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Climate Change and Environmental Assessment

Part 1: Review of Climate Change Considerations in Selected Past Environmental Assessments

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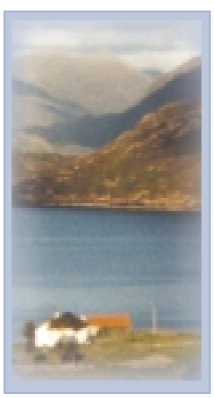
2001



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Executive Summary

Six projects subject to the *Canadian Environmental Assessment Act* (CEAA) or the Environmental Assessment and Review Process were reviewed to explore the consideration of climate and climate change in their design, planning, operation and, in one case, decommissioning. The following projects were reviewed: Diavik Diamond Mines, Cascade Heritage Power Park, Confederation Bridge (Fixed Link – Northumberland Strait), Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake, Little Bow Reservoir/Highwood Diversion and Dredging of the St. Lawrence River between Montreal and Cap à la Roche. These projects were selected because they have climate change impacts or medium to long lifetimes, and they represent a Canada-wide sample of Environmental Assessments (EAs). These projects are important because they have physical remains that could have environmental impacts for centuries. In one case, toxic remains will be a part of Canada's landscape for a millennium or more. In all cases, the physical remains will be subject to climate extremes, climate variability and climate change.

Climate change has been considered in all of these projects to varying degrees. This demonstrates that climate change is a shared concern for proponent and governments alike over the past decade. This review found examples where considerations of climate change has affected project designs and those where it did not. The extent to which climate change was factored into the EAs varied considerably; however, common appreciation for the impact of climate change was substantial. Improved science and sharing of knowledge will help build a stronger consensus on the potential impacts of climate change.

Summary of Key Findings

Data Related Issues

- The use of historical climate data in projects subject to EAs was widespread, including the consideration of norms, climate variability and extremes. Special studies were undertaken to determine, for example, probable maximum precipitation. Some proponents consider the use of historical data as an adequate indication of the future; others believe that climate change will remain within the range of historical natural variability.
- Observational records were inadequate in many projects examined. For projects sensitive to climatic elements, where nearby or adequate climate observational data do not exist, atmospheric observation systems should be considered when such projects begin. Such observation systems should be functioning during the operational lifetime of the project so that, during decommissioning phases, data may be used with high-quality, long-running reference climate stations to provide a baseline and for appropriate correlation studies.
- Projects used a range of techniques to measure the sensitivity of a project to climate change, including statistical modelling and analogues.

Scientific Issues

- Many issues revolve around the scientific evidence for climate change. Many feel that the evidence is inadequate and that knowledge about the future climate is not precise enough and too uncertain to have the confidence to act upon it. Also, many would like to provide better guidance but cannot provide quantitative answers to questions from proponents.
- Climate change science has influenced project design. Proponents and governments believed that enough was known about climate change to include some anticipated response (e.g. design or operational changes) in a project (e.g. Confederation Bridge [Fixed Link – Northumberland Strait Crossing], and Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake). Except in one project, where climate change was considered but not pursued, all others considered and incorporated climate change, each in different ways. Specialized studies were undertaken in some cases. Climate change considerations, including physical structures, aquatic environment, and flora and fauna were noted in many areas.
- In cases where climate change information was considered to be inadequate for making decisions, the need for contingency plans, as well as ongoing environmental monitoring that would trigger action when required, was recognized.
- No immediate "climate" tools are available for use in projects whose lifetimes are greater than 100 years. Consideration of climate change from the past, using periods commensurate with the lifetime of the project, may be the only way now to assess the potential range of climate that might be experienced in the next millennium. Given the virtual certainty that climate is changing, the dual issues of advice from climate change science on the one hand – and operation and safety in perpetuity on the other – warrants a further investigation and should be the subject of a future study.
- Recognizing that projections of human activities upon which projections of future climate and climate scenarios are based will remain uncertain for the foreseeable future, uncertainty expressed as a range of possible outcomes will always surround climate projections. Shortfalls in climate change science in meeting the needs of the EA community are recognized. A need clearly exists for improved knowledge about climate change. The portrayal of the future climate needs to be defined on as fine a scale as possible (given the limitations of the science). Uncertainty must be addressed and a range of probable futures made available to support sensitivity studies in those projects where climate change is considered an issue.
- Projections from general circulation models need to include more climