999a).

3.2.2 Measures of effectiveness in impact assessment

In a study on the effectiveness of environmental assessment, Sadler (1996) presented an effectiveness triangle that established the inextricable link between policy, practice and performance. Sadler (1996) observed that policy determines practice, which in turn, determines results and therefore performance. Performance is established as a measure of effectiveness in terms of results. Through the effectiveness triangle, Sadler (1996) also demonstrated that performance is linked to the purpose of the process itself and to the contribution to decision-making. In the context of health impact assessment, this implies that

the effectiveness of an environmental assessment process to consider impacts on human health, is determined by the procedures followed in the assessment and can be measured in terms of the consideration of human health during the process and the contribution this has on the final decision.

Sadler (1996) also established that effectiveness of environmental assessments could be considered with respect to institutional objectives and efficient use of resources. However, these are not within the scope of this study.

3.2.3 Methods developed to evaluate the consideration of human health in environmental assessment processes

Several studies have specifically examined if health impact assessments have been successful at identifying human health impacts in the past. In Canada, Sadler (1995) surveyed environmental impact assessment practitioners and concluded that health was a neglected component of environmental assessment in Canada at that time. However, Sadler (1995) provided no additional information regarding the methodological design of his study.

Other studies identified in the literature review for this thesis have been empirical studies. In an internal report for the World Health Organization, Go (1987) reported on a draft study carried out by WHO/EURO (1986) in Denmark in 1986. Go (1987) did not provide details of specific research methods used, although it is understood that the 13 case studies were selected for evaluation. These encompassed Environmental Assessments of chemical industry projects, which, Arquiga, Canter and Nelson (1992) state, handled or manufactured known or suspected carcinogens and therefore had the potential to cause adverse health effects.

Arquiga, Canter and Nelson (1992) also report on a previous study by Canter (1990) in 1990, in the USA. Canter reportedly selected a sample of 11 Environmental Impact Statements that had been prepared between 1976 and 1986, for projects that Canter had determined may exhibit potential adverse effects (Arquiga, Canter and Nelson, 1992). For their study in 1992, which was carried out to

validate Canter's earlier study, Arquiga, Canter and Nelson (1992) selected 39 Environmental Impact Statements of federal projects from approximately 175 Environmental Impact Statements at the Environmental and Groundwater Institute library at the University of Oklahoma. The sample spanned a 20-year timeframe and was selected according to criteria that enabled coverage of as many types of projects as possible, with minimal use of draft documents. The documents were reviewed using a set of 5 questions, including whether any health impact was explicitly addressed in any part of the document and whether all potential health impacts were addressed. Questions regarding analysis type and technique were also noted. The study examined the scope of consideration of impacts on human health using categories of physical, chemical, radiological and biological hazards. Information on the methods used to determine which hazards should have been assessed is not provided in the article.

In 1996, in the UK, in a study carried out by the British Medical Association (1998), 39 Environmental Impact Statements for proposed developments that were produced between 1988 and 1994 were selected at random from a collection held at the Oxford Brookes University. Inferring from the details provided in the methods and results section, it would appear that the entire documents were reviewed for any mention of human health. The results were then grouped into common themes.

In 2000, Steinemann (2000) selected a sample of 42 Environmental Impact Statements of projects that were determined likely to have a potential for significant impacts to human health that were produced between the period of 1979 and 1996. The sample was selected so as to represent the assessment by a range of agencies, time, location and impact type. Each Environmental Impact Statement was reviewed for any mention of the phrases, "health impact", "human health", or "public health". In a second phase, a contextual analysis was carried out in cases where these phrases were identified. Site visits were undertaken as well as interviews with environmental practitioners and other participants of the process, including stakeholders. Findings were grouped in themes as determined in a critical analysis of this information. These themes included carcinogenic risks; study of single cause, single effects; and single generation versus cumulative effects.

In summary, methods used in previous studies to evaluate consideration of human health impacts appear to have been limited to interviews and simply designed reviews of documents at various levels.

3.3 Development of the Integrated Environmental Assessment framework in Canada

3.3.1 Introduction

In Canada, the environmental assessment process emerged first as a non-legislated process within the federal environmental government policy framework in Canada, and then as a legislated process. Simultaneously, Health Canada has developed a conceptual framework that regards economic developments as broad determinants of health and has issued guidelines relating to the consideration of human health concerns, that is, health impact assessment in order that these are better addressed within the current Environmental Assessment framework in Canada. These two developments and their conjunction are discussed below.

Participants in the environmental assessment process in Canada include the developer, government agencies, public, environmental assessment practitioner(s), and decision-makers (Health Canada, 1999a). The *developer* is often referred to as the *proponent* in environmental policy and governance. As discussed earlier *practitioners* are persons carrying out the assessment on behalf of the government (Health Canada, 1999a). A *panel* is a group of persons selected from the general public by the government to collectively assess a specific project proposal. The panel has an advisory role and presents recommendations to the government, which has discretionary power over these recommendations (Chambers & Winfield, 2000). Panel members are normally selected due to their expertise or familiarity with specific issues that are relevant to the project to be assessed.

3.3.2 Emergence of Environmental Assessment in Canada

Canada was one of the first countries to follow the lead of the US and establish an integrated Environmental Assessment framework. The federal Integrated Environmental Assessment framework has evolved over the past 35 years. For the first 20 years of environmental assessment, non-legislated approaches were used within the federal framework before entering federal legislation as the Environmental Assessment Review Process Guidelines Order (EARPGO 1984) in 1984 (Gibson, 2002) and later as the Canadian Environmental Assessment Act (CEEA 1995).

Under the Canadian constitution, provincial governments hold primary jurisdiction over most issues related to environment and human health, and provinces developed their own processes. Prior to the development of the federal Environmental Assessment Review Process (EARP), the province of Ontario was responsible for the introduction of the first legislated Integrated Environmental Assessment framework in Canada in 1975 (EEA 1975), which concerned policies only (Health Canada, 1999a). The other provinces followed during the 1980s with project based policies (Health Canada, 1999a). Later, in 1998 harmonization accords were signed between the federal government and the provinces that would enable joint provincial-federal reviews (Health Canada, 1999a).

Within the federal framework, impacts were initially controlled through licensing and permitting processes. Gibson (2002) observed that in 1972, the first federal environmental assessment policy was presented to parliament and recommended that federal departments screen new projects either proposed by the department or under their jurisdiction for "potential pollution effects", and refer those that were identified as likely to have significant effects to the Department of the Environment for further assessment (Federal Environmental Assessment Review Office).

In 1973, the Canadian Cabinet approved a more formal federal environmental assessment non-legislated policy that set out a detailed process that was applicable to appropriate federal government projects and projects requiring government money, land or approval. Assessments were, and still are, carried out on a self-assessment basis, that is, by the government department responsible for the project or the approval of the project. These departments are also known as the Initiating Department or Responsible Authority under EARPGO 1984 and CEAA 1995 respectively. Other formal processes included the referral of project proposals for review by public panel review if there was evidence of potential significant environmental effects or in cases that raised significant public concern (Gibson, 2002). The need for public hearings at the appraisal phase in an assessment by panel review was also established at this time. With regards to the requirements for assessment, the term *environmental effects* was defined

broadly to include social as well as environmental considerations (Gibson, 2002). The need to consider impacts on public health was not explicit at this early stage.

Gibson (2002) observed that in a second stage, between 1974 and 1977, the different federal departments came together to develop the Environmental Assessment Review Process (EARP). Public participation at an early stage in the process was introduced at this time. The prospect that EARP would become a legislated process would be considered later during 1981 and 1982 (Gibson, 2002).

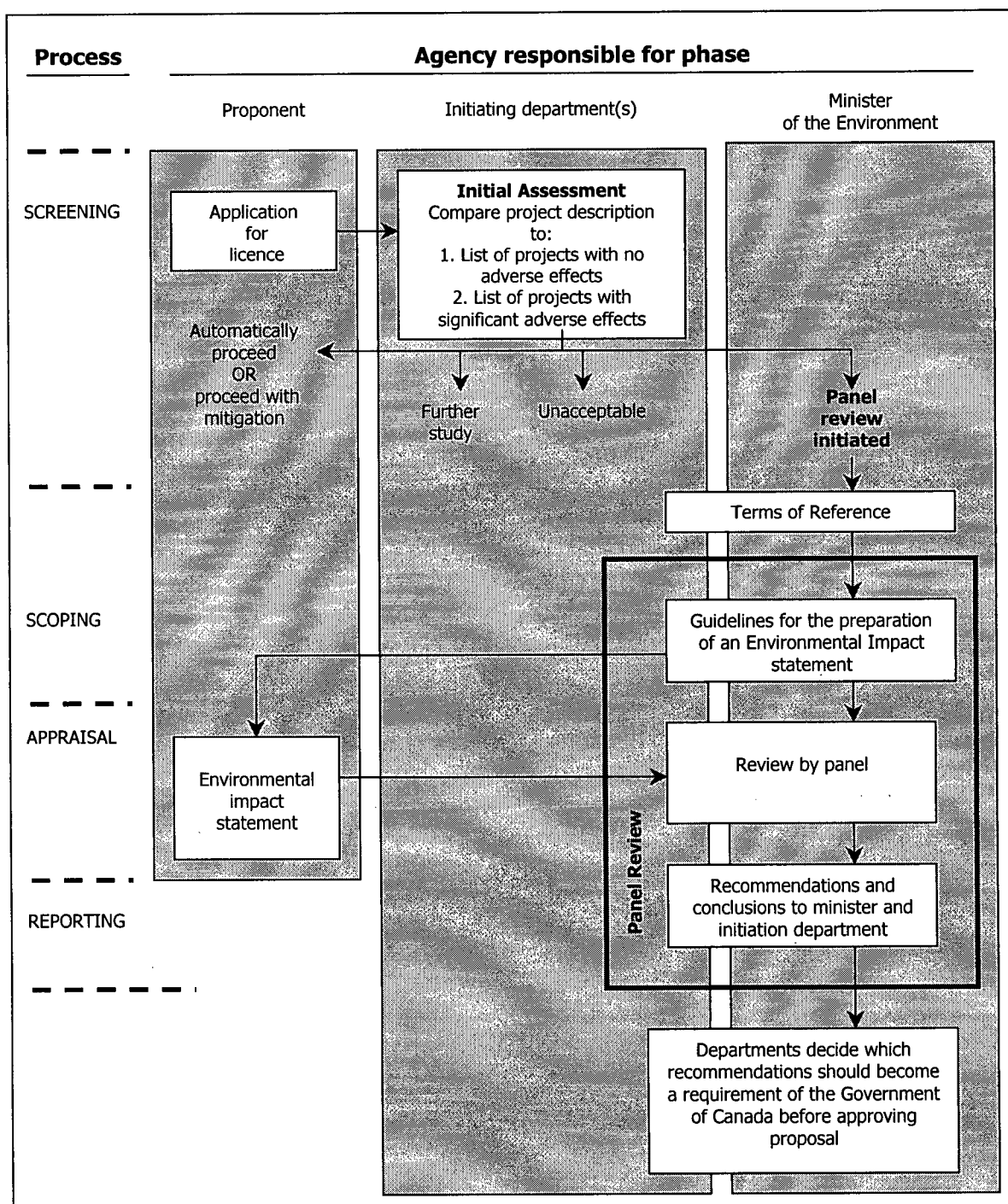
EARP entered legislation in 1984 as a Guidelines Order under the Government Organization Act and became the Environmental Assessment Review Process Guidelines Order (EARPGO 1984). However, the mandatory and legal status of EARPGO 1984 was not established until 1992 after the federal Court of Canada, federal Court of Appeal and Supreme Court of Canada ruled EARPGO legally binding (Gibson, 2002).

3.3.3 Environmental Assessment Review Process Guidelines Order (EARPGO 1984)

EARPGO 1984 (Government of Canada, 1984) required the process to be implemented as early in the planning process as possible and instructed consideration of a) the potential environmental effects of a proposal and the social effects directly related to that proposal and b) the concerns of the public regarding the proposal and its potential environmental effects of those proposals under federal jurisdiction. However, there were no definitions of environmental effects or social effects provided within the legislation, which was ambiguous with respect to human health concerns. Those projects that were either to be undertaken by a federal department, funded by the federal government or located on federal lands were all subject to EARPGO 1984. A Federal Environmental Assessment Review Office provided departments with procedural guidelines (Government of Canada, 1984).

The procedural framework that is described in the EARPGO 1984 legislation (Government of Canada, 1984) is presented as a flowchart in Figure 3.3 on the following page. The procedures involved in each step of this process are described below:

Figure 3.3. Flowchart of the process outlined in the Environmental Assessment Review Process Guidelines Order (EARPGO, 1984), illustrating responsibilities at each stage of the process



Step 1: Screening (to determine if assessment is required)

In order to determine whether an integrated environmental assessment of a proposed project was necessary, individual governmental departments were required to keep two lists, by which each proposal received or produced by the department would need to be screened. One list identified projects that would not cause "significant adverse environmental effects" and therefore would not need to be assessed and another list of projects with the potential to cause *significant adverse environmental effects*. A proposed project that matched the characteristics of projects on this list would trigger an environmental assessment at the federal level. Other departments were responsible for providing their specialist knowledge concerning the proposal, including the knowledge relating to potential impacts. At this stage it was determined whether the project would: a) automatically proceed; b) proceed with mitigation measures as conditions of approval; c) be subject to further study; d) be assessed by panel review; or 5) be deemed unacceptable (Government of Canada, 1984). Reviews by a public panel of experts were required where there was a potential for significant effects (as determined by the list or not) or where the potential for significant impacts was deemed uncertain or where public concern warranted (Government of Canada, 1984). Those projects selected for panel review were referred to the Minister of the Environment and subject to scoping where key issues would be determined (Government of Canada, 1984).

Step 2: Scoping (to identify key issues to be considered)

In conjunction with the Minister for the initiating department, The Minister of the Environment issued a Terms of Reference to the panel, which was, in turn, made available to the public. The Terms of Reference contained information relating to the major significant adverse environmental effects that would need to be expanded in the scoping phase and examined in the appraisal. The consideration of impacts to human health was discretionary under EARPGO 1984 and the panel was bound by the Terms of Reference produced by the Minister of the Environment (Canadian Environmental Assessment Agency, 1998). General socio-economic effects, technology used and need for the proposal were only to be considered after approval from the Minister of the Environment and the Minister of the initiating

department. The Minister of the Environment selected unbiased expert panel members with experience relevant to the anticipated effects (Government of Canada, 1984).

Step 3: Appraisal (Determining significance, mitigation and follow-up)

In order to carry out an appraisal, the panel could request an Environmental Impact Statement from the proponent at this stage and would issue guidelines for the preparation of the report. The panel was also able to request information from government departments, experts and the general public. The proponent would undertake tasks set by the panel, and the resultant information would be appraised together with the information provided by other stakeholders. The panel was required to hold informal public hearings to appraise each project proposal. General socio-economic effects, a technology assessment or needs assessment were needed to receive approval from the Ministers of the Environment and Initiating Department.

Step 4: Reporting (provision of information and recommendation to decision-maker)

At the conclusion of the appraisal stage, the panel was required to submit a report containing its conclusions and recommendations to the Minister of the Environment, who, with the various federal departments involved, would come together as the Government of Canada to consider the panel's report and decide whether the proposed project was acceptable and able to progress to the licensing and permitting stage.

3.3.4 Canadian Environmental Assessment Act (CEAA 1995)

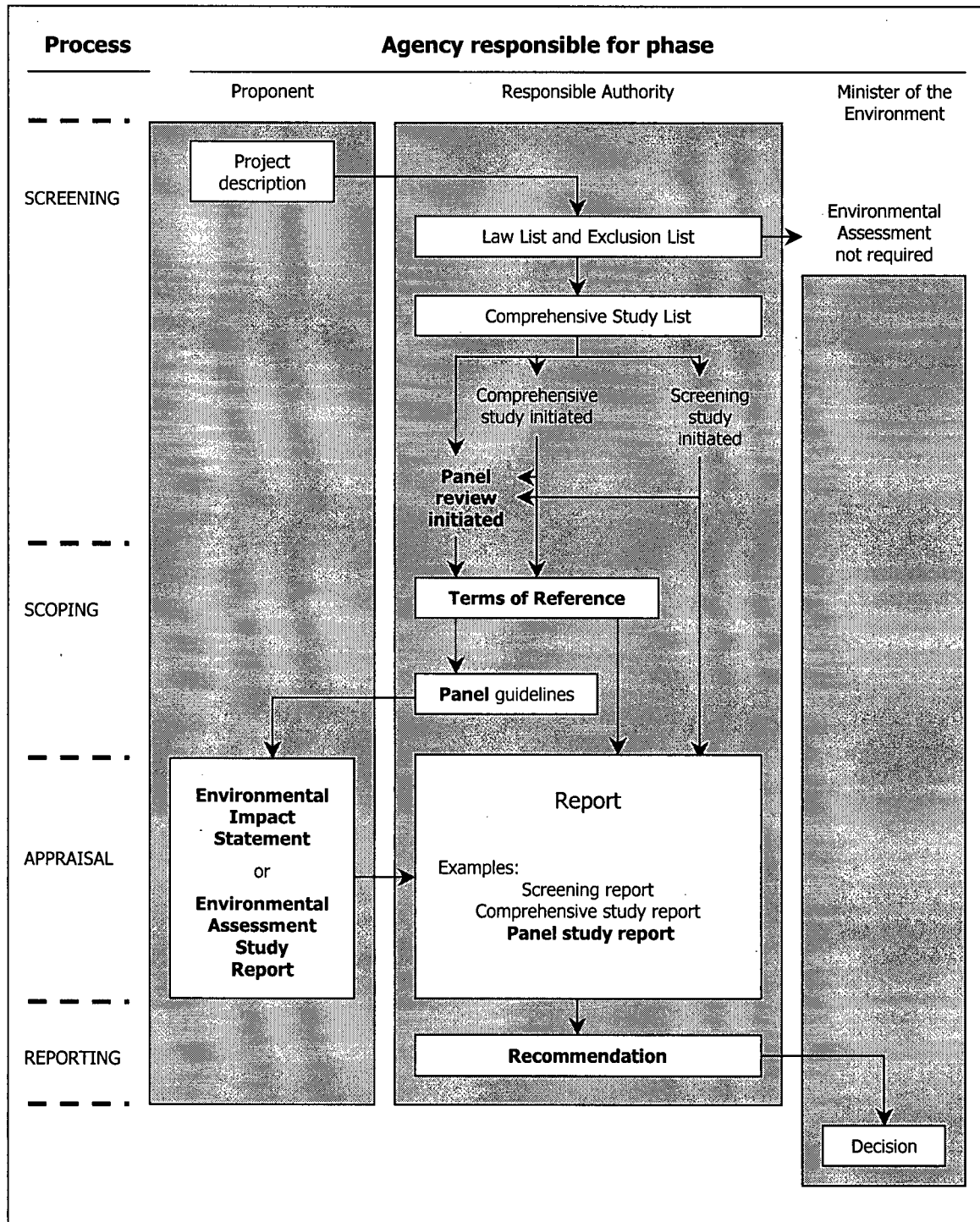
The process developed and trialed under EARPGO 1984 was updated and redefined within federal legislation under CEAA 1995. Fiscally, the overall responsibility for the federal Integrated Environmental Assessment framework remained with the federal Minister of the Environment. However, the newly formed Canadian Environmental Assessment Agency had been empowered with the coordination of the framework and responsibility for environmental assessments. The Canadian Environmental Assessment Agency promoted the environmental assessment as a planning tool to pursue the goal of sustainable

development. However, the framework also maintained a focus on the mitigation of *significant adverse environmental effects* (Gibson, 2002).

It is evident that The Canadian Environmental Assessment Act (CEAA, 1995) clarified the need for a health impact assessment with a definition of environmental effects that included "any change that the project may cause in the environment... on health." Specific determinants of socio-economic conditions, physical and cultural heritage were also included in this definition. CEAA 1995 also provided for the evaluation of needs, alternatives, cumulative effects and sustainability of projects and encouraged follow-up plans. CEAA 1995 also made provisions for participant funding (Gibson, 2002).

The procedural framework of the environmental assessment process described in the CEAA 1995 legislation (Government of Canada, 1992) is presented as a flowchart presented in Figure 3.4 on the following page and is outlined on the following pages:

Figure 3.4. Flowchart of the process outlined in the Canadian Environmental Assessment Act (CEAA 1995), illustrating responsibilities at each stage of the process



Step 1: Screening (to determine if assessment is required)

Under CEAA 1995, the two lists that were held by the various government departments under EARPGO 1984 to determine whether an assessment was necessary were replaced by the Inclusion List regulations, which was a list of applicable federal Acts. Some of these Acts indirectly concern human health outcomes such as the Indian Act, National Energy Coal Board and the Canadian Environmental Protection Act. The Comprehensive Study List regulations were implemented to systematically detect those projects requiring a comprehensive study rather than a review at a less intense screening level. In the case of mining and mineral processing projects, the Comprehensive Study List regulations used, and still uses, commodity mined (e.g. coal) and daily production rate (e.g. 3000 tonnes per day) to indicate the potential level of significance of a proposed project. This is evidence that a surrogate indicator of magnitude and possibly severity has been used to determine which projects should be considered at a comprehensive or panel review level. Projects reviewed at the screening level or in a comprehensive study could be referred to the Minister of the Environment for panel review at any stage in the process if intense public concern surrounded a project proposal or in cases of high uncertainty. A federal department other than the Minister of the Environment could take responsibility for a panel review and was referred to as the Responsible Authority. Coordination of the process was now provided for by the Canadian Environmental Assessment Agency who worked in conjunction with the Responsible Authority to prepare a Terms of Reference, which technically is part of the scoping phase as key issues are identified here.

Step 2: Scoping (to identify key issues to be considered)

Screening studies, comprehensive studies and panel reviews each involved different methods and intensities of scoping. In the case of a panel review, the expert panel established operating procedures for the appraisal stage and could choose to issue guidelines for the preparation of an Environmental Impact Statement. Under CEAA 1995, the panel was no longer bound by the Terms of Reference and was able to expand the Terms of Reference if it was deemed necessary. CEAA 1995 also required the

panel to extend an invitation to the general public to comment on proposals at this stage. In the case of a comprehensive study, the Responsible Authority would carry out the scoping exercise.

Step 3: Appraisal (Determining significance, mitigation and follow-up)

The opportunity for public comment at the appraisal stage became mandatory under CEAA 1995. In the case of a screening or comprehensive study, the Responsible Authority would carry out the appraisal. The procedures for review by a public panel remained similar to those in EARPGO 1984 except that the panel could request "information from the proponent" rather than an "Environmental Impact Statement." This might suggest that the role of proponent had been clarified as an information provider rather than appraiser. However, it is possible that change was made in order to avoid confusion with terminology used in the USA.

Step 4: Reporting (provision of information and recommendation to decision-maker)

As in EARPGO 1984, at the conclusion of the appraisal stage, the panel was required to submit a report containing its conclusions and recommendations to the Minister of the Environment, who with the various federal departments involved would come together as the Government of Canada to review the panel's conclusions and recommendations to decide whether the proposed project was acceptable and able to progress to the licensing and permitting stage. In a similar manner, in the case of screening and comprehensive studies, the environmental assessment practitioners would provide the minister of the Responsible Authority with a report and recommendations in order for a final decision to be made.

3.3.5 2003 Amendment to the Canadian Environmental Assessment Act (CEAA 1995)

In 2000, a five year review of the CEEA was initiated and examined efficiency, quality of assessment and public participation (Gibson, 2002). Then, in 2003, an amendment to the Canadian Environmental Assessment Act brought new developments and clarity to the framework. Class screening, where specific certain projects are subject to a predetermined scope, was introduced for those projects where model projects have been defined (Canadian Environmental Assessment Agency, 2003).

Proposals with potentially significant effects now commence at the comprehensive study level and after a specific time period has elapsed, the comprehensive study is reviewed. At this point, a mediation process or panel review can be initiated if necessary (Canadian Environmental Assessment Agency, 1994). The mediation process was introduced for those cases where monetary exchanges between communities and proponents are thought likely to resolve public concern (Canadian Environmental Assessment Agency, 2004). The need for consideration of impacts on human health and sustainable development as an overall goal is emphasized in the guidelines published on the Canadian Environmental Assessment Agency website (Canadian Environmental Assessment Agency, 2004).

3.3.6 Canadian Handbook on Health Impact Assessment

Health Canada (1999a) reports that after the adoption of the Determinants of Health framework by the Deputy Ministers of Health from all levels of government in Canada, efforts to enhance health impact assessment in the environmental assessment process were initiated by the Federal, Provincial, Territorial Committee on Environmental and Occupational Health (CEOH). The committee established the Health Impact Assessment Task Force in 1992, which consisted of federal and provincial representatives from the Ministries of Health, Labour and Environment (Health Canada, 1999a). The committee provided the Task Force with guiding principles as to the approach and scope of health impact assessment and provided a mandate to produce guidance materials for the various participants in environmental assessment processes (Health Canada, 1999a). This Health Impact Assessment Task Force held a series of workshops between 1995 and 1996, in which it was able to develop an understanding of the needs of the various stakeholders (Spiegel & Yassi, 1997). As a result of this work, in 1999, generic guidelines were published in the Handbook on Health Impact Assessment (Health Canada, 1999a; 1999b; 1999c). The Canadian Handbook on Health Impact Assessment was published as three volumes that inform those parties involved in the environmental assessment process of the role of health impact assessment in the environmental assessment process. In 1999, Volume I (Health Canada, 1999a) was fully published. Volumes II (Health Canada, 1999b) and III (Health Canada, 1999c), which are focused on the different levels of government agencies that may be either consulted prior to or during an environmental

assessment or involved as decision-makers and health impact assessment practitioners (e.g. consultants for developers) respectively, remained in draft format until November 2004.

In 1996, Sadler (1996), who had been commissioned by the Canadian Environmental Assessment Agency and the International Association of Impact Assessment to carry out an international study on the effectiveness of environmental assessment, surveyed a number of environmental practitioners in Canada and, as discussed earlier, concluded that the consideration of health impacts was lacking in this country. An unpublished version of Sadler's 1996 study (Sadler, 1996) and an article by Slooff (1995) that reported on the concern raised during the Commonwealth Secretariat Expert Group Meeting held in Aberdeen, Scotland were stated as the rationale for his study.

4. LITERATURE REVIEW: THE DEVELOPMENT OF MINING PROJECTS IN CANADA AND ITS EFFECTS

4.1 Mining projects

4.1.1 Introduction

Mining projects are one of many industrial activities that contribute to the economic life of Canadian and global society. Mining projects vary in scope of activities carried out but all follow the same basic lifecycle. Environmental assessments commonly occur prior to the exploration phase or operation phase.

4.1.2 Mining as an economic development

An economic development can be defined as the construction of a project from which to produce, consume and distribute goods and services (Centre for Alternative Development Initiatives, 2003), which are offered in order to increase the quality of life of owner, worker, consumer and nation. However, while positively contributing to the economic health of a nation, the physical presence of the project may also affect the local environment and populations in its vicinity. Effects on the natural and human environments may affect different population groups both negatively and positively in varying degrees and modes. Impacts of mining on worker health and the health of those in adjacent communities have been summarized by Stephens and Ahern (2001). The respective populations or stakeholders, who likely have some contrasting concerns, include workers, communities, vulnerable populations within communities, representatives of the natural environment, industry and government.

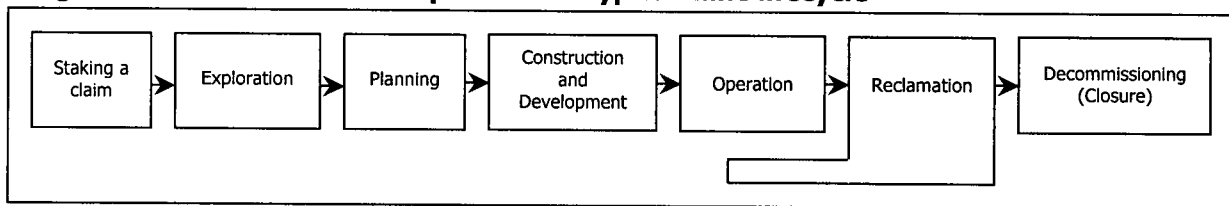
4.1.3 Description of the activities of the mining industry

Economic developments are classified by activity into industries, of which the mining industry is one example. The mining industry is concerned with the extraction and if necessary, concentration and smelting of minerals from an economically viable mineral deposit. Mining can involve both metal and non-metal mineral deposits and includes quarrying activities. Surface mines and underground mines are common mining methods.

4.1.4 Lifecycle of a mining project

Mining projects follow a lifecycle of seven fiscal phases: staking a claim, exploration, planning, construction and development, operation, reclamation, decommissioning and closure; illustrated in Figure 4.1 below. The activities that occur within each phase are not necessarily determined fiscally. Mining activities may occur over one or more phases and the phases in which they occur may differ between any two mining projects. For example, an underground mine would usually be expected to include the development of a mine shaft in the construction and development phase, however, a mine that commences with open pit extraction and progresses underground at a later date may plan for the shaft sinking activities to take place after mine production has started, that is, during the operation phase. Additionally, phases do not necessarily occur sequentially but are often concurrent. For example, activities pertaining to the reclamation phase often occur during the operation phase.

Figure 4.1. Illustration of the phases in a typical mine lifecycle*



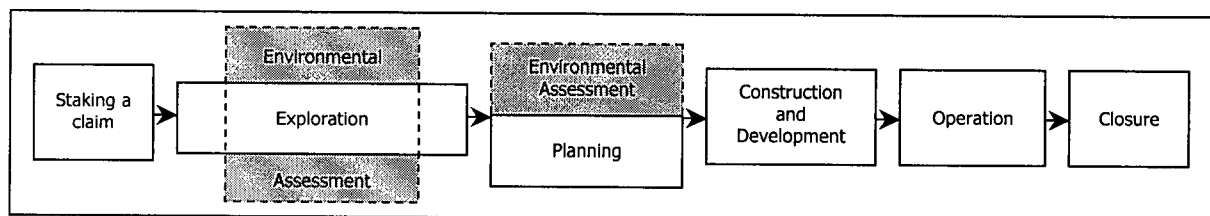
*adapted from Marbek Consultants (1998)

As the characteristics of the orebody determine many of the activities that are carried out in a mining project, any two mines may differ in activities. For example, a large disseminated low grade pyritic gold orebody may be economically mined as a surface operation with cyanide leach operation whereas a low grade vein deposit without pyritic mineralization may be mined as an underground operation with a non-cyanide extraction process.

The mining industry is subject to cyclic markets and performance fluctuates as metal and other commodity prices rise and fall. Mining projects are planned with a life of mine, which is determined by the results obtained during the exploration phase (Godoy, 1985). However, the predictions for life of mine are rarely accurate and can be shortened or exceeded due to loss or gain of economic value of the

orebody respectively (Godoy, 1985). Due to the uncertainty of the economic value of an orebody during the early stages of the mining lifecycle, mining projects commonly have two potential phases of environmental assessments. One phase is prior to significant exploration activities such as a test mine and another takes places at the planning stage prior to construction and development of a mining operation. The relationship between the mining lifecycle and the environmental assessment process is illustrated in Figure 4.2 below.

Figure 4.2. Illustration of the phases in a typical mine lifecycle and potential for an environmental assessment*



*adapted from Marbek Consultants (1998)

4.2. Size of the mining industry in Canada

4.2.1 Introduction

Canada is a resource rich country, with many remote areas remaining unexplored and unexploited. Many of these remote areas lie in Canada's North, where there is little precedent of industrial activity.

Currently, there are plans for the growth of mining activities in many provinces and territories in Canada, which highlights the relevance of this study.

4.2.2 Mining industry in Canada

Natural Resources Canada (NRCAN) (2005) reported that 190 mines and over 3000 quarries were operational in Canada at the start of 2004. All Provinces and Territories except Prince Edward Island have significant mining activities (Winfield, Kaufman, & Whorely, 2000). Economically important minerals in Canada include coal, diamonds, gold, iron ore, magnesium, nickel, potash and uranium (Natural Resources Canada, 2005).

Mining has an important role in the Canadian economy (Natural Resources Canada, 2005). During 2003, mining industry contributed \$41.1 billion (4.1% of the National Gross Domestic Product) to the Canadian economy (Natural Resources Canada, 2005) and employed 47 000 people. The industry also contributes to the economy indirectly by providing many of the raw materials for domestic manufacturing industry (Natural Resources Canada, 2005).

4.2.3 A growing mining industry in Canada

Mining activity is set to rise in Canada. Strategies for increased exploration, development and long-term sustainability of mining activities are either in place or in discussion in many areas in Canada. Evidence of this includes the work of the Industry-Government Overview Committee (IGOC) that was set up to examine ways of improving the mining investment climate in the 3 territories in Canada (Mining Association of Canada, 2005). Mining activity is also predicted to grow in British Columbia (Government of British Columbia, 2005). In Alberta, predicted oil sand production will triple to over 3,000,000 million

barrels per day by 2020 (Government of Alberta, 2005) due to the increasing economic viability of these mines. In addition to Alberta, Ontario is forming a strategic plan to sustain economic development in this province (Government of Ontario, 2005). In this strategic plan, the Government of Canada (Government of Ontario, 2005) predicted the movement of exploration and development to the less explored, and therefore mineral rich, North of Canada, which is remote and largely populated by Aboriginal peoples.

4.3. Federal jurisdiction and guidelines for the environmental assessment framework for the mining industry in Canada

4.3.1 Introduction

Although resource development is predominantly the responsibility of the provincial governments, there are some cases in which the federal government does retain partial or total responsibility for the environmental assessment of proposed mining project. The federal government also has a generic role in providing guidance and has produced draft guidelines with respect to the environmental assessment and health impact assessment of mining projects.

4.3.2 Federal jurisdiction over mining projects

In Canada, the provincial governments are chiefly responsible for regulating mining activities as they have jurisdiction over natural resources. However, the Canadian federal government has powers that may apply directly or indirectly to mining activities as well. Relevant Acts include the Fisheries Act, Parks Act, Indian Act and National Energy Board Act. Under the National Energy Board Act, all aspects of uranium mining whenever it may occur are subject to the regulatory authority of the federal government, specifically the Canadian Nuclear Safety Commission, which was formerly known as the Atomic Energy Control Board. The federal government retains responsibility for resources on federal lands found within the provinces and in Yukon and Northwest Territories. Under the Mackenzie Valley Resource Management Act (Government of Canada, 1998) the Mackenzie Valley Environmental Assessment Review Panel is responsible for environmental assessments in this sector of the Northwest Territories. Resources within Nunavut are controlled with resource management agreements under the Nunavut Agreement.

4.3.3 Guidelines for the environmental assessment of mining projects

Marbek Consultants (1998) prepared a "test version" document for Environment Canada, the Canadian Environmental Assessment Agency and Natural Resources Canada providing guidelines for the fulfilment of information requirements for federal environmental assessment of mining projects in Canada. The

document indicated the need to consider biophysical and social impacts on human health and well-being in the case of federal assessments and some provincial assessments as dictated by the relevant legislations. The draft volume II of the Canadian Handbook on Health Impact Assessment (Health Canada, 1999b) offers examples of human health impacts of gold mining operations. As explained above, the Canadian Handbook on Health Impact Assessment is intended to guide environmental assessments of all economic developments including mining projects.

4.4. Developments in environmental impact assessment in Canada

4.4.1 Introduction

Mining projects are commonly subject to controversy. In the past, some controversy has been directly related to human health effects. Internationally, the mining industry has taken initiatives to examine human health issues. In Canada, it is not evident that the industry has addressed human health issues explicitly. However, these issues may be addressed in the confidential Impact and Benefit Agreements that are drawn up between a developer and local Aboriginal groups prior to the development of a mining project in Canada.

4.4.2 Controversy over mining projects

This controversy over mining projects has included concern for the impact of mining projects on human health as well as to the natural environment (Young, 1997). Stephens and Ahern (2001) also acknowledged controversy in this field, noting that the mining industry, mine worker and mining communities are often in disagreement over the real health impacts of the sector. Examples of public controversy can be found on the *Mines and Communities* website (Mines and Communities, 2005) that acts as a forum for mining communities and concerned persons worldwide in which to discuss biophysical and social impacts of mining operations. Regional organizations that raise concern with respect to both environmental and human health issues include the Canadian Arctic Resources Committee (Canadian Arctic Resources Committee) and MiningWatch Canada (2005).

4.4.3 Initiatives by the mining industry

Promoted by the Mining Association of Canada, the Whitehorse Mining Initiative (Whitehorse Mining Initiative Leadership Council, 1994) brought many stakeholders together in an effort to discuss the potential for a socially, economically and environmentally sustainable, and prosperous mining industry in Canada that is underpinned by political and community consensus. As a result, the Mining Association of Canada became the first national mining body to adopt an environmental policy (Young, 1997). However, none of these initiatives were explicit in their goal to address human health concerns.

On a global level, in a commitment to sustainable development, a group of prominent mining companies initiated the Global Mining Initiative (2000) to explore the future role of the mining industry. At the end of the two year Global Mining Initiative, the Metals and Minerals Sustainable Development Project (International Institute for Environment and Development, 2005), an independent research program coordinated under the World Business Council for Sustainable Development, was set up to research the possibilities for a sustainable mining policy. The Mining, Minerals and Sustainable Development project provides the first evidence that human health had been explicitly addressed within the discussion forum of the mining industry. Stephens and Ahern (2001) and Jennings (2001) are just two examples of the studies commissioned that analyzed the impact of mining operations on the health and well-being of workers and mining communities.

4.4.4 Impact and Benefit Agreements (IBAs)

Impact and Benefit Agreements (IBAs) are confidential agreements that are drawn up between project developers and local Aboriginal communities prior to a mine development. IBAs are outside of the environmental assessment process (Robinson, 2006) and were initially directly related to land-rights issues and the right to self-determination of Aboriginal peoples. This has changed over time as Aboriginal groups without land claim have also entered IBA processes. Galbraith and Bradshaw (2005) indicate that IBAs have emerged from Environmental Agreements and Socio-Economic Agreements, which have set out conditions for monitoring and assured later evaluation of a project and have been drawn up between proponents, affected Aboriginal populations and governments at the conclusion of some (e.g. NWT Diamonds project) environmental assessment processes. There are no legal requirements for mine developers to participate in Impact and Benefit Agreements. However, there is a precedent in the petroleum industry (Armitage, 2005); Canada Benefits Plans are required under the Canadian Oil and Gas Operators Act (Robinson, 2006). After entering negotiations with local aboriginal communities located close to the proposed Voisey's Bay project site, Inco Limited (1997) stated that the negotiation of Impact Benefit Agreements has become a standard process that Canadian mining companies follow as part of the development of new mines near Aboriginal communities.

Information on the content of Impact and Benefit Agreement is sparse and inconclusive as unlike environmental assessments specific information in the IBAs is not in the public domain. This is due to the confidentiality of the agreements. However, some mine developers have provided insights into the topic. The proponent for the Voisey's Bay Mine and Mill project, Inco Limited (1997), stated that issues that may be negotiated include the protection of Aboriginal social and cultural values; education, training and employment; health and safety; and business opportunities amongst others. Armitage (2005) reported lifestyle and land rights, human health issues and sustainable development as important values held by the Aboriginal groups in the Mackenzie Valley of the Northwest Territories. Also, if IBAs are community driven then it seems likely that these values may be addressed. These issues somewhat overlap those reported by Inco Limited.

Armitage (2005) indicated that IBAs provide for the rights of Aboriginals in land claimed areas to share both the benefits of resource extraction and decision-making capabilities. Armitage (2005) also noted that IBAs have been made with Aboriginal groups where settlements have not been made but was unsure what the role of IBAs is in these instances. Sosa and Keenan (2001) stated that IBAs are negotiated for different reasons and in addition to land claims and Aboriginal rights on the part of affected communities, IBAs may be required, albeit not explicitly in legislation, by a government and most often in cases where land claims are outstanding.

Sosa and Keenan (2001) also viewed IBAs somewhat as a private sector initiative, describing how mining companies may use IBAs to reduce social risk and secure an economically viable labour force where projects are in isolated regions. This said, the lack of legal requirement might demonstrate an initiative on behalf of the mining companies to address important issues that may not be addressed at the level of environmental assessment.

Both Sosa and Keenan (2001) and Galbraith and Bradshaw (2005) have inextricably linked Environmental Assessment and IBA processes. Sosa and Keenan (2001) commented that it is believed that IBAs have become a *de facto* requirement of the Environmental Assessment process in the case of mining project and in this way governments are effectively transferring responsibility and costs to the mining company. However, in an examination of the rationale for IBAs, which included a systematic review of documentation and interviews with government and Aboriginal participants, Galbraith and Bradshaw (2005) concluded that IBAs complement the environment assessment process as they have arisen from specific deficiencies in the environmental process and are used to: ensure follow-up measures that are established in the environmental assessment are actualized; facilitate trust between the affected communities, mining company and government; address issues that are valued by a community that have not been addressed in an environmental assessment; and lastly, equalization of capacities of mining company and community. It is therefore evident the IBA process adds a degree of complexity to the environmental assessment of mining projects and raises questions as to the issues considered in the agreements, the effectiveness of environmental assessment and consequently the implications of the confidentiality of these agreements.

5. METHODS - OVERVIEW

5.1 Introduction

As a detailed retrospective analysis of four case studies, this thesis examines how environmental assessments have actually been carried out. This is in contrast to conceptual and abstract examinations essentially describing how impact assessment processes are ideally conducted [e.g. Ugoretz (2001) Mulvihill (2003), de Bruijn and ten Heuvelhof (2002), Wilkins (2003), Gibson (2002)]. The adequacy of how health factors have been considered during the environmental assessment process and at the decision-making phase is examined using the documents that were produced at both phases in each selected case. Health factors are analysed in the context of the *Health Impact Assessment Evaluation Tool* that has been developed as part of this study. Insights into the procedures that were followed in order to identify the health factors, details of the conclusiveness of the consideration and the degree of consensus regarding the relevance of the health factors to the mining project, are used to gain a contextual understanding of any shortcomings. The cases selected for this study are a 100% sample of mining project proposals that were reviewed by public panel under federal or part-federal responsibility in Canada and initiated since 1984 but prior to the 1999 publication of the Canadian Handbook on Health Impact Assessment.

5.2 Basic approach

The analysis is based primarily on documentation that has been produced as a record of formal environmental assessment processes. The effectiveness of health impact assessment of each case study assessment is evaluated in two ways, with regard to: 1) scope of health impacts considered and 2) the use of this knowledge in the final decision.

In an initial stage, evidence of how scientific knowledge is applied in the health impact assessment of mining projects was examined noting each omission to consider identified health factors or any lack of consensus regarding the applicability of the health factor. The number of published studies in specific areas is used to demonstrate the focus afforded to different types of health impacts in health science

literature, with regards to specific impacts of the mining industry. The level of consideration (see section 5.4.4) is also used as a measure of effectiveness, as this may coincide with a lack of consensus or at least may influence the way the decision-maker may treat the information. The consideration of health impact assessment at the decision-making stage is evaluated with respect to the scope of health impacts identified in the panel's report, as this is representative of the decision-makers' role.

These results allow for a discussion of the procedural challenges that occurred in the case studies and the potential effectiveness of the Canadian Handbook on Health Impact Assessment to overcome these challenges and provide meaningful guidelines so that the health impacts of mining operations are adequately assessed in the future.

5.3 Study scope, definitions and assumptions

5.3.1 Focus of the study

This study is carried out in the context of assessing impacts on human health. No consideration was given to consideration of impacts on the natural environment. Health impacts are defined as those health factors that are discussed with respect to a physical, mental or spiritual health outcome, recognizing that outcomes may be either positive or negative. No distinction is made between Aboriginal and non-Aboriginal issues.

5.3.2 Definition of a health factor

A *health factor* is a social or environmental factor that a person may be exposed to and is potentially associated with a health outcome. Those exposures that occur in the physical environment are traditionally the focus of the occupational and environmental hygiene field of study. However, this study also takes into account exposures that may occur in the social environment.

For the purposes of this thesis, a health factor is either explicitly considered with respect to a human health outcome (e.g. mercury emissions affecting persons who eat contaminated fish downstream) or inherently associated with a human population (e.g. occupational exposure to silica). In another example, an inclusive statement "emissions of silica particulate" would not be identified as a health factor in this study since it is not explicit in the evidence that effects on a human population have been considered.

Health factors occurring in the physical environment are the focus of the occupational and environmental hygiene field of study. Health factors occurring in the social environment, which do not correspond to any particular field of study, are also considered in this thesis.

5.3.3 General health references

General health references are defined here as general statements about health that are explicit in the consideration of human health but cross general impact categories, as found in the *Health Impact Assessment Scope Evaluation Tool* (see section 5.4.2). In this thesis, general health references are treated similarly to health factors and may include discussion of occupational health and safety regulations and statements of intent to comply with these regulations.

5.3.4 State of knowledge and uncertainty

Since the environmental assessment process is carried out within the context of considerable uncertainty, *state of knowledge* refers to all those suspected health factors and impact pathways that have been identified in the scientific literature in relationship to a human health outcome, whether or not an association or causal relationship has been firmly established. As such, the state of knowledge of health impacts of mining projects is assumed to be a subset of the general body of health science literature.

The failure to consider potential health impacts is considered with respect to both panel appraisal and the proponent's appraisal. Evaluation of both the proponent's and panel's appraisals is included in this study as it is recognized that the panel may have given specific instructions to the proponent with respect to the analysis of a health factor, which may not have been as thoroughly addressed in the panel's final report. It is also recognized that the proponent may have contributed its own expertise and included information that was not requested by the panel, which may or may not be considered by the panel. It is also understood that the decision-makers may have considered some parts of the proponent's assessment in addition to the panel's report. However, because the government is accountable only for a response to the panel's report and recommendations, the scope of health factors considered in the panel report was used to evaluate the impact on decision-making.

5.3.5 Definition of the mining industry

Mining projects are those that involve the extraction and/or processing of minerals, including quarries. Distinct exploration projects, smelting and refining operations are excluded from this study.

5.3.6 Environmental Assessment documentation

The formal documents reviewed in relation to the environmental assessment process included the following:

- Terms of Reference presented to the panel by the government agency responsible for the specific environmental assessment process, after a second scoping exercise;
- Terms of Reference presented to the proponent by the panel, after an initial scoping exercise;
- Proponent's report produced from the appraisal step;
- Panel's report produced from the appraisal step after considering the proponent's findings in public hearings and;
- Provincial and/or government response documents from the decision-making step

Peer-reviewed literature was also used as a source of evidence. The documents used in this research are listed separately as *case study documentation* in the references section at the end of this thesis.

5.4 Development of a tool to measure the scope of consideration of health impacts

5.4.1 Introduction

The *Health Impact Assessment Scope Evaluation Tool* has been developed as part of this study to measure the scope of health factors identified a mining project, while providing a visual snapshot of the scope of a health impact assessment. The tool integrates appropriate attributes of the mining lifecycle, impact pathway and broad determinants of health that are linked through an impact chain to allow a comprehensive evaluation of the scope of health impacts considered. As such, the tool allows the consideration of health factors to be evaluated with respect to broad categories of health impacts, termed *broad impact categories* in this study. The tool can be used to obtain either generic or phase-specific insights into the identification of health factors in an environmental assessment process.

5.4.2 The Health Impact Assessment Scope Evaluation Tool

The *Health Impact Assessment Scope Evaluation Tool* developed for this study is able to provide a visual snapshot of a health impact assessment and is introduced in Table 5.1 on the following page as a framework for conducting phase-specific evaluation. The tool essentially demonstrates the scope of consideration of *broad impact categories*. Attributes of the *broad impact categories* are integrated within each other. *Impact pathway* (Spiegel & Yassi, 1997) (see below) is integrated within broad determinants of health (Federal, Provincial and Territorial Advisory Committee on Population Health, 1994), which in turn are integrated within *environment type* (physical or social). *Hazard type* is integrated within the direct exposure and ecosystem mediated exposure pathways, which are integrated within workplace and community biophysical environments. The tool can be used in a generic format to identify *broad impact categories* considered in a case study or can be used to measure this scope with respect to mining lifecycle. The different categories that have been selected to measure the consideration of human health impacts are discussed below.

Table 5.1. A phase-specific Health Impact Assessment Scope Evaluation Tool. The tool is designed to demonstrate the scope of health factors considered in a health impact assessment of a mining project

Broad impact category		Consideration of lifecycle phase			
ENVIRONMENT TYPE		Construction and Development (C)	Operation (O)	Post closure (PC)	Generic (G)
Broad determinant of health					
Impact pathway	Hazard category				
PHYSICAL ENVIRONMENT					
Occupational (workplace)					
Direct exposure pathway	Safety hazards				
	Physical hazards				
	Ergonomic hazards				
	Chemical hazards				
	Biological hazards				
Ecosystem mediated pathway					
Direct employment and income pathway					
General community pathway					
Environmental (affected community)					
Direct exposure pathway	Safety hazards				
	Physical hazards				
	Ergonomic hazards				
	Chemical hazards				
	Biological hazards				
Ecosystem mediated pathway					
Direct employment and income pathway					
General community pathway					
SOCIAL ENVIRONMENT					
Employment and working conditions					
Direct employment and income pathway					
General community pathway					
Social support networks					
Direct employment and income pathway					
General community pathway					
Income and social status					
Direct employment and income pathway					
General community pathway					
Other broad determinants					
Direct employment and income pathway					
General community pathway					

Lifecycle

Go (1987) had drawn attention to the importance of considering the complete lifecycle of an economic development while addressing the methodological issues of health impact assessment. Three phases are determined to be relevant for this study. The *construction and development phase* and *operation phase* are selected due to their different activities that may impact populations in different ways. *Post-closure* is selected to observe if long-term health factors that continue beyond the mine life are assessed. Since it is possible that specific phases are not explicitly considered in a health impact assessment, a category for generic non-phase related statements has also been established.

Impact Pathway

The terminology used in the Spiegel and Yassi (1997) framework has been adapted in order to ease the distinction between the various descriptors relating to health impacts used in this study. The four impact pathways defined by Spiegel and Yassi (1997) are redefined as: 1) direct environmental exposure pathway, 2) ecosystem exposure pathway, 3) direct employment and income pathway and 4) indirect community pathway, in order to ease the distinction between the various descriptors relating to health impacts used in this study. The complete adaptation is illustrated in Table 5.2 below. Note that pathways three and four distinguish between workers and their families and other community members and not between worker and affected community. The definitions originally described by Spiegel and Yassi (1997) are presented in Table 3.1 in section 3.1.4.

Table 5.2. The four pathways of health impacts of mining developments* for use with the Health Impact Assessment Scope Evaluation Tool

Pathway 1	Direct exposure pathway: Direct exposure to physical, chemical, biological and ergonomic hazards among workers, local residents their respective second generations. e.g. noise, coal particulate in air, parasites in drinking water, prolonged sitting
Pathway 2	Ecosystem mediated exposure pathway: Exposure to hazards through changes in the ecosystem among local residents e.g. heavy metals in consumed fish
Pathway 3	Direct employment and income pathway: Exposures associated with direct participation of individuals employed at the mine and their immediate family e.g. workload, supervision, wages, prolonged separation,
Pathway 4	Indirect community pathway Exposures that contribute to the overall impact of the whole community, not just the mine employees and their families e.g. indirect and induced employment, overall income, decrease in fish stocks available to community

*adapted from Spiegel and Yassi (1997)

Broad determinants of health

The determinants of health model that was examined by the Federal, Provincial and Territorial Advisory Committee on Population Health (1994) specifies nine categories: social support networks; employment and working conditions; physical environment; education; healthy child development; biology and genetic endowment; health services; personal practices and coping skills; income and social status. For this study, the physical environment determinant is dichotomized into the workplace and affected community to distinguish between occupational and environmental exposures.

Environment type (physical and social)

Differentiating between physical and social environment helps illustrate the two purposes of health impact assessment: 1) to prevent adverse health effects resulting from biophysical impacts in the physical environment and; 2) to balance positive and negative social health factors.

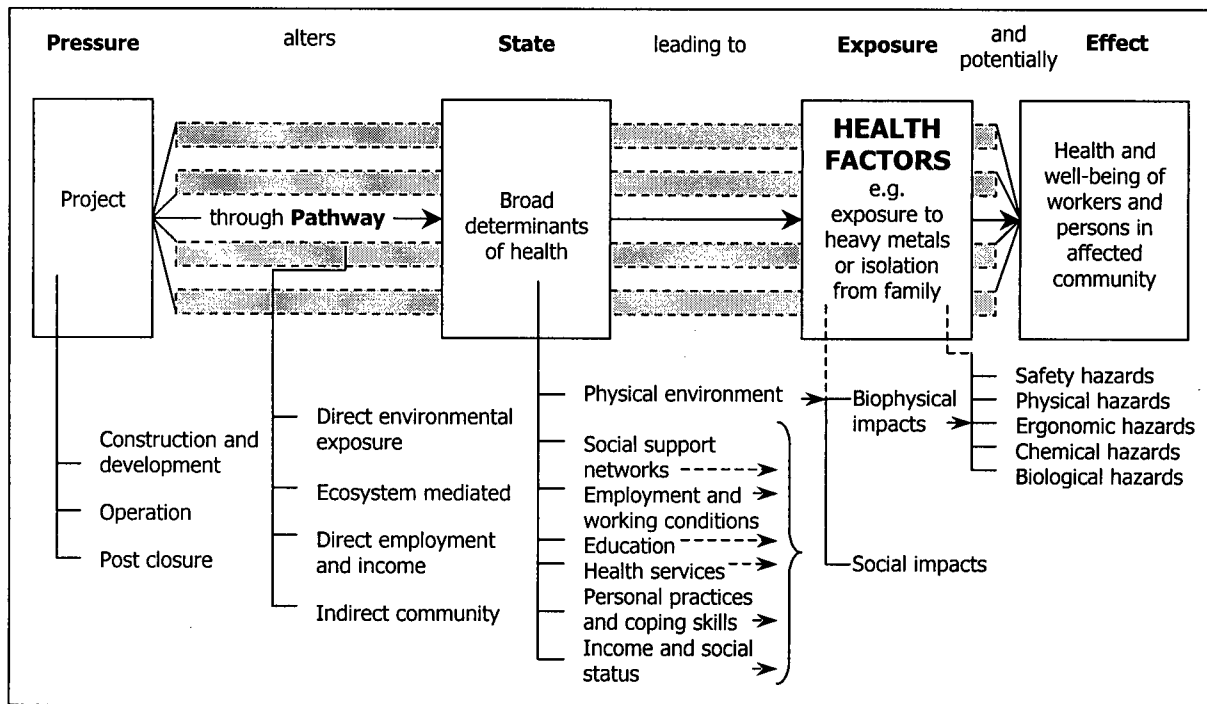
Hazard type

Whether in the workplace or in the environment, biophysical impacts can be subdivided into various categories of hazards. Those selected for this study are the safety, physical, ergonomic, chemical and biological hazard categories. For ease of use, all particulate matter is included in the chemical hazard category. In this study all radiological hazards are only classified as chemical hazards, since the multiple properties of these hazards (physical, chemical) would otherwise lead to multiple classifications.

5.4.3 Mapping the relationship between mining projects and effects on human health

The relationship between these impact categories outlined above can be illustrated by merging the different concepts together in the context of the DPSEEA (Driving force, Pressure, State, Exposure, Effect and Action) framework (Kjellstrom & Corvalan, 1995). The mining project is the pressure that impacts human health through different pathways. The broad determinants of health can be considered states that are altered through these pathways due to this pressure. Health factors, to which workers and affected community members are exposed, are linked to the exposure category. The result of this mapping exercise is illustrated in the *Map of human health impact relationships of a development project* in Figure 5.1 on the following page.

Figure 5.1. Map of human health impact relationships of a development project



5.4.4 Criteria to evaluate consideration of health factors

In order to maintain consistency across different kinds of health factors and across all four case studies, objective definitions were adopted. This also helped to ensure that I applied the same approach while reviewing the different documents from each case study.

Level of consideration

In a prior examination of environmental assessment documentation it had become evident that health factors are not necessarily acknowledged as potentially significant or examined as fully as they could have been, which may leave the decision-maker or other reader uncertain as to whether the health factor was applicable to the proposed project or not. In order to assess the thoroughness of how health factors have been taken into account, three categories were formed: complete, partial and proponent only. The definitions of these categories and examples of evidence are presented in Table 5.3 on the following page.

Table 5.3. Categories of level of consideration, definitions and types of evidence

Category	Definition	Types of evidence
Complete	Conclusive discussion regarding relevance of health factor or a general health reference in panel report	Conclusive positive or negative acknowledgement of health factor
Partial	Inconclusive discussion of health factor or general health reference evident in panel report	The report may leave discussion unfinished, ask questions for further consideration or provide weak links between health factor and human health in the report
Proponent only	Discussion evident in the report of the proponent, which is not discussed in the panel report	Any conclusive or inconclusive identification of health factor or general health reference made by proponent that is not discussed in the panel report

Degree of consensus

Degree of consensus is measured in this study as a lack of consensus indicates a failure to utilize scientific knowledge in the environmental assessment process, which is the purpose of the assessment process. In a prior examination of panel review reports, it became evident that it may be difficult to judge if consensus had been reached between the various stakeholders involved in an environmental assessment. In order to account for this, three categories were formed: consensus, potential consensus and no consensus. Definitions are provided in Table 5.4 below.

Table 5.4. Categories of degree of consensus and definitions

Category	Definition
Consensus	Issue considered a potential health impact by proponent and panel, without evidence that other stakeholders disagree
Potential consensus	Reporting of opinions without commitment or contrasting opinions evident with either evidence of opposition and mediation or without recorded evidence of opposition
No consensus	Contrasting opinions with recorded evidence of opposition and without mediation measures

Level of omission

Level of omission is measured in this study and indicates a failure to utilize the range of scientific knowledge that specifically addresses the relationship between mining activities and human health. Three categories were formed: omitted, omitted from panel review and consideration. Definitions are provided in Table 5.5 on the following page.

Table 5.5. Categories of level of omission and definitions

Category	Definition
Omitted	Issue considered a potential health impact by proponent and panel, without evidence that other stakeholders disagree
Omitted from panel review	Reporting of opinions without commitment or contrasting opinions evident with either evidence of opposition and mediation or without recorded evidence of opposition
Consideration	Contrasting opinions with recorded evidence of opposition and without mediation measures

5.5 Case studies

5.5.1 Selection

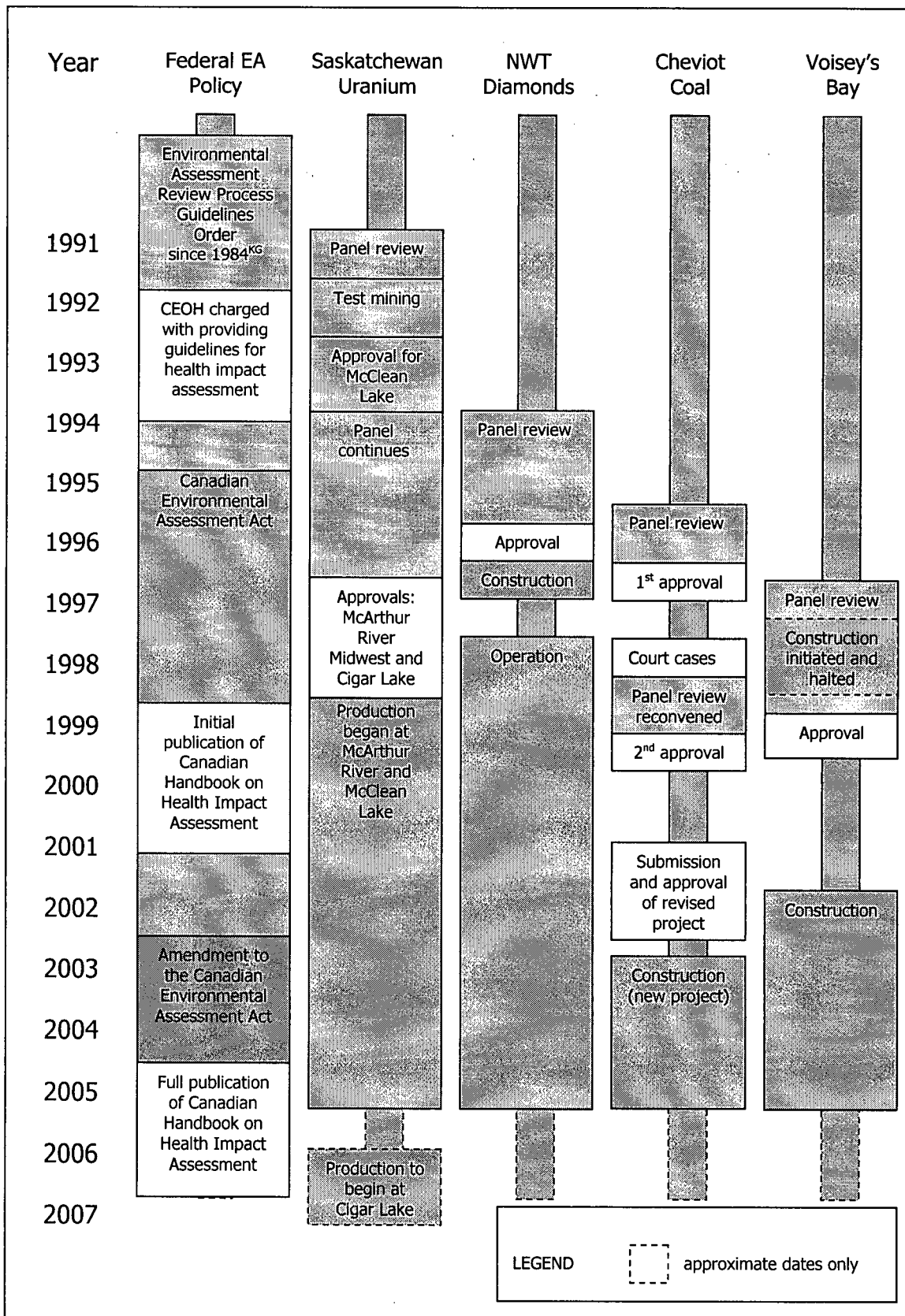
The mining projects reviewed for this project were selected as those that were assessed by a public panel either wholly or partly under federal jurisdiction and initiated prior to the publication of the Canadian Handbook on Health Impact Assessment. It was felt that as the guidelines were produced under federal jurisdiction, their departments would therefore be more likely to be aware of the need for health impact assessment and therefore more likely to include a human health component. It was also felt that those assessed by a panel review would be more likely to discuss human health due to the large range of participants in the process, who could potentially influence the assessment. Four mining projects matched the above criteria: Uranium Mining Developments in Northern Saskatchewan, NWT Diamonds, Cheviot Coal and Voisey's Bay project proposals.

5.5.2 Description of case studies

The assessments of the Uranium Mining Developments in Northern Saskatchewan, NWT Diamonds, Cheviot Coal and Voisey's Bay project proposals spanned a period from 1991 to 1999. The timelines of the case study proposals are illustrated in Figure 5.2 on the following page.

The assessments were conducted under two federal integrated environmental assessment frameworks. The reviews of the Uranium Mining Developments in Northern Saskatchewan and NWT Diamonds project proposals were initiated in 1991 and 1994 respectively and conducted under the Environmental Assessment Review Process Guidelines Order (EARPGO 1984). The reviews of the Cheviot Coal and Voisey's Bay project proposals were initiated in 1996 and 1997 respectively and conducted by joint federal-provincial panels under the Canadian Environmental Assessment Act (CEAA 1995) and the respective provincial counterpart.

Figure 5.2. Selected timelines of the four case studies in context of the federal environmental assessment policy and guidelines for health impact assessment



The four case study projects involved four separate proponents. The proponents for the McArthur River and NWT Diamonds projects were joint ventures and the specific operators that were proposed took on the role of proponent in each case. The case study projects were assessed under the guidance of one of three governmental departments 1) Natural Resources Canada; 2) Ministry of the Environment and; 3) Department of Fisheries and Oceans. The Department of Fisheries and Oceans was responsible for assessment of both the Cheviot Coal and Voisey's Bay projects. A summary of the proponents and proposed project operators at the initiation of the panel review together with the initiating departments and departments charged with responsibility of the environmental assessment are presented in Table 5.6 below.

Table 5.6 Proponents and proposed project operators at the initiation of the panel review and the principal government departments responsible for the environmental assessment for the McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay case studies

Parameter	Project			
	McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
Proponent at initiation of panel review	McArthur River Joint Venture	BHP Joint Venture	Cardinal River Coals Limited	Voisey's Bay Nickel Company (subsidiary of Inco Limited)
Proposed operator at initiation of panel review	Cameco Corporation	BHP Diamonds	Cardinal River Coals Limited	Voisey's Bay Nickel Company
Initiating and/ or responsible governmental department (federal)	Atomic Energy Control Board (now defunct), Natural Resources Canada	Department of Indian Affairs and Northern Development, Ministry of the Environment	Department of Fisheries and Oceans	Department of Fisheries and Oceans

The proposed projects were situated in three provinces and one territory of Canada, specifically Saskatchewan, Northwest Territories, Alberta and Newfoundland and Labrador. A selection of physical and operational characteristics of the case studies is presented in Table 5.7 on the following page.

Table 5.7. Various physical and operational characteristics of the four case study projects reviewed in this study for the McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay case studies

Parameter	Project			
	McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
Commodity	Uranium	Diamonds	Coal	Nickel, cobalt, copper
Mine	Underground mine	5 surface mines, 2 to extend underground	Surface or underground* mine	Surface to underground mine
Processing plant	None	Yes, physical processes only	Yes (if surface mine)	Yes
Other facilities	Permanent camp, winter road	Permanent camp, airstrip and short all-weather haul road	Temporary camp, road and rail access, power line	Permanent camp
Facilities already on site	Temporary camp, test mine	Temporary camp	None	Temporary camp
Final product	Uranium ore	Rough diamonds	Bituminous Coal	Concentrates
Transport of final product	Truck to nearby mill at Cigar Lake	Air	Rail	International shipping
Predicted mine life	20 years	25 years	20 years if surface mine; 2-3 years* if underground mine	30 years
Work schedule	Rotational, fly in fly out	Rotational, fly in fly out	Regular, 8 and 12 hour shifts	Rotational, fly in fly out

*After a court case in 2000, the federal government was ordered to consider underground mining as an alternative

6. RESEARCH QUESTIONS AND SPECIFIC METHODS

6.1 Research question 1: Identification of procedures followed to identify impacts to human health in the environmental assessment of mining projects

6.1.1 Introduction

To investigate the adequacy of the procedures that were followed in the case studies, documents from each stage of the environmental assessment process from each case study were examined in two stages. In the first stage, each case study was evaluated once to form a comprehensive list of criteria, then each case study was re-reviewed against this full list.

6.1.2 Search techniques

As proponent's reports are voluminous, often exceeding 1000 pages (Marbek Resource Consultants, 1998) relevant volumes and/or chapters of the proponent's report were identified using a manual search of the index and a detailed review of the full project description. All other documents were examined in their entirety. Published literature that described the environmental assessment process was used as a supplement to information not gained through this exercise.

6.1.3 Search design

Documents from each stage of the environmental assessment process were hand searched for evidence of procedures that had possibly led to the human health factors being identified. Any potentially limiting factors were also noted. This information was pooled together and converted into a generic list of criteria that could be used as a checklist. The following criteria were developed:

Scoping phase

Evidence of the following characteristics of the procedures followed by the responsible authorities or others that were responsible for initiating the panel and its activities:

- Who were the participants at this phase, specifically:
 - Responsible parties,

- Other participants;
- Whether any key issues had been identified;
- Extent of scoping exercise:
 - How specific were human health issues defined,
 - Clarity in requiring panel to consider human health,
 - Definition of boundaries;
- If the panel contained expertise in human health issues and;
- Instructions provided to the panel regarding its role and methods to be used:
 - Objective of scoping exercise,
 - Required procedures,
 - Suggested procedures,
 - Objective of panel's assessment

Evidence of the following characteristics of the procedures followed by the panel to provide instructions to the proponent was identified:

- Additional participants (other than panel);
- Whether key issues had been identified;
- Objectives identified for proponent;
- Methods used by panel to identify scope of human health issues to be considered and;
- Scoping exercise, specifically:
 - Whether scope had been redefined (outside boundaries set by government),
 - How specific were human health issues defined,
 - Clarity in requiring proponent to consider human health,
 - Definition of boundaries

Appraisal phase

Evidence of the following characteristics of the procedures followed by the proponent to provide the information requested by the panel was identified:

- Whether additional health factors had been identified at this stage;
- Whether there had been a shift in scope (outside the boundaries set by panel) and;
- Methods used by proponent to identify health factors

Evidence of the following characteristics of the procedures followed by the panel to appraise the project proposal was identified:

- Additional participants to panel (other than panel and proponent). It is assumed that the proponent or representative of the proponent was present at this phase;
- If beyond panel's original scope and;
- Methods used in panel review to identify health factors

These criteria were then used to gather information on each case study in a second hand search of the same documentation. The results of the case studies were compared and contrasted in order to identify consistencies in the procedures that have been used to identify health impacts in the past. These results are presented in section 7.1.

6.2 Research question 2: Identification of health impacts that have been considered during the environmental assessment of mining projects

6.2.1 Introduction

To explore the scope of health impacts identified in the past, evidence of the identification of health factors was obtained from both the proponent's report and panel's report for each case study. The impact categories considered in the case studies were evaluated both generally, with respect to phase using the Health Impact Assessment Scope Evaluation Tool. Case studies were examined together in order to establish the consistencies in the scope of health impacts identified in the past. Occurrences of partial consideration and lack of consensus were also identified.

6.2.2 Data collection

The report of the public panel and the proponent's report from each case study were manually searched for evidence of the identification of *health factors* (see section 5.3.2) or any *general health references* (see section 5.3.3). Panel reports were read in their entirety. Relevant volumes and/or chapters of proponent's reports were identified using manual index searching techniques and those chapters that indicated some appraisal of health impacts were selected for review and read in their entirety. The project description contained in the proponents' reports were read in their entirety and used to extract evidence where appropriate.

The following characteristics were determined for each health factor or general health reference identified in the respective reports of each case study:

- a) Evidence of generic or phase-specific consideration;
- b) Impact pathway;
- c) Broad determinant of health;
- d) Environment type;
- e) Hazard category, if appropriate, and;
- f) Positive or negative impact;

See section 5.4.2 for definitions

For those health factors identified in the panel and/or proponent's report, the following characteristics were noted:

- g) Level of consideration and;
- h) Degree of consensus

See section 5.4.4 for definitions.

The health factors that were identified during the course of this study used to compile the information presented in the tables in this section are presented in Appendix I.

6.2.3 Analysis of *overall* (non phase-specific) scope of health factors identified in the **panel** report

Positive and negative health factors and general health references identified from each panel report were grouped into non phase-specific *broad impact categories* that correspond to those in the non phase-specific *Health Impact Assessment Scope Evaluation Tool*, that is *impact pathway, broad determinant of health, environment type* and if appropriate, *hazard category*. This information was then used to fill a non phase-specific *Health Impact Assessment Scope Evaluation Tool* and is presented together with the results from the proponents reports in Appendix I. This information was then translated into a generic format so as to observe only where negative and positive impacts had been identified. In this thesis, dots (•) and addition symbols (+) replaced information on the identification of negative and positive health factors. The results are presented in Table 7.4. The resultant tool was used to observe consistencies in the identification of health factors at the panel level. These results and the discussion are presented in section 7.2.2.

6.2.4 Analysis of *overall* scope of consideration of health factors by **panel and proponent**

Those positive and negative health factors and general health references that had been designated a *proponent only* (see section 5.4.4) level of consideration were similarly grouped into *broad impact categories* and integrated with the results from section 6.2.3 above in a second *Health Impact Assessment Scope Evaluation Tool* (see section 5.4.2), using the symbol P. The resultant tool was used

to observe consistencies in the identification of health factors at the panel level. These results and the discussion are presented in section 7.2.4.

6.2.5 Analysis of *phase-specific* scope of consideration of health factors, level of consensus and degree of consensus by **panel and proponent**

Positive and negative health factors and general health references identified from each panel report were grouped into phase-specific *broad impact categories* that correspond to those in the *Health Impact Assessment Scope Evaluation Tool* (see section 5.4.2), that is, *phase, impact pathway, broad determinant of health, environment type* and if appropriate, *hazard category*. This information was used to fill a phase-specific *Health Impact Assessment Scope Evaluation Tool*. The overall *level of consideration* (see section 5.4.4) and range of *degree of consensus* (see section 5.4.4) for each *broad impact category* were demonstrated where these had been identified. The resultant tool was then examined for patterns in the consideration of phase, level of consideration and degree of consensus. The results are presented in section 7.2.4.

6.3 Research Question 3: Evidence that the health impacts considered during past environmental assessments of mining projects have been consistent with the state of knowledge

6.3.1 Introduction

To evaluate how science has been used in health impact assessment, the state of knowledge regarding impact categories for each case study was established. The Stephens and Ahern (2001) literature search was used as the initial focus. This information was integrated with the results from research question 2 (see section 7.2) in a *Health Impact Assessment Evaluation Tool*, which allowed any failure to consider potential health impacts in the past to be identified.

6.3.2 Literature search

The Stephens and Ahern (2001) review had covered the period between 1953 and 2000. The Stephens and Ahern (2001) keyword search of the PubMed health science database was repeated and extended to encompass additional studies published between 1953 and June 2005. Following the methods established by Stephens and Ahern (2001), *mining* and *health*, *mining* and *occupational health*, *mining* and *community health*, *mining* and *health* and *employment*, *mining* and name of principle commodity (e.g. *nickel* for nickel mine) were used as keywords. Non-English publications were retained.

The publications were then divided into two groups. Those published before the latter initiation date, by month and year, of the case study panel reviews were designated as group 1 and those published after this date were designated as group 2.

Review articles that had involved a literature review of the health impacts of mining operations were selected from group 2 to provide further evidence of state of knowledge prior to the latter initiation date of the case study panel reviews. These publications are presented in Appendix II. The health science publications cited in these articles were added to group 1, while the remaining group 2 publications were removed from consideration.

For each publication in group 1, the full document, abstract or title of the each publication identified in the literature review was inspected for evidence of any discussion of a health factor or health factors that fall within the scope of this study. Abstracts and/or titles were used only where full documents were unavailable. For example, publications that did not describe any specific mining related health factors were removed from consideration. Those relating to smelting or refining operations, which are excluded from this study, were also eliminated at the point, as these do not fall within the scope of this study.

6.3.3 Determination of state of knowledge

For each publication, the information in the full text, abstract, title or the appropriate text in the review article was used to determine the following characteristics of the discussion of health factors or general health references in the publication:

- a) Mining phases (construction and development, operation or post-closure); if phase was not established in the publication, phase was determined to be non phase-specific,
- b) Impact pathways,
- c) Broad determinants of health,
- d) Environment types,
- e) Hazard categories, if appropriate and,
- f) Whether general health reference or health factor

See section 5.4.2 for definitions.

The date of publication (month and year) was also recorded. The month of publication was set to December if only year could be determined. The information gathered in (a) to (f) were used to define for which phase-specific *broad impact category* or *categories* the publication was relevant. Publications were then grouped manually according to *broad impact category*. Publications were counted multiple times where multiple *broad impact categories* were relevant to a publication.

In order to establish state of knowledge for each case study, the phase-specific *broad impact categories* determined from above were matched to each case study using the initiation date of the panel review (month, year) to account for change in state of knowledge over time. The number of publications per impact category was treated as a descriptor to *broad impact category* and therefore linked in this

matching exercise. These exercises were all manually executed. The results were presented in the *Health Impact Assessment Scope Evaluation Tool* and are presented in section 7.3.3.

6.3.4 Analysis of overall consistency of the identification of health factors with respect to state of knowledge

In order to observe if the health impacts considered during past environmental assessments of mining projects have been consistent with the state of knowledge, the results from 6.3.3 above and the results from section 6.2.3 from the previous research question were integrated in a *Health Impact Assessment Scope Evaluation Tool* by impact category. Level of omission (see Table 5.5 for definition) was determined and discussed. The results are presented in section 7.3.4.

6.3.5 Phase-specific analysis of the consistency in the identification of health factors with respect to state of knowledge

The above analysis was carried out with respect to phase, matching the specific phase results from section 6.2.4 from the previous research question to the results of an analysis of impact categories-phase, grouping categories from (a) to (f) above. Level of omission with respect to level of consideration and degree of consensus was discussed. The results are presented in section 7.3.5.

6.4 Research Question 4: Evidence that the consideration of health impacts has had an impact on the governments' final decision

6.4.1 Introduction

The scope of the consideration of health factors considered by the decision-makers was identified for each case study using the respective government's response documents. For each case study, this scope was compared to the scope of the health factors reported in the respective panel report. The influence of level of consideration and degree of consensus was also examined.

6.4.2 Documents selected for review

The documents published by the government as a record of the governments' decisions and/or responses were selected for review. Where the panel reports formed part of these documents, these were not included in the review, since it would likely be included only as reference material and could not serve to indicate that every health impact reported within it was used at the decision-making stage any more than other cases where the panel reports were not placed in appendices.

6.4.3 Data collection

The selected text was read in its entirety and any evidence that a health factor or general health reference (see section 5.3.2 and 5.3.3 respectively) of health factors had been discussed was manually recorded. The following characteristics were determined:

- a) Evidence of phase-specific consideration;
- b) Impact pathway;
- c) Broad determinant of health;
- d) Hazard category, if appropriate and;
- e) Environment type

See section 5.4.2 for definitions. These results are presented in Appendix III.

6.4.4 Analysis of overall scope of health factors identified

The data collected for each government decision above was arranged manually in the generic *Health Impact Assessment Scope Evaluation Tool* (see section 5.3.2) and integrated with the scope of the health factors considered at the panel review phase for each case study produced from research question 2. Where it had been previously determined (in research question 2) that a lack of consensus and partial consideration had occurred in specific *broad impact categories*, these were also illustrated. Information on phase-specific consideration was treated as a descriptor and not explicitly shown in the table. From the table, the influence of level of consideration and the relationship between knowledge and consensus were evaluated. The results are presented in section 7.4.2.

7. RESULTS AND PRELIMINARY DISCUSSION

7.1 Research question 1: Procedures followed to identify impacts to human health in the environmental assessment of mining projects

7.1.1 Introduction

In general, even on a broad level, the procedures that have been followed in the case study environmental assessments have progressed somewhat differently in the stages of the process that led to the appraisal. It is evident that the scoping of key issues has been carried out either both by the responsible parties and the panel or either one of these groups. Although one may expect the term Responsible Authority to be used here, the term responsible parties is used to better reflect the Voisey's Bay case in which the environmental assessment was governed by a Memorandum of Understanding that was drawn up between the governments, proponent and two Aboriginal groups rather than that set out in the Canadian Environmental Assessment Act (CEAA 1995). There has been more consistency at the appraisal phase with health factors predominantly identified by the proponent. However, health factors have continued to be identified at the panel review phase.

7.1.2 Observations on the scoping phase

Procedures followed by the Responsible Authority and other responsible parties to initiate the panel review

The evidence of procedures that have been followed by the responsible parties to initiate the panel review and other pertinent characteristics of the four case studies are presented in Table 7.1 on the following page.

Table 7.1. Summary of the characteristics and procedures followed by the responsible parties in order to initiate the panel reviews in the environmental assessment of the McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay project proposals. Evidence relates to the consideration of human health concerns only and has been gathered from the Terms of References, proponent's report, panel report and governments' response documents from each case study.

		Case study			
		McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
Participants	Terms of Reference issued by	Federal Minister of the Environment; Provincial Minister of Saskatchewan Environment and Public Safety	Federal Minister of the Environment	Provincial Alberta Environmental Protection	Federal Ministers of Environment; Fisheries and Oceans; Provincial Ministers of Environment, Labour and Intergovernmental Affairs; President of Innu Nation President of Labrador Inuit Association
	Other participants involved	None evident	Federal Department of Indian Affairs and Northern Development; Federal Government of Northwest Territories; Directly affected First Nation and Inuit organizations	Federal Department of Fisheries and Oceans Federal Ministry of the Environment	None evident
Key issues identified at this stage		Yes	No	Yes	No
Scope required in appraisal	How specific were human health issues defined	Broad scope (e.g. long and short-term impacts) supplemented with specific areas for assessment (e.g. health); including changes in biophysical and social impacts	As described in Environmental Assessment Review Guidelines Order (i.e. requirement to consider environmental effects without interpretation of phrase)	Broad scope supplemented with specific issues for assessment, including changes in biophysical and social environment	As described in Canadian Environmental Assessment Act (i.e. requirement to consider any change on health)
	Clarity with respect to human health	Some ambiguity. Some issues clearly required consideration of effect on human health		Some specific issues (e.g. chemicals) clearly required consideration of effect on human health	
	Boundaries defined	Population Mining lifecycle	Geographic Mining activities (e.g. construction; activities, mining and milling operations)	Geographic Impacts on public health to be assessed with respect to contingency Recognized stakeholder groups only	Mining lifecycle

this table is continued on the following page

continuation of the table on the previous page

Instructions to panel	Expertise in human health on panel	Health professional (Medical Doctor, academic in occupational and environmental health*	Not detected	Health and Safety expert	Not detected
	Objective of scoping exercise	Not directly addressed	To identify priority issues	n/a	To identify priority issues
	Methods explicitly required in scoping exercise	Scoping meetings in appropriate communities	Proponent to provide satisfactory project description prior to scoping exercise. Project description to undergo (environmental) technical evaluation by governmental regional committee. Scoping meetings in appropriate communities	n/a	To use documentation To do a site visit (possibly with stakeholders) Obtain comments on panel's draft EIS guidelines
	Suggested sources of information	Review of available information on regional uranium mining information to date; Review of past performance of region's uranium mining industry; Review of Environmental Impact Statement; Public hearings for review; Public concerns outside of the panel's scope may be expressed	May obtain independent expert advice	n/a	May obtain independent expert advice
	Objective of assessment	Acceptability Identify short and long term impacts and cumulative effects; Consider adequacy of mitigation measures Compliance	To decide on acceptability of proposal (indirect statement) May identify issues to be studied in regional baseline study	Compliance with appropriate regulation	Report information on state of environment, use of precautionary principle and provided all comments received

*Remained on the panel until August 1996 six months before the McArthur River panel report was published. (Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan (Canada), 1997)

From Table 7.1 above, is also evident that the preparation of the Terms of References has often involved other participants in addition to the responsible parties. This is observed in three of the four case studies. Only in the earlier McArthur case is there a lack of evidence of participation other than the respective federal and provincial responsible authorities. There is evidence of public participation at this stage in two of the four cases studies, specifically in the NWT Diamonds environmental assessment and the Voisey's Bay example outlined above.

From the Table 7.1, it is evident that the Responsible Authority has normally provided broad guidance for the panel to carry out a scoping exercise. However, scoping has not always been a characteristic feature of this step; identification of key issues occurred in only two of the four case studies at this stage. In the other two cases, the NWT Diamonds and Voisey's Bay examples, the responsible parties had chosen to use the instructions stipulated in the appropriate federal environmental assessment legislation to provide instruction as to the scope of assessment that was expected of the panel. In both these cases the public were either consulted or shared responsibility regarding the Terms of Reference issued at this stage. However, in the NWT Diamonds case, it is also evident that the responsible authority had felt that it had not received a satisfactory project description prior to the issue of the Terms of Reference.

Assessment boundaries and objectives have consistently been issued to the panel at this stage. However, it is evident there has been little consistency in the boundaries and the number of boundaries that have been defined in the initial Terms of References. The commonly used boundaries are geographic, population and lifecycle type boundaries that have each been defined in two of the four case studies. The number of boundaries used has ranged from one to three. However, of three boundary types used in the Cheviot Coal initial Terms of Reference, the population boundaries were not clear and the instruction to consider impacts to public health with respect to contingencies was indirect and ambiguous.

How specific the human health issues have been defined has also varied between the Terms of Reference issued by the responsible parties. In those two cases where scoping had occurred at this stage, key issues had been addressed differently. In another example of contrasting approaches, the Terms of Reference issued to the McArthur River panel used only broad determinants (e.g. use of the phrase "changes in biophysical impacts") whereas the Terms of Reference issued to the Cheviot Coal panel detailed some specific issues (e.g. use of the term "chemicals").

There has not always been clear instruction to consider human health within the initial Terms of Reference. An expectation of health impact assessment was evident with respect to some issues in the two case studies where key issues had been identified. However, there was also some ambiguity within these case studies. For example, the Terms of Reference issued to the McArthur River panel had clearly indicated a need to consider worker health and safety but was ambiguous in its instruction to consider community health as an outcome when expressing a requirement to assess environmental quality.

The selection of the panel members has also been inconsistent. In two of the four case studies, the responsible parties selected experts in human health or determinants of human health. A health professional was selected for the McArthur River panel. However, in its report the panel indicated that this expert had stepped down from the panel prior to the completion of the appraisal phase (Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan (Canada), 1997). A Health and Safety expert was selected in the case of the Cheviot Coal review. Panels more commonly include experts in the technical aspects of mining, socio-economics and Aboriginal issues.

The instructions to the panel regarding its role and necessary procedures have also differed between cases in the past. Although it is evident that panels had been either directly or indirectly instructed to carry out further scoping exercises before the appraisal in three of the four case studies, similar instructions were not evident in the Terms of Reference issued to the Cheviot Coal panel. The Terms of Reference issued to the McArthur River and NWT Diamonds panels had explicitly required the panel to

hold scoping meetings with the public. It is evident that the responsible parties have furnished panels with specific procedural instructions in some cases. For example, the Voisey's Bay panel was presented with explicit procedural instructions, which included instruction to use documented evidence and carry out a site visit accompanied with stakeholders. Similarly, the McArthur panel was provided with a detailed list of suggested sources of information. In some cases, panels have been given the option to consult independent experts. This occurred in the NWT Diamonds and Voisey's Bay examples. In one of the four cases, the NWT diamonds panel was instructed to consult a regional governmental committee in order for a technical evaluation to be performed. In these latter examples, the purpose of these procedures is unclear, that is, whether these were tools to identify health factors or to assess their significance. However, it is assumed that any of these procedures could have resulted in health impacts being identified.

The overall objectives of the panel have also differed in the past. The panels reviewing the McArthur River and NWT Diamonds project proposals were asked to comment broadly on acceptability. In addition to acceptability, the panel reviewing the McArthur River proposal was also asked to consider whether the project could be expected to comply with Canadian and Saskatchewan law with respect to environmental quality and worker health and safety. However, ensuring compliance was the only objective evident in the Terms of Reference issued to the panel reviewing the Cheviot Coal proposal. In a different format the panel reviewing the Voisey's Bay proposal was instructed to report any information gathered in the assessment, suggesting that any judgment would be considered superfluous.

Procedures followed in panel's scoping exercise to inform the proponent of information needs

The procedures followed by the panel to publish instructions for the proponent is presented in Table 7.2 on the following page. Conclusions that can be drawn from the tables are discussed below.

The panels have not always carried out scoping exercises in the past. This appears to have occurred in three of the four case studies. The Cheviot Coal case appears to be the exception. During the document

Table 7.2. Summary of characteristics and procedures followed by the panel to instruct the proponent on the identification of health factors in the environmental assessment of McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay project proposals. Evidence relates to the consideration of human health concerns only and has been gathered from the Terms of References, proponent's report, panel report and governments' response documents from each case study.

Case study				
	McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
Additional participants	General Public	Federal government departments General public	n/a	General public
Identification of key issues	Yes	Yes	No	Yes
Objectives identified for proponent	Consideration direct and indirect impacts on human health; identification of significant risks and assessment of significance	Consider the socio-economic effects on public health and other social parameters	n/a	Required to answer three specific research questions. One of three made direct reference to human health: 1) Would the project affect country foods of prevent Aboriginal people from harvesting them, either now or in years to come? Other questions were related to wildlife and socio-economic parameters
Methods used by panel to identify scope	Panel's expertise Health study option report and biophysical assessment specifically prepared for review Literature review Review of information proposed in Terms of Reference (see Table 2)	Panel's expertise Used definition of sustainability to define its objectives Visits to project site Review of written submissions	n/a	Panel's expertise
Scope required in appraisal	Redefinition of scope	No	No	No
	How specific were human health issues defined	All encompassing statements requiring examine any potentially significant short term, long term or cumulative effect to be identified. Specific issues (e.g. worker health and safety) and specific health factors (e.g. radiation risks) also identified	Broad issues only (e.g. socio-economic effects)	Broad scope with respect to social impacts (e.g. education). Specific scope with respect to biophysical impacts (i.e. country foods)
	Clarity of consideration with respect to human health	Clear instruction to consider impacts from changes in biophysical and social environment on human health (e.g. effect on local land-users)	Clear instruction to consider effects of social change on health (e.g. socio-economic effects on public health)	Some ambiguity with respect to social impacts. Requirement to consider biophysical impacts in context of human health
	Boundaries defined	Population (e.g. workers) Geographic	Geographic	Population Geographic Required evidence of causal relationship
			n/a	

acquisition stage of this study, a Terms of Reference issued by the panel could not be identified. As the proponent for the Cheviot Coal project included the Terms of Reference issued by the responsible parties in the Appendices of its study report, it is assumed that panel, which was presented with the most defined Terms of Reference with respect to key issues and received no instruction to carry out scoping, did not choose to issue a Terms of Reference of its own. In the three cases where scoping had occurred, it is evident that the panels had narrowed the scope from that set out in the initial Terms of Reference from the responsible parties.

From Table 7.2, it is also evident that the general public has consistently been consulted in the panels' scoping exercises. Other participants have also been involved at this stage. For example, it is evident that the panel reviewing the NWT diamonds project proposal had not received instruction on key issues and narrowed scope other than the legislated requirements, also involved the federal departments in creating a scope. However, this may have been due to the lack of a satisfactory project description prior to the Responsible Authority's Terms of Reference being issued.

There have been different methods employed in presenting objectives to proponents. The panels that had reviewed the McArthur River and NWT Diamonds project proposals set out types of impacts or effects that were to be assessed. Maybe creatively, the Voisey's Bay panel presented specific research questions that the proponent had to answer, thus narrowing the scope tremendously while giving specific direction to issues that had been judged important. Various methods have been employed in this exercise. It is evident that the McArthur River panel had followed the specific suggestions provided in the Terms of Reference coupled with its own expertise. It is evident that the panel for NWT Diamonds project proposal used a definition of sustainability, their own expertise and stakeholder values to define their scope. Evidence is sparse regarding the methods used by the Voisey's Bay panel. However, the panel's expertise and participation of the public is evident in this case, suggesting values were significant in the scope.

The degree of scoping by the panel has been inconsistent in the past. Overall, the scope had been narrowed in all three cases where the panel had carried out a scoping exercise, and in most cases a broad scope had been maintained. However, the McArthur River panel, while retaining a broad scope, had also stipulated specific issues and specific health factors be considered. As in the Terms of References issued to the panel, the Terms of Reference issued by the panel to the proponent have also been both clear and ambiguous in stipulating consideration of human health concerns. For example, the Voisey's Bay panel had required consideration of biophysical impacts in the context of human health but was not so specific with respect to social impacts. Overall, however, all three Terms of References prepared by the panels contained some clear instruction to consider human health for specific issues.

The definition of boundaries has been a consistent characteristic of this step. Geographic boundaries were defined in all three case studies where scoping had been carried out. In two of four cases, specifically the panels for the McArthur River and Voisey's Bay project proposals, had defined general and specific target populations for study. It is also evident that approaches to uncertainty have not always been consistent. In one example, the Voisey's Bay panel had stipulated that evidence of a causal relationship between a health factor and human health would be required in order for the health factor to be considered during the appraisal phase. Such statements had not been made in the other three cases.

7.1.3 Observations on the appraisal phase

The procedures followed by the proponent and panel to identify health factors in the appraisal phase are presented in Table 7.3 on the following page. Conclusions that can be drawn from this table are discussed below.

Procedures followed by the proponent

Proponents have sometimes involved potentially affected communities during their appraisal of the project. This is evident in two of the four cases and corresponds to the NWT Diamonds and Voisey's Bay cases. Proponents have consistently identified specific health factors or concerns that were a progression

Table 7.3. Summary of the characteristics and procedures followed by the proponents and review panels of the McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay project proposals. Evidence relates to the consideration of human health concerns only and has been gathered from the proponent's report, the panel report and governments' response documents from each case study.

		Case study			
		McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
Proponent	Additional participants	None evident	Communities	None evident	Communities
	Additional identification of potential health factors	Yes	Yes	Yes	Yes
	Shift in scope	No	Yes	Yes	Yes
	Methods used to identify health factors	Own expertise Review of scientific literature Surveys in local communities Past experience of mining in region Hazard analysis	Own expertise Review of scientific literature Inspection of regulations/legislation	Own expertise Evident that none had been identified in a value-based prioritization exercise of 99 potential impacts Elaboration of specific issues when justifying underground mining alternative	Own expertise Examination of regulations Examination of stakeholder values Literature review Select results of literature review and appraisal submitted by Innu Nation Taskforce on Mining Activities Interviews and map biography submitted by Aboriginal groups Multiple exposures- Multiple effects approach used
Panel	Additional participants	General public Government departments Experts	General public Government departments	General Public (recognized stakeholders only) Government departments Consultant hired by panel after federal court review	General public Experts
	Additional identification of potential health impacts	Yes (cursorily, general determinants of community health)	Yes	Yes	Yes
	Beyond of panel's original scope	Yes	Yes	Yes	Yes

this table is continued on the following page

continuation of the table on the previous page

Methods used to identify additional health factors	Literature review submitted by Provincial Saskatchewan Health	Elaboration of issues (e.g. environmental quality) not previously considered with respect to human health	Integrated approach taken by panel; all issues addressed with respect to humans; albeit often cursorily and/or assumptive	Reporting of issues raised at the public hearings (e.g. expert on behalf of Innu Nation)
Potentially limiting factors	Panel appeared constrained by workplace Health and Safety regulation	Panel stated that it had not commented on any issues to be addressed in the Impact and Benefits Agreement	Confidential Impact and Benefits Agreement carried out simultaneously	Confidential Impact and Benefits Agreement carried out simultaneously

of the broad scope defined by the panel. Furthermore, in three of the four case studies, it is evident that the proponent had addressed issues outside of the scope defined by the panel. The proponent for the McArthur River project did not digress from the scope of the issues in the Terms of Reference is had been issued; however, as mentioned above, this scope was broad.

Proponents have used various methods to identify relevant health factors. The proponent's reports for three of four case studies all contain evidence of peer-reviewed literature, suggesting a literature review has been a fairly common element of proponent's appraisals. However, it is also evident that peer-reviewed literature has not been cited in some statements made in these reports, suggesting that a proponent's and/or their consultants own expertise is often utilized at this stage. However, this may also be indicative of value-based approaches. The proponent of the Voisey's Bay project proposal included details from stakeholders who had carried out their own appraisal. It is evident that a review of peer-reviewed literature had also been carried out in this appraisal.

Procedures followed by the panel

As required by legislation, public hearings have consistently been held at the panel review stage. There have often been held in the affected communities. It is evident that the health factors considered at this phase have been beyond the panel's original scope. It is apparent that there have been a variety of reasons for this. In the NWT Diamonds panel review there is evidence that sporadic elaboration of issues that had initially been environmental oriented were later linked to human health during the public hearings. With respect to the Cheviot Coal panel review, it is evident that the panel had taken an

integrated approach to all issues. However, many issues were considered in a social or economic context. With respect to the Voisey's Bay panel review, it is evident as that new issues had been raised as a result of input from attendees at public hearings. This was especially evident in the Voisey's Bay assessment as the panel had been required to present all issues raised in its final report to the decision-maker.

There is also evidence that indicates that panels may have chosen not to report specific health factors. For example, the panel that reviewed McArthur River project proposal expressed concern for the quality of the appropriate Health and Safety regulations but did not elaborate on its concerns for specific health factors. This suggests that the panel may be constrained by regulation in reporting concerns for worker health and safety. It seems possible that this may have been due to an outside pressure, for example, the proponent or regulatory authority. Three cases, the NWT Diamonds, Cheviot Coal and Voisey's Bay were subject to IBAs. It is evident that these were concurrent to the environmental assessments of the project proposals. The NWT Diamonds panel had been explicit in explaining the lack of discussion of factors that had been discussed in relation to the IBA.

7.2 Research question 2: Identification of health impacts that have been considered during the environmental assessment of mining projects

7.2.1 Introduction

Environmental assessments of mining projects have included a health impact assessment component. Biophysical health factors have been given considerably more attention than health factors acting through the social environment. Nonetheless, there has been some consideration of positive effects of social factors on human health.

Discussions regarding health factors have occasionally been left unresolved and the relevance of some health factors proposed may have remained unclear after the conclusion of the environmental assessment. Consensus regarding the relevance of a health factor has not always been reached. This lack of consensus appears to have occurred with respect to chemical hazards in the workplace and community environment. However, the lack of consensus has also been evident in the discussions regarding health impacts in the social environment.

On a specific level, different phases of the mine lifecycle have been discussed at the proponent level. This has mostly been with respect to the consideration of chemical hazards in the community environment. However, explicit consideration of human health concerns in the report of the public panel is not evident.

7.2.2 Overall scope of health factors identified in the panel report

The overall scope of the consideration of workplace, community and social environment health factors in the environmental assessment of the four case studies are presented in Table 7.4 on the following page.

Table 7.4. Overall scope of health factors identified by the panels reviewing the project proposals in the McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay Environmental Assessments. Scope is defined by broad impact categories that relate to hazard type, impact pathway, broad determinant of health and environment. General health references are also shown.

Broad impact category	Project			
	McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
ENVIRONMENT TYPE				
Broad determinant of health				
Impact pathway/hazard category				
PHYSICAL ENVIRONMENT				
Occupational (workplace)				
Direct exposure to safety hazards	•	•		
Direct exposure to physical hazards				
Direct exposure to ergonomic hazards				
Direct exposure to chemical hazards	•	•		•
Direct exposure to biological hazards				
GENERAL HEALTH REFERENCE (direct exposure hazards only)	•	•	•	•
Ecosystem mediated exposure to chemical hazards	•			
Direct employment and income				
Physical Environment (affected community)				
Direct exposure to safety hazards	•	•		
Direct exposure to physical hazards			•	
Direct exposure to ergonomic hazards				
Direct exposure to chemical hazards	•	•	•	•
Direct exposure to biological hazards				
Ecosystem mediated exposure to chemical hazards	•	•	•	•
GENERAL HEALTH REFERENCE (multi-pathway)			•	
Direct employment and income pathway				
Indirect community pathway	•			
SOCIAL ENVIRONMENT				
Employment and working conditions				
Direct employment and income pathway		•		•
Indirect community pathway				
Social support networks				
Direct employment and income pathway				
Indirect community pathway				
Income and social status				
Direct employment and income pathway		•		
Indirect community pathway		•		
GENERAL HEALTH REFERENCE of broad (social) determinants of health				
Direct employment and income pathway				
Indirect community pathway	• +	•		• +

KEY: • negative impact(s); + : positive impact(s)

From Table 7.4 above, it is evident that there has been some consistency in the scope of health impacts considered in health impact assessments of mining projects. This is especially evident with regards to the identification of environmental health factors. A general reference to workplace health and safety has been consistent in the four case studies. With respect to workplace exposures, chemical hazards

were most consistently identified in the at the panel review level. Specific safety hazards were considered in half of the case studies. Workplace exposure to environmental hazards through the ecosystem mediated exposure pathway has been less commonly considered. In one case, the McArthur River case study, considered environmental exposures of a workforce residing on a permanent camp.

With respect to mining communities, again, chemical hazards (e.g. heavy metals) have been most consistently identified at this level. Community exposure to chemicals through both the direct and ecosystem mediated exposure pathways has been consistent in the past. More conventional hazards types, safety hazards and exposures to physical hazards, have been less frequently considered. In one case study, impacts through the general community pathway had been identified at panel review level. Here, the anxiety caused by the potential effects on human health as a result of the operation of a mine in the vicinity of the community was considered.

With respect to the social environment, in three of the four environmental assessments examined, health factors have been considered at least cursorily. In two of these cases, positive impacts on health had been identified, albeit on a broad scale. Employment and working conditions of employees and changes in income and social status were specific broad determinants of health that had been identified. However, a consistent consideration of these factors has is not been evident. Impacts through the direct employment and income pathway on workers and their families had been the most commonly identified pathway with respect to the social impacts on human health. Overall, it is evident that the consideration of adverse impacts on human health has been more predominant than the consideration of positive impacts on human health.

7.2.3 Overall scope of consideration of health factors in the appraisal phase

Health factors that have not been identified in the panels' reports to the decision-makers have often been identified in the study report of the proponent. This is demonstrated in Table 7.5 on the following page. From this table it is evident that the proponent often has contributed the identification of physical and chemical hazards and less frequently, ergonomic and biological hazards, with respect to workplace

exposures. Examples are exposure to extreme cold, exposure to process reagents, whole body vibration due to prolonged sitting in heavy trucks and exposure to parasites in mine water respectively.

Table 7.5. Overall scope of health factors identified evident in the environmental assessment of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. Health factors are categorized by impact pathway and broad determinant of health or by general health references where relevant.*

Broad impact category	Project			
	McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
ENVIRONMENT TYPE				
Broad determinant of health				
Impact pathway/hazard category				
PHYSICAL ENVIRONMENT				
Occupational (workplace)				
Direct exposure to safety hazards	•	•	P	P
Direct exposure to physical hazards	P	P		P
Direct exposure to ergonomic hazards		P		
Direct exposure to chemical hazards	•	•	P	•
Direct exposure to biological hazards		P		P
GENERAL HEALTH REFERENCE (direct exposure hazards only)	•	•	•	•
Ecosystem mediated exposure to chemical hazards	•			
Direct employment and income pathway				P
Physical Environment (affected community)				
Direct exposure to safety hazards	•	•	P	P
Direct exposure to physical hazards			•	P
Direct exposure to ergonomic hazards			P	
Direct exposure to chemical hazards	•	•	•	•
Direct exposure to biological hazards				
Ecosystem mediated exposure to chemical hazards	•	•	•	•
GENERAL HEALTH REFERENCE (multi-pathway)	P		•	
Direct employment and income pathway	P			
Indirect community pathway	•			
SOCIAL ENVIRONMENT				
Employment and working conditions				
Direct employment and income pathway	P	•		•
Indirect community pathway				
Social support networks				
Direct employment and income pathway				
Indirect community pathway		P		P
Income and social status				
Direct employment and income pathway		•		P
Indirect community pathway		•		P
GENERAL HEALTH REFERENCE of broad (social) determinants of health				
Direct employment and income pathway	P			
Indirect community pathway	• +	•		• +

KEY: * General health reference categories are highlighted in grey; P: Identification of negative impact(s) evident in proponent's report; • Identification of negative impact(s) evident in panel report; + : Identification of positive impact(s) evident in panel report

With respect to environmental health factors in the affected community, it is evident that ergonomic, safety and physical hazards through the direct exposure pathway have been presented in proponent reports. Examples are vibration due to the potential close proximity of drilling, fly-rock and low frequency noise and respectively. It is also evident that on occasion, proponents have identified health factors in the physical environmental that act through the direct income and employment pathway and indirect community pathway, for example, the anxiety of caused to prospective employees and family due to a concern for their health.

In three of the four case studies, proponents have also identified social health factors that were not reported at the panel level. It is evident that the proponent of the most recent environmental assessment, the Voisey's Bay had presented a range of social health factors in their report.

7.2.4 Analysis of scope of health impact assessment by phase, level of consideration and degree of consensus

The level of consideration, degree of consensus and phase-specific scope of health factors occurring in the workplace, community environment and social environment that were identified in the four case studies are presented in Table 7.6, Table 7.7 and Table 7.8 on the following pages. The following conclusions can be drawn from these tables.

Consideration by phase

On a general scale, panels have rarely referred to the construction and development phase specifically. However in some cases, it is evident that the proponent has addressed the different phases to some extent in its own report. Health factors occurring post closure, which are dependent upon the action of closure and/or reclamation activities have been considered separately.

Table 7.6. Scope of consideration of health factors relating to the physical environment in the health impact assessments of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. Health factors are categorized by impact pathway, hazard type and phase.

Broad impact category ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category Phase	Project															
	McArthur River				NWT Diamonds				Cheviot Coal				Voisey's Bay			
	C	O	P	G	C	O	P	G	C	O	P	G	C	O	P	G
Physical Environment (workplace)																
Direct exposure to safety hazards		P	n/a	? ✓		P	n/a	✓	P		n/a	P	P	P	n/a	P
Direct exposure to physical hazards		P				P								P		
Direct exposure to ergonomic hazards						P										
Direct exposure to chemical hazards	P	P		✓		P		✓				P		P		X
Direct exposure to biological hazards						P								P		
GENERAL HEALTH REFERENCE	P	P		X Q	P	P		✓				✓ Q	P	P		X ✓
Ecosystem mediated exposure to chemical hazards	P	P		✓												
Direct employment and income																P

KEY: Phases: C: construction and development; O: operation; P: post-closure; G: no phase specified; **Level of consideration:** P: Proponent only; Q partial (inconclusive) consideration by panel; **Degree of consensus:** ✓ Consensus; ? Potential consensus; X lack of consensus; **Other:** n/a: not applicable

Table 7.7. The scope of consideration of health factors relating to the physical environment in the health impact assessments of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. Health factors are categorized by impact pathway, hazard type and phase.

Broad impact category ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category Phase	Project															
	McArthur River				NWT Diamonds				Cheviot Coal				Voisey's Bay			
	C	O	P	G	C	O	P	G	C	O	P	G	C	O	P	G
Physical Environment (mining community)																
Direct exposure to safety hazards			P	? Q			?	?				P			P	
Direct exposure to physical hazards									P	P		✓				P
Direct exposure to ergonomic hazards												P				
Direct exposure to chemical hazards	P	P	P	✓				? Q	X ✓	X ✓	P	X ✓				✓
Direct exposure to biological hazards																
Ecosystem mediated exposure to chemical hazards	P	P	P	✓				? Q	P	P	P	X Q				✓
GENERAL HEALTH REFERENCE				P								✓				
Direct employment and income pathway				P												
Indirect community pathway				✓												

KEY: Phases: C: construction and development; O: operation; P: post-closure; G: no phase specified; **Level of consideration:** P: Proponent only; Q: partial (inconclusive) consideration by panel; **Degree of consensus:** ✓ Consensus; ? Potential consensus; X lack of consensus

Table 7.8. The scope of consideration of health factors relating to the social environment in the health impact assessments of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. Health factors are categorized by broad determinants of health category, impact pathway and phase.

Broad impact category ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category Phase	Project															
	McArthur River				NWT Diamonds				Cheviot Coal				Voisey's Bay			
	C	O	P	G	C	O	P	G	C	O	P	G	C	O	C	G
Employment and working conditions																
Direct employment and income				P				?								✓
Indirect community pathway																
Social support networks																
Direct employment and income pathway																
Indirect community pathway								P								P
Income and social status																
Direct employment and income pathway								XQ							P	
Indirect community pathway								XQ								P
GENERAL HEALTH REFERENCE of broad (social) determinants of health																
Direct employment and income pathway				P												
Indirect community pathway				?				?Q								✓

KEY: Phases: C: construction and development; O: operation; P: post-closure; G: no phase specified; **Level of consideration:** P: Proponent only; Q: partial (inconclusive) consideration by panel; **Degree of consensus:** ✓ Consensus; ? Potential consensus; X lack of consensus

Differences in the way phases have been taken into account are apparent at the broad determinant of health level. Proponents have frequently made general references to occupational hazards occurring at the construction phase. This has involved the inclusion of all encompassing statements that have applied the health factors identified for the operation phase to those of the construction phase. Proponents have taken into account different phase scenarios when considering the environmental exposures to chemicals (e.g. heavy metals) through the direct and ecosystem mediated exposure pathways. With respect to environmental exposures in the affected community, the consideration of health impacts by the panel is predominantly non phase-specific. General health references have often been used to discuss findings that have been analyzed by the proponent in specific phases. One exception is the Cheviot Coal panel, which made specific reference to both the construction and development phase and the operation phase when reporting conclusions with respect to direct exposure to coal dust and volatiles on public health. The identification of health factors acting through the direct income and employment pathway and indirect community pathway by both proponent and panel has generally been non phase-specific.

The consideration of social health factors by both proponent and panel has generally been non phase-specific. An exception is the consideration of the closure phase, which had occurred in one of the four case studies. Due to the ambiguity of the health impact assessment for social health factors, it is unclear if the construction phase has been considered as a separate group of activities and characterized by different impacts.

Level of consideration

The consideration of human health has not always been conclusive. Ambiguous statements regarding the relevance of a health factor or health factors are evident in three of the four case studies. In many of these cases, the consideration of the health factor had first occurred during the panel hearings. Inconclusive statements have been made with respect to both environmental and social health factors. For example, the Cheviot Coal panel stated that the proponent had offered to provide information on specific occupational and environmental hazards, but did not provide information on which hazards had

been identified. In another example, as mentioned in section 6.2 above, the McArthur panel had not provided information on specific concerns regarding the Health and Safety regulations, while expressing concern for the aged legislation. In the NWT Diamonds case, the panel had asked that the proponent and government agency clarify that levels of radionuclides would not be a hazard to public health thus leaving the relevance of this health factor unanswered.

Degree of consensus

Consensus had not always been reached in the past. Lack of consensus is evident in three of the four case studies and covers both physical and social environments. Three modes of potential lack of consensus have been identified:

- Between panel and public;
- Between government agencies and;
- Between panel and proponent

In the McArthur River panel review, in addition to the lack of consensus regarding the appropriateness of the regulations that were in use, the proponent had been resistant to considering exposures to radiation and chemical impacts through the ecosystem mediated pathway. In the NWT Diamonds example, the panel had suggested that increased income could lead to drug use, gambling and increased alcohol and later linked these to poor human health. However, the proponent had suggested that increased income would likely result in the decrease of this consumption in the communities. In the Voisey's Bay example, the panel had concluded that exposure to nickel was not a relevant health hazard as an expert attending the public hearing as an intervenor had suggested. This expert had also presented other occupational exposures to be considered, however, the panel did not provide a list of these in the report. In the Cheviot Coal example, Health Canada had expressed concern for exposure to polycyclic aromatic hydrocarbons through the consumption of fish. The panel had consulted Environment Canada and determined that levels would be low. However, it is unclear if the issue of potential human health outcome had been directly addressed here or if there was a consensus between parties.

7.3 Research Question 3: Evidence that the health impacts considered during past environmental assessments of mining projects have been consistent with the state of knowledge

7.3.1 Introduction

Overall, the scope of human health factors identified in the environmental assessments of mining projects has been somewhat consistent with state of knowledge. This is most evident in the assessment of the physical environment of the affected community. However, there is little consistency evident in the identification of health factors in the social environment. This said, the scope of this body of literature is small, as is the scope of health factors identified in the case studies, which limits the ability to form clear conclusions.

There have been failures to take advantage of scientific knowledge. Discussion in areas that have been discussed at a scientific level have been omitted from review. General failure to identify health factors in an appraisal have principally occurred with respect to the workplace environment or have been considered at a later stage in the process where discussion of an issue has been incomplete. There is also evidence of some failure to use scientific knowledge in the face of lack of consensus. Phase has not been considered in the health science literature and the little consideration given of the mine lifecycle has been at the discretion of the proponent.

7.3.2 Literature search

The panel reviews of the McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay project proposals were initiated in April 1991, December 1994, October 1996 and January 1997 respectively. A search of the PubMed health science database for literature published between 1953 and December 1996 inclusively led to the identification of 123 publications that could be used to demonstrate the scope of the state of knowledge at the time of these case studies with respect to health impact categories. Two review articles, each of which contained historical citations of health science literature between these dates provided an additional 29 publications. These 123 publications are assumed to represent the

state of knowledge regarding the health factors that may occur as the result of a mining operation prior to January 1997.

7.3.3 State of knowledge

The health factors that were identified spanned four broad determinants of health categories: workplace environment, affected community environment, social support networks, employment and working conditions. The pathways through which these health factors impact human health spanned the direct exposure, ecosystem mediated and direct employment and income categories. The complete list of these publications by impact category is presented in Appendix II. Examples of the health factors identified in the literature review are presented in Table 7.9 below.

Table 7.9. Examples of health factors identified review of health science literature between 1953 and 1996 inclusive The tool measures the scope of health factors considered in a health impact assessment of mining projects.

Broad impact category	Example of health factor
ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category	
PHYSICAL ENVIRONMENT	
Occupational (workplace)	
Direct exposure to safety hazards	Risk of transport accidents (Hunting & Weeks, 1993) Ventilation (Shy, 1979)
Direct exposure to physical hazards	Exposure to extreme cold (Bell et al., 1990)
Direct exposure to ergonomic hazards	Exposure to vibration (Brubaker, Mackenzie, & Hutton, 1986)
Direct exposure to chemical hazards	Exposure to silica (Amandus & Costello, 1991)
Direct exposure to biological hazards	Exposure to hookworms (Jochelson, Mothibeli, & Leger, 1991)
Physical Environment (affected community)	
Direct exposure to physical hazards	Exposure to noise (Berglund, Hassmen, & Job, 1996)
Direct exposure to chemical hazards	Exposure to cadmium (Carruthers & Smith, 1979)
Ecosystem mediated exposure to chemical hazards	Exposure to lead (heavy metal) through consumption of vegetables grown in the local area (Gallacher et al., 1984)
SOCIAL ENVIRONMENT	
Employment and working conditions	
Direct employment and income pathway	Piecework (Accidents have been reduced when time wages replaced piece wages.1973)
Social support networks	
Direct employment and income pathway	Migrant labour (sexually transmitted diseases) (Jochelson et al., 1991)

Table 7.10 on the following page, illustrates the number of publications relevant to each *broad health impact category* that has been encompassed by the health science literature; phase is also illustrated.

From Table 7.10, it is evident that the body of health literature may be heavily weighted towards chemical hazards in the workplace. Such a heavy weighting is most likely due to the divisions of hazard

classification used in this study. For example, radiological hazards are classified as chemical hazards. In any case, as identical methods have been used to compile the data from both environmental assessment case studies and the literature review, the numbers presented in Table 7.10 can be used to demonstrate the relative availability of health science literature with respect to the *broad impact categories*. Also, only two of the 139 publications identified in the literature review for this thesis concerned chemical hazards and were related to closure phase. It is therefore evident that little knowledge of phase-specific risks has been generated in the past.

Table 7.10. State of knowledge of health impacts of mining projects on human health for the environmental assessment of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. State of knowledge is determined by number of publications between 1953 and initiation of the panel review of each project.

Broad impact category ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category	Project			
	McArthur River	NWT Diamonds	Cheviot Coal	Voisey's Bay
PHYSICAL ENVIRONMENT				
Occupational (workplace)				
Direct exposure to safety hazards	6	9	9	9
Direct exposure to physical hazards	3	3	4	4
Direct exposure to ergonomic hazards	4	5	6	6
Direct exposure to chemical hazards	64	88	101	101
Direct exposure to biological hazards	1	1	1	1
Physical Environment (affected community)				
Direct exposure to physical hazards	-	-	1	1
Direct exposure to chemical hazards	4*	6†	8†	8†
Ecosystem mediated exposure to chemical hazards	2	3*	4*	4*
SOCIAL ENVIRONMENT				
Employment and working conditions				
Direct employment and income pathway	68	7	8	8
Social support networks				
Direct employment and income pathway	1	2	2	2
GENERAL HEALTH REFERENCE of broad (social) determinants of health				
Direct employment and income pathway	-	-	1	1

Key: * 1 publication referred to closure phase; † 2 publications referred to closure phase

7.3.4 General observations of consistency

Table 7.11 on the following page illustrates the degree to which the health factors identified in the case studies correspond to the state of knowledge. However, what is also evident from Table 7.11 is that the scope of health factors identified in environmental assessments has often included health factors that had not yet been discussed in the health science literature.

Table 7.11. Consistency of scope of health factors identified with respect to state of knowledge evident in the environmental assessment of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. The number of publications at initiation date of panel review illustrates the distribution of state of knowledge over the health impact categories.

Broad impact category	Project							
	McArthur River		NWT Diamonds		Cheviot Coal		Voisey's Bay	
ENVIRONMENT TYPE								
Broad determinant of health								
Impact pathway/hazard category								
PHYSICAL ENVIRONMENT								
Occupational (workplace)								
Direct exposure to safety hazards	6	■	9	■	9	Δ	9	Δ
Direct exposure to physical hazards	3	Δ	3	Δ	4	0	4	Δ
Direct exposure to ergonomic hazards	4	0	5	Δ	6	0	6	0
Direct exposure to chemical hazards	64	■	88	■	101	Δ	101	■
Direct exposure to biological hazards	1	0	1	Δ	1	0	1	Δ
GENERAL HEALTH REFERENCE of occupational hazards		•		•		•		•
Ecosystem mediated exposure to chemical hazards		•						
Direct employment and income pathway								P
Physical Environment (affected community)								
Direct exposure to safety hazards	-	•	-	•	-	P	-	P
Direct exposure to physical hazards	-		-		1	■	1	Δ
Direct exposure to ergonomic hazards	-		-		-	P	-	
Direct exposure to chemical hazards	4	■	6	■	8	■	8	■
Direct exposure to biological hazards	-		-		-		-	
Ecosystem mediated exposure to chemical hazards	2	■	3	■	4	■	4	■
GENERAL HEALTH REFERENCE of environmental hazards		P				•		
Direct employment and income pathway								
Indirect community pathway		•						
SOCIAL ENVIRONMENT								
Employment and working conditions								
Direct employment and income pathway	6	Δ	7	■	8	0	8	■
Indirect community pathway								
Social support networks								
Direct employment and income pathway	1	0	2	0	2	0	2	0
Indirect community pathway				P				P
Income and social status								
Direct employment and income pathway				•				P
Indirect community pathway				•				P
GENERAL HEALTH REFERENCE of broad (social) determinants of health								
Direct employment and income pathway		P			1+/-	0	1+/-	0
Indirect community pathway		• +		•				• +

KEY: ■: Consideration; Δ: Omitted in panel review; 0: Omitted; P: Consideration by proponent in absence of evidence of knowledge in health science literature; •: Consideration of negative impact(s) by panel in absence of evidence of knowledge in health science literature; +: Consideration of positive impact(s) by panel in absence of evidence of knowledge in health science literature;

The omission of health factors relating to the physical environment of the workplace is especially evident at the level of panel review. Generally, of the workplace hazard categories, biological and ergonomic

hazards have been omitted most frequently. However, evidence of discussion in the health science literature was least common here. A similar pattern is generally evident throughout the other *broad impact categories* in the table. However in the case of chemical hazards, even though state of knowledge was more prominent with respect to direct exposure pathway, the ecosystem mediated pathway had tended to be equally discussed.

7.3.5 Specific observations of consistency

The consistency of the identification of health factors with respect to level of consideration, degree of consensus and phase-specific scope of health factors occurring in the workplace, community environment and social environment that were identified in the four case studies are presented in Table 7.12, Table 7.13 and Table 7.14 on the following pages. The following conclusions can be drawn from these tables.

Phase

As can be seen from Tables 19, the closure phase has consistently been considered in the past for exposures to chemicals thorough the direct exposure and ecosystem mediated exposures in the physical community environment at the proponent level, which has been consistent with state of knowledge. It is also evident that the proponents have at times identified health factors specific to the construction and development phase, which are not evident in the scientific literature at this time.

Lack of consensus and consideration

From Tables 7.12, 7.13 and 7.14, it is evident that lack of consensus has sometimes occurred where there is evidence available in the scientific literature, indicating a failure of the process to incorporate scientific knowledge at these times. It is also evident that discussions regarding health factors have been inconclusive and failed to reach a stage where scientific literature has been consulted. The processes have therefore failed to allow for this step to be taken.

Table 7.12. State of knowledge and the scope of consideration of health factors relating to the physical environment in the health impact assessments of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. Health factors are categorized by impact pathway, hazard type and phase.

Broad impact category ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category Phase	Project															
	McArthur River				NWT Diamonds				Cheviot Coal				Voisey's Bay			
	C	O	P	G	C	O	P	G	C	O	P	G	C	O	P	G
Physical Environment (workplace)																
Direct exposure to safety hazards		P		6 ? ✓		P		9 ✓	P			9 P	P	P		9 P
Direct exposure to physical hazards		P		3		P		3				4		P		4
Direct exposure to ergonomic hazards				4		P		5				6				6
Direct exposure to chemical hazards	P	P		64 ✓		P		88 ✓				101 P		P		101 X
Direct exposure to biological hazards			n/a	1		P	n/a	1			n/a	1		P	n/a	1
GENERAL HEALTH REFERENCE	P	P		X Q	P	P		✓				✓ Q	P	P		X ✓
Ecosystem mediated exposure to chemical hazards	P	P		✓												
Direct income and employment																P

KEY: Phases: C: construction and development; O: operation; P: post-closure; G: no phase specified; Shaded box: State of knowledge; **Number:** number of publications identified in literature review of PubMed database to establish state of knowledge; **Level of consideration:** P: Proponent only; Q partial (inconclusive) consideration by panel; **Degree of consensus:** ✓ Consensus; ? Potential consensus; X lack of consensus; **Other:** n/a: not applicable

Table 7.13. State of knowledge and the scope of consideration of health factors relating to the physical environment in the health impact assessments of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. Health factors are categorized by impact pathway and broad determinant of health. Consideration is categorized by phase and cursory consideration.

Broad impact category ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category Phase	Project															
	McArthur River				NWT Diamonds				Cheviot Coal				Voisey's Bay			
	C	O	P	G	C	O	P	G	C	O	P	G	C	O	P	G
Physical Environment (mining community)																
Direct exposure to safety hazards			P	? Q			?	?				P			P	
Direct exposure to physical hazards									P	P		1 ✓				1 P
Direct exposure to ergonomic hazards												P				
Direct exposure to chemical hazards	P	P	1 P	3 ✓			2	4 ? Q	X ✓	X ✓	2 P	6 X ✓			2	6 ✓
Direct exposure to biological hazards																
Ecosystem mediated exposure to chemical hazards	P	P	P	2 ✓			1	2 ? Q	P	P	1 P	3 X Q			1	3 ✓
GENERAL HEALTH REFERENCE				P								✓				
Direct income and employment				P												
Indirect community pathway				✓												

KEY: Phases: C: construction and development; O: operation; P: post-closure; G: no phase specified; Shaded box: State of knowledge; **Number:** number of publications identified in literature review of PubMed database to establish state of knowledge; **Level of consideration:** P: Proponent only; Q partial (inconclusive) consideration by panel; **Degree of consensus:** ✓ Consensus; ? Potential consensus; X lack of consensus

Table 7.14.State of knowledge and the scope of consideration of health factors relating to social environment impact assessments of the proposed McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay projects. Health factors are categorized by impact pathway and broad determinant of health. Consideration is categorized by phase and cursory consideration. Shaded boxes denote state of knowledge

Broad impact category ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category Phase	McArthur River				NWT Diamonds				Cheviot Coal				Voisey's Bay			
	C	O	P	G	C	O	P	G	C	O	P	G	C	O	C	G
Employment and working conditions																
Direct employment and income pathway				6 P				7 ?				8				8 ✓
Indirect community pathway																
Social support networks																
Direct employment and income pathway				1				2				2				2
Indirect community pathway								P								P
Income and social status																
Direct employment and income pathway								XQ							P	
Indirect community pathway								XQ								P
GENERAL HEALTH REFERENCE of broad (social) determinants of health																
Direct employment and income pathway				P								1				1
Indirect community pathway				?				? Q								✓

KEY: Phases: C: construction and development; O: operation; P: post-closure; G: no phase specified; Shaded box: State of knowledge; **Number:** number of publications identified in literature review of PubMed database to establish state of knowledge; **Level of consideration:** P: Proponent only; Q partial (inconclusive) consideration by panel; **Degree of consensus:** ✓ Consensus; ? Potential consensus; X lack of consensus

7.4 Research Question 4: Evidence that the consideration of health impacts has had an impact on the governments' final decision

7.4.1 Introduction

All four case study project proposals were approved by the respective federal and provincial or territorial governments. With respect to the McArthur River project, the Government of Saskatchewan approved the project upon some terms and conditions, some of which were derived independently from the panel's recommendations and public's comments. The response from the Government of Canada was somewhat ambiguous in the respect that there was no explicit requirement for the measures or actions that were described in each response to the panel's recommendations.

With respect to the NWT Diamonds project, the Government of Canada incorporated some of the panel's recommendations into licenses and permits. Other recommendations that addressed long term monitoring agreements were incorporated in an Environmental Agreement and a Socio-Economic Agreements that were drawn up between the proponent and the government. Federal approval was also subject to "satisfactory progress" on Impact Benefit Agreements between the proponent and Aboriginal groups.

With respect to the Cheviot Coal project, the proponent had previously advised the government that it did not intend to exploit the orebody defined in the project proposal but did want to complete the Environmental Assessment process, which in Alberta, includes licensing and permitting. The Government of Alberta approved the project subject to a number of conditions; for example, the operator would have to provide a preliminary assessment of any potential effect on safety of the operational features of the coal processing plant. The Government of Canada approved the project while expressing justification for the adverse and significant impacts on affected Aboriginal groups that had been identified by the panel and expressed confidence that adequate compensation would be provided through an IBA.

With respect to the Voisey's Bay project, the Government of Newfoundland and Labrador incorporated some of the recommendations of the panel as conditions on the "authorization to proceed". The Government of Canada supported the decisions of the Government of Newfoundland and Labrador and offered contributions within its jurisdiction.

Overall, the consideration of health impacts at the panel level has had some impact on the government's final decision. However, this impact is small in relationship to the scope of health factors identified by the panel. It is evident that within this, there has been some impact on government decisions where there has been a lack of consensus and where discussions of the health factors have been inconclusive. However, it is possible that this has only occurred where the environmental assessment process is integral to a licensing process.

7.4.2 General observations

Table 7.15 on the following page illustrates the degree of impact the identification of health factors in the panel report has had on the influence on the decisions made by the ultimate decision-makers in each case study. It is apparent that most impact has occurred with respect to health factors related to chemical exposures, both in the workplace and the affected community environment. There is little evidence of health factors of the social environment being used at the decision-making stage. Only 1 of 5 governments had discussed broad social determinants of health, where these had been identified in reports. In one case, the provincial authorities did take into account issues where there had been lack of consensus evident in the environmental assessment process. These were addressed cursorily in the conditions for approval, explicitly requiring the proponent to prevent hazards to worker and public safety. This consideration of public safety was surplus to the discussion in the panel report but reflected discussion by the proponent in its report. However, this case is anomalous as unlike in the other case studies the provincial environment assessment process is an Alberta approvals process, and the documents produced at this stage are different than other decision-making documents produced at this stage of other environmental assessments where the licensing and permitting stage has yet to be entered.

Table 7.15. Summary of the impact of the consideration of health factors in the McArthur River, NWT Diamonds, Cheviot Coal and Voisey's Bay panel reports on the respective governments' ultimate decision. The consideration of health factors in the governments' decisions is plotted in relationship to the consideration of health factors in the panel report.

<i>Broad impact category</i>	Project											
	McArthur River				NWT Diamonds				Cheviot Coal*			
	Reported by panel	Discussed in provincial response	Discussed in federal response	Reported by panel	Discussed in federal response	Reported by panel	Discussed in provincial response	Discussed in federal response	Reported by panel	Discussed in provincial response	Discussed in federal response	Reported by panel
ENVIRONMENT TYPE Broad determinant of health Impact pathway/hazard category												
PHYSICAL ENVIRONMENT												
Occupational (workplace)												
Direct exposure to safety hazards	•			•								
Direct exposure to physical hazards												
Direct exposure to ergonomic hazards												
Direct exposure to chemical hazards	•	■	■	•	■				•	X	X	
Direct exposure to biological hazards												
GENERAL HEALTH REFERENCE (direct exposure hazards only)	•	X Q	X Q	•		•	Q ■	Q	•	X	X ■	
Ecosystem mediated exposure to chemical hazards	•											
Direct employment and income pathway												
Physical Environment (affected community)												
Direct exposure to safety hazards	•		Q	•		•						
Direct exposure to physical hazards						•						
Direct exposure to ergonomic hazards												
Direct exposure to chemical hazards	•			•	Q	•	X	X	•			
Direct exposure to biological hazards												
Ecosystem mediated exposure to chemical hazards	•		■	•	Q	•	X Q	X Q	•	■	■	
GENERAL HEALTH REFERENCE (multi-pathway)						•	■					
Direct employment and income pathway												
Indirect community pathway	•											
SOCIAL ENVIRONMENT												
Employment and working conditions												
Direct employment and income pathway				•					•			
Indirect community pathway												
Social support networks												
Direct employment and income pathway												
Indirect community pathway												
Income and social status												
Direct employment and income pathway				•	X Q							
Indirect community pathway				•	X Q							
GENERAL HEALTH REFERENCE of broad (social) determinants of health												
Direct employment and income pathway												
Indirect community pathway	• +	■		•	Q				• +			

*Cheviot coal provincial report included whole panel report in the decision document and this was not included in the analysis.

KEY: •: Consideration of negative impact evident in panel report; + : positive impact evident; ■ explicit consideration in government's report; c: GENERAL HEALTH REFERENCE in panel report; Q: inconclusive discussion in panel report X: No consensus

7.4.3 Phase-specific observations in consistency of health impact assessment with state of knowledge

None of the four case studies made explicit mention of phase with respect to health factors. However, the provincial government for the Cheviot project had stated that baseline studies should be completed prior to the construction phase. However, it is possible that this statement was made in the context of a condition-based decision rather than a recognition that impacts may start at the construction phase.

8. SUMMARY AND PERSPECTIVES

8.1 Summary

In summarizing the findings of this examination of how the health impact assessment of mining projects has been conducted in Canada, the following observations can be made:

- Procedures to support health impact assessment have been incorporated but inconsistent;
- Consideration of human health has tended to focus on chemical hazards;
- Consideration of human health has been somewhat consistent with state of knowledge and;
- Health impact assessment has influenced the governments' final decision

These statements reflect the four research questions of this thesis and are explained below. More detailed observations are presented in Appendix IV.

On a general level, the range of procedures followed by the various participants of the process has been different in each case. With respect to human health, some panels, proponents and communities have sporadically use scientific literature and it is evident that proponents have consistently used their own expertise.

Overall, a broad range of health factors has been addressed in the environmental assessment processes reviewed in this study. However, the range of health factors considered has differed in each case. Exposure to chemical hazards at the workplace and community level has been the most consistently considered type of health factor. Health factors pertaining to the social environment have not always been addressed.

The consideration of environmental hazards has reflected state of knowledge but the consideration of occupational hazards has been lacking, especially at the panel level. The consideration of the social environment health factors has not reflected state of knowledge; there are gaps but there is also identification of health factors in the absence of formal health science literature.

For the most part, the discussion of human health issues in the panel report had some impact on the final decision-making phase, more so at the provincial level than the federal level. Health factors that are taken into account at this stage have related to the physical environment more than the social environment.

8.2 Perspectives

8.2.1 Introduction

In summarizing the study findings above, it is evident that there have been limitations to health impact assessment at both the process and the decision-making level. Since there is evidence that human health is considered at the decision-making phase, in this section I focus on the challenges to identify potentially significant health factors that may be important in a mining development so that they may be considered at the decision-making phase.

The potential utility of the Canadian Handbook on Health Impact Assessment is then assessed in relation to the shortcomings that have been observed in the case studies. Health Canada defines the expectation of health impact assessment within the environmental process through the publication of the Canadian Handbook on Health Impact assessment, which serves to promote the consideration of human health concerns within the framework and serve as a tool to aid practitioners in reaching these expectations. With this in mind, the utility of the health impact assessment process as well as the capacity to promote the integration of knowledge and evidence in decision-making is also considered.

The role of IBAs and their impact on the potential effectiveness of health impact assessment is also considered since Galbraith and Bradshaw (2005) have previously concluded that IBAs are filling a void that environmental assessment processes have not filled and may in fact be modifying the context in which future health impact assessment activities are conducted. These findings are presented below.

8.2.2 Procedural based (institutional) challenges

Limited role of scientific knowledge

The limited role of scientific knowledge, which is evident by the inconsistency of the human health impacts discussed in the environmental assessments with the state of knowledge, may have contributed to the lack of health impact assessment. It is apparent that expert systems are at play and are probably at least partly responsible for the impacts identified in the assessments that both are and are not evident

in the scientific literature. It is possible that uninformed values or beliefs that are formed without scientific basis may have also contributed. Since Ali (2000) reported that the health professional in the McArthur study had also expressed concern for the lack of opportunity for knowledge to be passed to affected parties in order that they make fully informed value judgments, this is likely. However, it is noteworthy that communities have at times played a large role in contributing scientific knowledge to the assessments at both proponent and panel level. Therefore, perhaps assessors have been overconfident when using value judgments and personal expertise as a source of information and have not felt the need to consult scientific literature. Also, the different federal departments, provincial departments, proponents and communities have different value sets, which in itself could have overridden a conscientious search for knowledge. In this respect there may be a lack of buy-in for knowledge.

Scope limiting policies

Environmental assessments have not been conducive to the consideration of such a wide range of health factors that have been discussed with respect to mining operations in the scientific literature. Some policies that have been used at the government level to guide the panel have limited the potential scope of impacts identified or reported in the process. For example, the instruction to identify priority issues may be interpreted to suggest that a select few among potentially many should be addressed. Since the MEME (Multiple Exposure Multiple Effects) framework (World Health Organization, 2005a) highlights the significance of a number of exposures on the overall health and well being of a person, this issue will become increasingly important as this framework progresses from its current role as a tool for *child health* policy and becomes mainstream. As a result, in the future, a health impact assessment will need to take into account the sum of the different exposures a worker may be exposed to rather than each exposure singularly. In this case, the concept of identifying priority issues will become defunct.

Another potentially scope limiting policy is the instruction to consider compliance without complementary instruction to comment on the overall acceptability of project. There are many drawbacks to relying only on compliance. The drawbacks include: the time lag between knowledge and legislation, which prevents new knowledge from being accepted into the process; the many human health impacts that are regulated indirectly through environmental legislation, which limits the context in which the impact can be considered; and the fact that social impacts are not subject to legislation. However, this does not explain the limited consideration of occupational exposures at the government and panel level exercises, indicating that there are other issues involved.

Ambiguity appears to have also played a role in the scope. The Cheviot Coal case is a very clear example of this, where very clear and specific expectations of health impact assessment were placed within an ambiguously titled heading, "contingency," in the Terms of Reference published at the governmental level, which may have downplayed the necessity for specific occupational exposures to be discussed or reported at the panel level.

The restriction of reporting at the panel level has also presented challenges to the range of impacts explicitly considered, at least to the decision-making phase. However, it isn't evident whether these are self-restricting exercises or proponent driven. One panel commented that it had restricted its reporting due to the confidentiality of a simultaneous IBA process. In other scope restricting exercises, panels had not discussed human health impacts identified by the proponent in their reports. It would seem necessary for panels to at least comment on these issues if transparency is to be maintained. This may have other advantages too, for example, it may reduce the frequency that the voluminous proponent's reports are read thereby reducing long-term costs. Earlier, the possibility of proponent driven assessments has been identified, and there is evidence that this has occurred in the past. For instance, Ali (2000) reported that the health professional on the McArthur River panel had felt isolated from panel and pressured to resign. However, this occurred under the EARPGO 1984 framework when Environmental Impact Statements were submitted by proponents. Environmental Impact Statements

have since been replaced by Environmental Assessment Study Reports. Nevertheless, this does raise concern as to the impact of the conflict of interest, which regulatory bodies find themselves in, as Andrews (1988) identified.

Utility of scoping phase

The scoping phase has been largely independent of the appraisal phase and has therefore had a limited role in the past. Several questions are raised when some of the procedures that were not consistently used in all the case studies are considered. One would expect that a clear instruction to consider human health issues, having a health expert on the panel, and the provision of information relating to human health issues would result in a wider scope of human health issues, but this appears not to be true. There is little difference in the size of the range of health impacts identified in each case study. This may be explained by the change in scope at the proponent level and again at the panel level, which is consistent with an ineffective scoping phase. Once more, it needs to be acknowledged that without further scoping by the proponent and panel at the public hearing stage the range of health impacts identified would have been greatly reduced.

More attention should be given to scoping out the specific key issues that should be identified at the scoping stage. The proponent should then describe how these will be addressed in the project, which the panel should then evaluate. It may be that it's just a case of knowledge coming into play much too late in the process and the results of this work do show that many issues are incompletely discussed due to this reason. For example, in the Cheviot Coal case study, the panel discussed workplace hazards only after a judge had ruled that an underground alternative should be considered. However, the Terms of References issued to the proponents have put the onus on the proponent to identify the key issues in the past. This could indicate a trade off between government funded and proponent funded activities but there could be other reasons other than cost: the need for flexibility or lack of buy-in for health and other issues discussed above. There is also the possibility that health impacts are being edged out over issues of the natural environment as Gibson (2002) suggests. However, since there is no evidence of a

learning curve and no real evidence of a differentiation between evidence of *good* and *bad* examples of case studies, I can only speculate. However, it seems probable that procedural challenges have occurred on a broad level and therefore are perhaps rooted in the framework. In any case, since the scoping phase should be an effective pre-cursor to the appraisal phase, it seems clear that the identification of specific health issues should occur prior to the proponent's assessment.

Another complication is the involvement of affected communities at the scoping phase. Key issues have not been identified at the government level in cases where communities have been involved. In these cases legislation is essentially repeated and the panels have assumed most responsibility for scoping. Many potential scenarios arise here. Perhaps there may be a disagreement between government and community as to which of its values are scientifically valid and warrant assessment or it may be that the community does not trust the government at this phase or that the community does not want to commit to a narrow scope and would prefer the panel to narrow it down. Since there has ultimately been no impact on the final scope of health impacts identified, this has not been important in the past. However, if scoping is going to be more prominent at the government and initial panel level, this may become more important in the future.

Individualized processes

The lack of consistency in both the procedures followed throughout the processes and the scope of health factors considered in the case studies reviewed here indicates that participants have exercised a high degree of autonomy. To some extent, this may be expected as each process involves different federal departments, provincial departments, panels, proponents and communities each with different expertise, with each group inherently containing different value sets and behavioural characteristics. However, this may be one of the most important challenges in attaining consistent consideration of human health. This challenge has perhaps been exacerbated by the ambiguous legislation and lack of guidance with respect to the health impact assessment component of integrated environment assessment process and framework. Without specific guidance, there has been a challenge to promote

the consideration of the known scope of potentially significant health factors associated with the mining industry.

The trade-off between rigidity and flexibility of the process must be acknowledged. It is important to retain some flexibility to enable each assessment to be individualized with respect to mining activity, affected populations and stakeholder specific value judgments, and allow a progressive pattern of learning. However, since the success of each process has been similar in the past and without evidence of a trend in the procedures followed at the government and panel levels (see tables 7.1-7.3), there is no evidence of an overall learning curve in place. This is in contrast to the characteristics of the proponents' work over time that does illustrate a learning curve (see table 7.3). As such, the proponent's shift in scope is contributing to the comprehensiveness of the assessment and therefore the success. Even so, the large amount of flexibility afforded to the process at the scoping phase has presented challenges to health impact assessment in Canada. Also, it is possible that lack of government wide buy-in for comprehensive consideration of public health issues may have led to the ambiguity used in the Terms of References. Therefore, the introduction of clear but broad instruction and expectations of health impact assessment requirements in a guideline format may improve the progress and consistency of the health impact assessment component.

Decision-making phase

Although many health impacts considered in the panel report are considered at the decision-making phase, it is evident that there are some omissions. This may be partly due to a difference between the scope identified in the panel's report and the scope of health impacts that feature in the panel's recommendations to which the decision-makers directly respond. It is also evident that decision-makers have taken steps to incorporate instructions to complete or carry out additional assessments of human health impacts in conditions for assessment, indicating that there is buy-in of health issues at this final decision-making phase. As this contrasts the low level of buy-in at the scoping stage, a system that

ensures each process is built upon the experience of prior cases would likely raise the level of buy-in at this early phase and therefore raise the overall quality of the process.

8.2.3 Guidance in the Canadian Handbook on Health Impact Assessment

Expectations

For the health impact assessment of proposed mining operation to be effective in Canada, the following expectations for Canadian Handbook on Health Impact Assessment need to be addressed.

These are:

- To address all participants in the process and decision-making phases
- To deliver a clear expectation of a health impact assessment component of environmental assessment
- To provide specific guidance with respect to scoping exercise, especially specific health impacts to scoping exercise
- To promote the identification of numerous impacts
- To promote the use of scientific knowledge
- To encourage explicit reporting and reinforce importance of transparency
- To facilitate a learning curve

The ability of the Canadian Handbook on Health Impact Assessment to fulfill these expectations is discussed below.

Intended audience and scope

The Canadian Handbook on Health Impact Assessment is an information package of broad scope and contains a wealth of guidance for all stakeholders including environmental practitioners, government agencies and panels directly involved in the governmental side of environmental assessment process, including decision-makers, health experts, proponents and consultants or professionals who are considered external to the governmental process. The information is provided at both a general and specific level and touches upon many aspects of health impact assessment, reaching beyond the scope of this thesis.

Clarity of expectation

There is a clear expectation of a health impact assessment component of environmental assessment throughout the handbook. The message that health impact assessment is a requirement of environmental assessment is delivered in many ways, as is illustrated by the different chapters that address the history of health impact assessment, recommended procedures, an approach to health, use of traditional knowledge and methodological tools among many others. However, methodologically, the expectations for environmental assessment practitioners and proponents are inconsistent, which may not be conducive to an effective process and does not attend to the need to unite the scoping and appraisal phase. In fact, this inconsistency is evidence of a confusion of roles and needs to be addressed if health impact assessment is to be consistently addressed in environmental assessment processes.

Provide specific guidance with respect to scoping exercise, especially specific health impacts to scoping exercise

The handbook is very informative with respect to the scoping exercise and provides specific instructions. For example, the consideration of negative and positive impacts is encouraged as are various hazard categories, exposure pathways, exposure conditions (environments) and effects on physical health and social well-being. The handbook also addresses bringing specific issues further forward in the process by guiding these in the proponent's project description, as discussed above, putting the onus on the proponent to identify pertinent issues.

Number of impacts

In the handbook it is advocated that it is unreasonable to expect a wide range of impacts to be assessed in an environmental assessment, which contradicts the needs identified in this thesis. However, the proponent is expected to provide this information together with exposure pathways and likely effects within the project description that is presented to a government agency prior to the initiation of an environmental assessment process. This would appear to require proponents to have carried out a basic

level assessment for numerous impacts prior to the assessment. The scoping exercise would then act as filter to select the priority issues. This does retain the burden of cost to the proponent but it appears to contrast specific objectives of environmental assessment such as public participation (Canadian Environmental Assessment Agency, 2004; Health Canada, 1999a), transparency and as an integrated planning tool (Canadian Environmental Assessment Agency, 2005). Additionally, since this appears to be potentially the most important stage in the process, there should be guidance for this step, which the handbook does not provide.

Promote the use of scientific knowledge

The Canadian Handbook on Health Impact Assessment advocates the combining of science, people and feasibility for an effective assessment. However, science is really only discussed in the context of attaining levels of significance within the appraisal phase. For instance, the use of literature reviews is discussed along with expert experience, public input, case studies and social impact assessments as tools to attain the significance of an impact but not to identify the impact itself. However, this is to be expected as this reflects the discussion found in the environmental assessment literature, which is focused on methodologies and tools that analyze risk or identify values rather than at the simpler level that acknowledges the body of scientific knowledge as an integral tool to health impact assessment, as outlined in the literature review for this thesis, see sections 3.1.3 and 3.1.5.

The Canadian Handbook on Health Impact Assessment includes a chapter on the importance of value judgments, which would be a great opportunity to discuss the benefits of informed value judgments, where stakeholders make value judgments in the face of scientific knowledge, however, this discussion does not occur. However, a discussion on the dangers of risk perception in the context of the identification of key issues does appear in the section relating to risk assessment and risk management, and therefore appears to be ill-placed.

The handbook also gives specific guidance of the potential role of health professionals, including occupational hygienists and those in health agencies who are able to provide pertinent knowledge. Occupational hygienists are singled out due to their specialist knowledge at the interface of health factors and health effects, relevant to both occupational and environmental exposures.

Encourage explicit reporting and reinforce importance of transparency

Transparency is only addressed on a level of public participation during the environmental assessment process that is very short-term and at an individual level. The handbook fails to explain the long-term value of explicit reporting or the benefits of full transparency of the process that would enable a true record of the process and therefore good quality information for later evaluation.

Facilitation of learning curve

The handbook facilitates a learning curve in two ways. Firstly, the handbook provides examples of methods, variables and information sources that have been used in environmental assessments in the past. Secondly, the handbook serves as a memory by listing examples of health impacts of specific industries including mining, albeit limited in number and scope.

8.2.4 Role of Impact Benefit Agreements

The Canadian Handbook on Health Impact Assessment warns against offering compensation for health arguing that it is a contradiction of people's core values of health. However, if human health is addressed in IBAs, it would seem that at least in the short term, affected mining communities are willing to trade here. Also, since IBAs are legal agreements and are carried out in the *honeymoon period* (McMahon & Remy, 2001) of a mine development when persons are likely to focus on the likely benefits of project, it is possible that affected communities may not feel satisfied in the long term. In fact, this could be said about mining companies too. In the face of potential long-term implications, it is therefore important that these issues are discussed in the forum of environmental assessment, where the direct influence of monetary compensation is removed and a judgment of acceptability at a general public level

can be made, rather than making the default assumption that an impact addressed at the IBA level is *acceptable*.

Due to their confidentiality, those issues considered both directly and indirectly with respect to human health in an IBA may not be addressed in an environmental assessment. For example, a panel may feel restricted in a discussion regarding the impact of increased wages on the overall health and well-being of a community, if wages had been discussed in the IBA without any direct reference to health. As such, IBAs are potentially encroaching on the potential transparency, comprehensiveness and overall effectiveness of environmental assessment. However, since IBAs have come about since the environmental assessment process has been lacking in the past, by not being efficient or effective in addressing the needs of affected communities, the likelihood that communities will relinquish control of this aspect to the government seems challenged. Coupled with the level of security assured for mining companies this prospect seems even further remote. In the absence of a resolution that would allow issues to be discussed in both the IBA and environmental assessment process, it is likely that, in the case of mining projects, IBAs will overshadow the environmental assessment process, unless the level of confidentiality is reduced. However, it is evident that IBA processes are increasingly exercising discretion and transparency.

The role of IBAs may alter and possibly be eliminated due to the recent changes in the environmental assessment legislation that has integrated a mediation option as an alternative for review by public panel. The current information available on the mediation process (Canadian Environmental Assessment Agency, 2003) does not indicate whether the process will be confidential or not and if the mediation option is similar in process and objectives as the IBA process, then those challenges that are associated with the IBA, will become integral to the Canadian Environmental Assessment framework.

8.2.5 Knowledge based challenges

The review of health science literature carried out for this thesis has shown that there are multiple health factors that are discussed in context of the mining industry, acting through different pathways,

which span both the workplace and community environments, and for both physical and social aspects. However, there is little knowledge regarding the relationship between health factors and the specific phases of the mining lifecycle.

8.3 Strengths and limitations

This thesis' strengths lay in the unique and innovative approach to evidence-based decision-making that led to a rare example of systematic and qualified evidence based policy analysis. Using the population of panel reviews that have been carried out in the past has maximized the access to evidence and therefore the quality of results. The size of the case study sample (4) is small for conclusive results. However, for analyses of this type, and at such a comprehensive level, the number is unusually high and, as such, has allowed more conclusive evidence than would normally be expected. Using the McArthur River case study to represent all the Uranium Developments may have reduced the quality of results for this case. However, this may have resulted in a bias towards this unusual group of environmental assessments and using all the case studies retained a balance to the analysis.

Another strength of the work is the range of environmental assessment documents that were used to extract data, although transcripts from the panel reviews were not used and could have been useful in detecting issues that perhaps were not included in the panel report. The utilization of initial project description may also have provided some additional insights as to the role of the scoping phase.

The Health Impact Assessment Evaluation Tool, developed as part of this study, was able to produce succinct snapshots of the range of human health impacts identified in environmental assessment. The tool proved to be versatile and performed excellently. The tool was able to demonstrate gaps in the use of knowledge in the case studies and the gaps in scientific knowledge. The tool also generated key informative insights at a broad level.

There are also some limitations to this work. The thesis looked at health impact assessment inclusively and there is a lack of comparison between other components of the environmental assessment process that could have indicated the degree to which health is integrated into the process and provided a better context to the results. Also, a retrospective analysis of case studies was used and therefore the results are at most an estimation of the potential for effective health impact assessment. As screening and

comprehensive studies were excluded from the analysis, the results are only indicative of what may be happening in these cases. Also on a general level, the analysis was to some extent subjective and the conclusiveness of results is limited by the lack of validation with regards to the interpretation of data and the critical analysis. Information gathered by interviews may have supported and clarified the results. In addition, the analysis failed to demonstrate the number of impacts considered in each category, which could have provided additional insights with respect to the comprehensiveness of the health impact assessment. On a specific level, since Aboriginal and non-aboriginal issues were not separated, variations in the scientific knowledge and consideration of human health impacts could not be observed.

The literature review of potentially significant health factors of the mining industry to establish state of knowledge was limited to peer-reviewed health science literature. Donoghue (2004) had reported that much information concerning the mining industry is not published in scientific literature but is often presented at conferences and this avenue was not examined. Donoghue (2004) and McPhee (2004) also used Health and Safety regulations in their reviews and this was excluded from this thesis. This thesis did not consider traditional knowledge or peer-reviewed social science literature.

8.4 Recommendations and suggestions for future research

8.4.1 Introduction

Since new tools and information have been produced as a result of this work, it is useful to comment on how these may contribute to the development of the environmental assessment framework. In this section I describe how this new information may be applied in the future as well as research that should be pursued in order that Health Impact Assessment in Canada continues to develop.

8.4.2 Recommendations

Adoption of tool

The Health Impact Assessment Evaluation Tool is a potentially significant contribution to the development of health impact assessment and the human health component of the integrated environmental assessment process and frameworks worldwide. The versatility of the tool means that it can easily be adapted to achieve different objectives and could prove useful as a guidance tool or checklist by participants at various stages of the environmental process, including panels, proponents and practitioners at the government. The tool could also be used as an evaluation tool as it has been used here and has applications to all economic developments, not just the mining industry.

Timing of IBAs

It would be prudent for IBA processes to benefit from health impact assessments. This could be achieved if environmental assessments are carried out prior to IBAs. However, since IBAs are linked to issues of consent, self-management and self-determination, it is evident that the process of consultation, whether formally linked to an IBA or not, should occur at the planning phase of the project. It may be wise for mining companies and aboriginal groups to include the environmental assessment process as part of a broader consultation process. If IBA and environmental assessment processes are to be integrated, or in parallel, the IBA processes should not restrict, or have the potential to restrict, the discussion and reporting of human health issues during the legislated environmental assessment process.

Changes in legislation

There are some challenges that have been identified that would be better addressed within legislation and relate to the ambiguity of the need for health impact assessment. I recommend that the legislation should be as explicit about human health as it is with respect to the natural environment and include specific health issues. For example, specify "any change that the project may cause in the environment... on human health...and biophysical and social impacts on worker and community health."

Review of objectives of environmental assessment process in Canada

Important health factors may be ignored due to the narrow boundaries that are currently in place. Shifting from the selection of a few risks for sophisticated analysis to a more broad analysis that captures the range of potential impacts may be a more useful exercise. This would facilitate an analysis that adheres to the MEME (Multiple Exposure Multiple Effects) model and principles.

There also needs to be a discussion regarding the balance of natural environment and human health within the environmental assessment process. Since social benefits will likely appear to outweigh the sum of occupational, environmental and social risks in each case, provisions should be made for adverse risk to play a primary role.

In order to achieve these, there should be a review of objectives of the integrated environmental assessment process in Canada at the framework level, which should result in the publication of explicit objectives so that there is a consensus and clear understanding of the role of health impacts assessment, environmental assessment and the role of knowledge in these processes by policy makers, panels, public participants and other stakeholders. Consideration should be given to role of mediation processes and Impact Benefit Agreements. Any developments should be monitored.

Continuing development of Canadian Handbook on Health Impact Assessment

In order that there is a learning curve in the development of health impact assessment in Canada, the Canadian Handbook on Health Impact Assessment (Health Canada, 1999a; 1999b; 1999c) should be updated with respect to the findings of this thesis and should be updated as new developments are made in the health impact assessment and environmental assessment field⁴. A continual process of updating should be sustained.

8.4.3 Suggestions for future research

In order to expand the scope of knowledge regarding the effectiveness of health impact assessment, future research should perhaps focus on an evaluation of more recent screening and comprehensive studies. Also, studies in the future should look at the consideration of multiple exposures that has not necessarily been a feature of health impact assessment in the past since the MEME (Multiple Effects Multiple Exposures) model (World Health Organization, 2005a) is an emerging knowledge.

In the political science field, more research is required on the impact of IBAs on environmental assessment. There is also a need for a closer look at informed decision-making and the influence of knowledge in value judgments. Research is also required in the health science field to address the lack of knowledge regarding health factors over development lifecycles and the application of knowledge from other industries, for example, other natural resource industries and the construction industry in the environmental assessment process. McMahon and Remy (2001) reported that the construction phase is most significant for social impacts. I think this could be also be true for occupational hazards, especially in the case of underground mining, where workers commonly work in blind airways and workers may be inexperienced. These issues need to be examined.

⁴ The Canadian Handbook on Health Impact Assessment has been updated since this work but many outstanding issues that have been identified as a result of this study remain.

9.0 CONCLUSIONS

Health impact assessment has been used to inform decisions regarding the economic development of mining projects in Canada. However, the health impact assessment process itself, which is used to inform decision-making, has been lacking with respect to consideration of health factors. Exposures in the occupational and social settings are particularly lacking. The highly individualized processes of the past have been characterized by a general lack of use of knowledge, scope limiting policies and ambiguous instruction with respect to human health at the government level, which have led to shortcomings in the range of health factors considered in each case.

The Canadian Handbook on Health Impact Assessment (Health Canada, 1999a; 1999b; 1999c) has considerable potential to improve upon the health impact assessment practices of the past. The clear expectations of a consideration of human health and specific guidance on the scoping phase that is delivered in this media addresses the challenges of the past and will likely bring consistency to the health impact assessment of mining projects in the future. However, in order to maximize the potential, the handbook should be supplemented with guidance on the use of scientific knowledge and the benefits of transparency. Regular updating will ensure a development of health impact assessment.

The effectiveness and future development of health impact assessment may be threatened as a result of current policies and these issues need to be discussed at a broad level of Environmental Assessment. There needs to be a discussion regarding the objectives of the environmental assessment, as currently presented, which appear counterintuitive to the paradigm of health impact assessment. Since there is evidence that the IBA process may have directly and indirectly affected the consideration of human health concerns at the environmental assessment and have the potential to negatively impact the development of health impact assessment in the future, there also needs to be a discussion regarding the future role of Impact Benefit Agreements (IBAs). This discussion needs to extend to the role of the mediation option, which has recently been introduced to the Canadian Environmental Assessment framework, if there is a potential for transparency to be compromised.

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APPENDIX I

RAW DATA for Health Impact Assessment Scope Evaluation Tool

Health factors and relevant information considered in the environmental assessment of the McArthur River project proposal

Health Impact Category	Health factors considered in proponent's report	Health factors considered in panel's report
ENVIRONMENTAL HEALTH FACTORS		
Physical environment (workplace)		
	Drilling	Rock stress conditions in context of mine safety
	Blasting	Underground lighting standards
	Rock removal	Mine ventilation - adequate supply of fresh air to workers
Direct exposure to safety hazards	Rock fall in disaster scenario, ground falls underground On-site traffic - injuries/fatalities Open holes Mobile and stationary equipment - accidents/incidents Explosion - disaster scenario Mobile equipment as fire risk Other fire risks	
Direct exposure to physical hazards	Exposure to extreme cold Exposure to extreme heat	
	Working with potentially hazardous substances including chemicals and radioactive materials	Radiation
Direct exposure to chemical hazards	Uncontrolled release of chemical material/disaster Radiation dose, arsenic, nickel, copper, lead Ionizing radiation, gamma radiation, radon progeny underground	Water into worksites. General health reference; referenced to EIS discussion: radiation dose, arsenic, nickel, copper, lead
GENERAL HEALTH REFERENCE of direct exposure hazards	Objective to provide employees with working environment free of hazards and to eliminate and control all potential risks to health and safety Proponent to monitor and evaluate contractors by same health and safety standards (recognition of construction phase)	Aged Radiation and Health and Safety regulations
Notes on direct exposure hazards (phases)	Specific in explaining the proponent was talking about operation phase and that was going to apply the same rules to construction phase	
Ecosystem mediated exposure to chemical hazards	Radiation dose, arsenic, nickel, copper, lead; all three phases analyzed (heavy metals and radiation); resistance by proponent to modeling	Discusses water quality and IMPACT model results; considers same chemicals by default; not discussed by phase in panel report, but referenced to EIS
Physical environment (Affected community)		
Direct exposure to safety hazards	Closure - shafts capped to prevent injury	Traffic - accidents
Direct exposure to chemical hazards	Radionuclides and heavy metals (inc arsenic) in drinking water; radiation dose, arsenic, nickel, copper, lead; all three phases analyzed	Discusses water quality and IMPACT model results - consider same chemicals by default. Not discussed by phase in panel report, but referenced to EIS
Direct exposure to chemical hazards	Radionuclides and heavy metals (inc arsenic) in drinking water (Radiation dose, arsenic, nickel, copper, lead; all three phases analyzed; resistance by proponent to modeling but panel agreed to low risk in report	Discusses water quality and IMPACT model results - consider same chemicals by default. Not discussed by phase in panel report, but referenced to EIS
GENERAL HEALTH REFERENCE of direct exposure hazards	To promote physical and mental well-being of residents in communities Conclude no local, regional or cumulative health risks to members of the public	
Direct employment and income pathway	Anxiety about health of prospective employees	

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Indirect community pathway	Fear of environmental pollution – anxiety	Fear of environmental pollution – anxiety
SOCIAL HEALTH FACTORS		
Employment and working conditions		
General (social) determinants		
Direct employment and income pathway	Physical and mental well-being of all employees and residents of the communities in which it operates	
		Examples of broad determinants of health (6) (positive context)
Indirect community pathway		Panel reported that provincial health authority had completed a literature review on potential physical health effects of uranium mining on adjacent human populations. Recommendations were to be made later – partial consideration (context both positive and negative)

**Health factors and relevant information considered in the environmental assessment of the
NWT Diamonds project proposal**

Health Impact Category	Health factors considered in proponent's report	Health factors considered in panel's report
ENVIRONMENTAL HEALTH FACTORS		
Physical environment (workplace)		
Direct exposure to safety hazards	Blasting (safety)	Visibility in pit due to ice fog
	Fire hazards	
	Safety of truck drivers - require rest breaks and required to work in pairs	
	Visibility due to windstorms and snow falls	
	Encounters with wildlife (attacks)	
	Hazards of air travel	
	Road vehicle safety	
	Stability of ice roads (drowning in cold water)	
	Slope failure - open pit	
	Roof falls - underground	
	Flooding underground	
	Icy, slippery ground - slips, trips and falls	
	Confined workspaces	
	Shaftsinking	
	Ventilation	
Direct exposure to physical hazards	Exposure to extreme cold	
	Exposure to noise	
Direct exposure to ergonomic hazards	Manual handling	
	Hand-arm vibration (drillers)	
	whole-body vibration (mechanics, truck drivers - prolonged sitting)	
Direct exposure to chemical hazards	Exposure to kimberlite dust	Exposure to diesel emissions in pit, when weather inversion
	Exposure to silica	
	Exposure to asbestos	
	Exposure to blasting fumes	
	Gaseous fumes in pit if inversion (weather) (respirable combustible dust (RCD), CO ₂ , CO, NO _x , SO ₂ , NH ₃ , aldehydes, PAHs (polycyclic aromatic hydrocarbons)	
	Exposure to ferrosilicon	
	Exposure to radiation (particulate matter/rock dust, x-ray units)	
	Welding (CO, CO ₂ , ozone, welding fume/metals, chromium, nickel)	
	Particulate matter	
	Chemicals (to be evaluated on a case-by-case basis) - general health reference	
	Exposure to blood borne pathogens (HIV/Hepatitis B etc) for mine rescue workers	
	Exposure to blood (Hepatitis B), water (Hepatitis A) and airborne (tuberculosis) pathogens from catering crew	
Direct exposure to biological hazards	Exposure to tapeworm from foxes	
GENERAL HEALTH REFERENCE of direct exposure hazards	Progressive health and safety policy	Comment regarding comprehensive consideration of worker health and safety
	Eight relevant Acts for Health and Safety	
	Health and safety policy for construction phase	
	Number of other statements re: health and safety policies; all GENERAL HEALTH REFERENCE	
Ecosystem mediated exposure to chemical hazards	Exposure to Ni, Al and radionucleides	

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Physical environment (Affected community)	
Direct exposure to safety hazards	Traffic ("will not have a significant effect on public safety") Backfilling of pits (post-closure)
Direct exposure to chemical hazards	Emergency response and spill contingency planning to prevent or minimize health effects Tailings Radionuclides and downstream users of water (radium-226 and Thorium-288, specifically re: human health) - unfinished topic
Ecosystem mediated exposure to chemical hazards	Downstream users of fish (non-specific phase)
SOCIAL HEALTH FACTORS	
Employment and working conditions	
Direct employment and income pathway	Remoteness Stress due to separation
Social support networks	
Direct employment and income pathway	In-migration and sexually transmitted diseases
Income and social status	
Direct employment and income pathway	Drug, alcohol and gambling considered with respect to social issues, however there are linked to poor health and social issues in section on baseline information - consideration therefore general health reference (no-consensus)
Indirect community pathway	Drug, alcohol and gambling considered with respect to social issues, however there are linked to poor health and social issues in section on baseline information - consideration therefore cursory (no-consensus)
General (social) determinants	
Indirect community pathway	Aboriginal participants feared they could not cope - anxiety

**Health factors and relevant information considered in the environmental assessment of the
Cheviot Coal project proposal**

Health Impact Category	Health factors considered in proponent's report	Health factors considered in panel's report
ENVIRONMENTAL HEALTH FACTORS		
Physical environment (workplace)		
Direct exposure to safety hazards	Electrical safety Explosive contractor Tire shop person Methane gas (explosion/spontaneous combustion) Presence of underground workings in construction phase of open pit (rock stability) Unsafe conditions, unstable ground conditions underground (identified after court case)	
Direct exposure of chemical hazards	Reagents for processing coal (as hazards)	
GENERAL HEALTH REFERENCE of direct exposure hazards	"Proponent will ensure that human health, well-being and safety of its employees are safeguarded by keeping abreast of relevant laws and regulations and updating of procedures" Mine inspectors will make frequent visits	Proponent offered to provide information on "other" occupational hazards if requested Mining is a hazardous industry
Physical environment (affected community)		
Direct exposure to safety hazards	Flyrock (general public) Public safety (general)	
Direct exposure to physical hazards	Exposure to noise (general public in vicinity of drilling) Exposure to noise in construction and operation phase – trucks Exposure to noise - underground option (identified after court case)	Exposure to noise
Direct exposure to ergonomic hazards	Exposure to vibration (general public in vicinity of drilling)	
Direct exposure to chemical hazards	Exposure to heavy metals - aboriginal communities (surface water quality) Coal dust/tailings and impact on general public Hazards of reagents including diesel fuel on site	Drinking water for Native communities (NON PHASE) Dust and gaseous emissions at construction and operation phase. "There will no significant effects on public health" Exposure to Particulate Matter Exposure to coal dust and volatiles in mines (general public, water users)
Ecosystem mediated exposure to chemical hazards	Bioaccumulation, heavy metals	Exposure to coal dust/PAHs through wildlife/fish; effects on public health. Health Canada concerned; Environmental Canada not concerned
GENERAL HEALTH REFERENCE (multi-pathway)		Proponent offered to provide information on "other" environmental hazards if requested

Health factors and relevant information considered in the environmental assessment of the Voisey's Bay project proposal

Health Impact Category	Health factors considered in proponent's report	Health factors considered in panel's report
ENVIRONMENTAL HEALTH FACTORS		
Physical environment (workplace)		
Direct exposure to safety hazards	General health reference that all accidents are preventable, injury free and safe working environment Aircraft transport – personnel Fire Construction safety Visibility in pit (snowstorm) Ice-shipping Snowmobiles falling through ice Ventilation underground	
Direct exposure to physical hazards	Exposure to extreme cold	
Direct exposure to chemical hazards	Welding fumes and gases	Exposure to nickel particulate - no consensus
Direct exposure to biological hazards	Bacteria and parasites in water and sewage; permanent camp	
GENERAL HEALTH REFERENCE of direct exposure hazards	Construction -phase: all contractors will provide EHS staff at site and conduct activities in accordance with plan; expresses different phases	Expert submitted many occupational health issues Health and Safety plan appeared satisfactory
Direct employment and income pathway	Accidental events and effects on families	
Physical environment (affected community)		
Direct exposure to safety hazards	Reclamation - sealing of shafts (injury)	
Direct exposure to physical hazards	Low frequency noise	
Direct exposure to chemical hazards	Nickel, copper, aluminum	Exposure to nickel, copper, aluminum + mercury
Ecosystem mediated exposure to chemical hazards	Contamination of country foods (heavy metals); each phase. After panel requested additional information, mercury was modeled - but general reference to human health. Human consumption not modeled.	Panel asked for mercury to be modeled for human consumption
SOCIAL HEALTH FACTORS		
Employment and working conditions		
Direct employment and income pathway	Shift length Remoteness Job rotation Air travel and stress Isolation - work-related stress (workers and families) mood swings, sleep loss, anxiety, alcohol Lack of highly nutritious food (lifestyle)	Loss of homeland because of harvest disruption - spiritual health
Social support networks		
Indirect community pathway	In-migration and potential spread of sexually transmitted diseases	
Income and social status		
Direct employment and income pathway	Stress after closure of mine	
Indirect community pathway	Community stress (those who lack skills to work at site) Lower self-esteem from in-migration	
General (social) determinants		
Indirect community pathway		General impact on health - related to socio economic effects

APPENDIX II

State of knowledge of health factors 1953-1996 inclusive

Publications identified by keyword search of PubMed database

1. REVIEW DOCUMENTS USED TO IDENTIFY ADDITIONAL HEALTH SCIENCE LITERATURE

Donoghue, A. M. (2004). Occupational health hazards in mining: An overview. *Occupational Medicine (Oxford, England)*, 54(5), 283-289.

Stephens, C., & Ahern, M. (2001). Worker and community health impacts related to mining operations internationally. A rapid review of the literature. (25), 03 October 2001

McPhee, B. (2004). Ergonomics in mining. *Occupational Medicine (Oxford, England)*, 54(5), 297-303.

2. HEALTH SCIENCE LITERATURE IDENTIFIED IN LITERATURE REVIEW (organized by broad impact categories and initiation date of panel reviews)

PHYSICAL ENVIRONMENT (workplace)

Safety Hazards

State of knowledge prior to initiation of the McArthur River panel review, April 1991

Shy, C. M. (1979). Toxic substances from coal energy: An overview. *Environmental Health Perspectives*, 32, 291-295.

Koba, S. (1968). History of mining medical service in staropolskie zagłębie in the 1st half of the 19th century. *Przegląd Lekarski*, 24(4), 445-449.

Kotania, W., Janik, M., Msciszewska-Baranowska, K., Binkiewicz, E., Klosowicz, K., & Nocon-Dukatowa, W. (1981). Blindness following injuries to the visual system in patients in a mining-industry health service hospital (author's transl). *Klinika Oczna*, 83(7-8), 349-350.

Watson, A. P., & White, C. L. (1984). Workplace injury experience of female coal miners in the united states. *Archives of Environmental Health*, 39(4), 284-293.

Boden, L. I. (1985). Government regulation of occupational safety: Underground coal mine accidents 1973-75. *American Journal of Public Health*, 75(5), 497-501.

Bellucci, L. P., Ligeri, E., & Loi, A. M. (1989). Description of an accident in the Carrara marble mines. *La Medicina Del Lavoro*, 80(6), 506-511.

Additional state of knowledge for the NWT Diamonds panel review, April 1991 and December 1994 (exclusive)

Hodous, T. K., & Layne, L. A. (1993). Injuries in the mining industry. *Occupational Medicine (Philadelphia, Pa.)*, 8(1), 171-184.

Hunting, K. L., & Weeks, J. L. (1993). Transport injuries in small coal mines: An exploratory analysis. *American Journal of Industrial Medicine*, 23(3), 391-406.

Lee, T., Anderson, C., & Kraus, J. F. (1993). Acute traumatic injuries in underground bituminous coal miners. *American Journal of Industrial Medicine*, 23(3), 407-415.

Physical Hazards

State of knowledge prior to initiation of the McArthur River panel review, April 1991

Shearer, S. (1990). Dehydration and serum electrolyte changes in south african gold miners with heat disorders. *American Journal of Industrial Medicine*, 17, 225-239.

Bell, C. A., Stout, N. A., Bender, T. R., Conroy, C. S., Crouse, W. E., & Myers, J. R. (1990). Fatal occupational injuries in the united states, 1980 through 1985. *JAMA : The Journal of the American Medical Association*, 263(22), 3047-3050.

Hessel, P. A., & Sluis-Cremer, G. K. (1987). *Hearing loss in white South African goldminers*. SOUTH AFRICA:

Additional state of knowledge for the Cheviot Coal panel review, between December 1994 and October 1996 (exclusive)

Berglund, B., Hassmen, P., & Job, R. F. (1996). Sources and effects of low-frequency noise. *The Journal of the Acoustical Society of America*, 99(5), 2985-3002.

Ergonomic Hazards

State of knowledge prior to initiation of the McArthur River panel review, April 1991

Chatterjee, D. S., Petrie, A., & Taylor, W. (1978). Prevalence of vibration-induced white finger in fluorspar mines in Weardale. *British Journal of Industrial Medicine*, 35(3), 208-218.

Brubaker, R. L., Mackenzie, C. J., & Hutton, S. G. (1986). Vibration-induced white finger among selected underground rock drillers in British Columbia. *Scandinavian Journal of Work, Environment & Health*, 12(4 Spec No), 296-300.

Bovenzi, M., Franzinelli, A., & Strambi, F. (1988). Prevalence of vibration-induced white finger and assessment of vibration exposure among travertine workers in Italy. *International Archives of Occupational and Environmental Health*, 61(1-2), 25-34.

Village, J., Morrison, J. B., & Leong, D. K. (1989). Whole-body vibration in underground load-haul-dump vehicles. *Ergonomics*, 32(10), 1167-1183.

Additional state of knowledge for the NWT Diamonds panel review, April 1991 and December 1994 (exclusive)

Narini, P. P., Novak, C. B., MacKinnon, S. E., & Coulson-Roos, C. (1993). Occupational exposure to hand vibration in northern Ontario gold miners. *The Journal of Hand Surgery*, (18A), 1051-1058.

Additional state of knowledge for Cheviot Coal Project Proposal review Health factors between December 1994 and October 1996 (exclusive)

Dasgupta, A. K., & Harrison, J. (1996). Effects of vibration on the hand-arm system of miners in India. *Occupational Medicine (Oxford, England)*, 46(1), 71-78.

Chemical hazards

State of knowledge prior to initiation of the McArthur River panel review, April 1991

Lainhart, W. S. (1969). Roentgenographic evidence of coal workers' pneumoconiosis in three geographic areas in the United States. *Journal of Occupational Medicine. : Official Publication of the Industrial Medical Association*, 11(8), 399-408.

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Sluis-Cremer, G. K. (1970). Asbestosis in South African asbestos miners. *Environmental Research*, 3(4), 310-319.

McDonald, J. C., McDonald, A. D., Gibbs, G. W., Siemiatycki, J., & Rossiter, C. E. (1971). Mortality in the chrysotile asbestos mines and mills of Quebec. *Archives of Environmental Health*, 22(6), 677-686.

Morgan, W. K., Burgess, D. B., Jacobson, G., O'Brien, R. J., Pendergrass, E. P., & Reger, R. B. et al. (1973). The prevalence of coal workers' pneumoconiosis in US coal miners. *Archives of Environmental Health*, 27(4), 221-226.

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Hobbs, M. S., Woodward, S. D., Murphy, B., Musk, A. W., & Elder, J. E. (1980). The incidence of pneumoconiosis, mesothelioma and other respiratory cancer in men engaged in mining and milling crocidolite in Western Australia. *IARC Scientific Publications*, (30)(30), 615-625.

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Additional state of knowledge for the NWT Diamonds panel review, April 1991 and December 1994 (exclusive)

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APPENDIX III

Notes on evidence of consideration of health factors in the final decisions

Notes on evidence of consideration of health factors in the McArthur River decision

	Provincial response	Federal response
Government's approach	Government's position (Ministers Decision and governments response)	Governments response
Environmental health factors	Province assures that projects will provide for the health and safety of workers (general health reference) Incorporated radiation exposure standards into lease agreements* To review the Mines Regulations (general health reference)* To enforce new standards of occupational and health safety (general health reference) To continue involvement in health study of uranium workers To ensure frequent inspection of mines* (general health reference) The public health act, health services act, public eating establishments regulations, sanitation regulations: explicitly linked to public health (general health reference)	Priority to ensure that uranium mine sites will not pose any undue risk to the health and safety of the local people (general health reference) Panel concluded that the mine should provide adequate shielding for underground workers from exposure or radioactive ore and contaminated water or air Remind proponent of importance of ALARA principle with respect to exposure to radiological protection Exposure to radon gas and progeny* plug holes Potable water for mine site (with respect to mine effluent)/ Assumed to be chemically related Underground workers depend on mine regulators to ensure safe workplaces (general health reference) Occupational safety laws Radiological health protection Health and safety regulations (general health reference)
Environmental health factors	Long-term vitality (health) of northern communities with respect to environmental contamination (no pathways discussed)*	Monitoring of northern food web should be continued. Monitoring of country foods
Social health factors	Saskatchewan health committed funds for development of baseline community health status assessment* Discussions to link Environmental Quality Committees and empergine northern health boards and uranium industry to be facilitated *	

Notes on evidence of consideration of health factors in the NWT Diamonds decision

	Federal response
Government's approach	Governments response
Environmental health factors	Air quality program most likely to be establishes to monitor air quality as it relates to occupational health and safety and/or mine safety and therefore regulated under GNWT legislation
Environmental health factors	None
Social health factors	None

Notes on evidence of consideration of health factors in the Cheviot Coal decisions

	Provincial response	Federal response
Government's approach	List of approvals and panel report	Governments response
Environmental health factors	Any discard material shall be disposed of in a manner satisfactory to prevent it from become a hazard to worker or public safety (assumed chemical as Coal Conservation Act)	None
Environmental health factors	Any discard material shall be disposed of in a manner satisfactory to prevent it from becoming a hazard to worker or public safety (assumed chemical)	None
Social health factors	None	None

Notes on evidence of consideration of health factors in the Voisey's Bay decision

	Provincial response	Federal response
Government's approach	Government's position (Ministers Decision and government's response)	Governments response
Environmental health factors (workplace)	None	Health and safety program
Environmental health factors	Proponent to implement a program to monitor contaminants levels in country foods, including collection baseline data prior to commencement of construction	Supports provincial decision with respect to country foods
Social health factors	None	None

APPENDIX IV

Summary of observations

Table of Conclusions. Research question 1.

	Research Question 1 Process
Overall	<ul style="list-style-type: none"> • Consistencies on broad level only • Key issues are identified throughout process
Scoping phase	<ul style="list-style-type: none"> • Government and/or panel have been responsible for scoping exercise/identification of key issues • Different degrees of intensity at/between government and/or panel level • There have been various approaches used in the assessment (objectives, purpose, instruction) • Wide range of methods have been used to identify key issues • Issues have mostly been addressed at a broad determinant of health level • There have been few instances where the expectation to consider human health is clear
Appraisal phase (proponent)	<ul style="list-style-type: none"> • Various methods have been used to identify health factors • Examination of regulations, literature review and collection of community values are common examples of methods used to identify health factors • Proponent's own expertise has been consistently used in the identification of health factors
Appraisal phase (panel)	<ul style="list-style-type: none"> • The range of issues that has been addressed is consistently beyond scope originally defined by panel <p>Human health issues have been raised as a result of:</p> <ul style="list-style-type: none"> • reports submitted by various parties • intervenors/participants raising issues • evolution of discussion from natural environment • an integrated approach to review (in one case)

Table of Conclusions. Research questions 2, 3 & 4

	Research Question 2 Health factors	Research Question 3 Performance (use of science)	Research Question 4 Impact on decision
Overall	<ul style="list-style-type: none"> • Range of health factors greater at proponent level than at panel level • cursory consideration of occupational and social health factors at panel level • Specific consideration of environmental health factors at panel level • Chemical and safety hazards are predominant • Lifecycle has sometimes been addressed at proponent level, though this has rarely been made explicit at panel level • Discussion has not always been conclusive • Consensus has not always been evident 	<ul style="list-style-type: none"> • The health factors identified have been somewhat consistent with the state of knowledge • There has been inconclusive discussion and lack of consensus in circumstances where knowledge has existed 	<ul style="list-style-type: none"> • For the most part, human health issues have had some influence on the final decisions; provincial and federal level; most consistently at provincial level • Consideration of human health has not normally influenced final decisions where discussion has been inconclusive at panel level or there has been evidence of lack of consensus
Occupational health factors	<ul style="list-style-type: none"> • Direct exposures to safety, physical, ergonomic, chemical and biological hazards; ecosystem mediated exposure to chemical hazards and impacts through social pathways have been identified, albeit inconsistently • Panels have consistently given at least cursory consideration to occupational hazards, albeit non phase-specific • Proponent has often given cursory consideration to hazards in construction phase 	<ul style="list-style-type: none"> • Specific hazards that occur through direct exposure pathway have been omitted at panel and/or proponent level 	<ul style="list-style-type: none"> • Consideration of human health at panel level has sometimes influenced the final decision, even where discussion has been inconclusive; i.e. judgment has been made in absence of complete information in panel report
Environmental health factors	<ul style="list-style-type: none"> • Identification of direct and ecosystem mediated exposures to chemical hazards has been consistent at panel level • Direct exposures to safety, physical and ergonomic hazards and impacts through social pathways have been identified, albeit inconsistently 	<ul style="list-style-type: none"> • Identification has been consistent with state of knowledge • Some health factors identified have been extra to state of knowledge (in health science literature); specifically safety hazards through direct exposure pathway and impacts through indirect community pathway 	<ul style="list-style-type: none"> • Consideration of human health at panel level has sometimes influenced final decision
Social health factors	<ul style="list-style-type: none"> • Health factors pertaining to employment and working conditions, social support networks and income and social status have been identified, albeit inconsistently • Positive impacts through the social environment have often been identified cursorily 	<ul style="list-style-type: none"> • Identification has been generally mismatched with state of knowledge • There has been some matching of knowledge regarding employment and working conditions • Health factors acting in social support networks have been consistently omitted from proponent and panel's appraisal • cursory consideration of social determinants has predated health science literature 	<ul style="list-style-type: none"> • Consideration of human health at panel level has rarely influenced decision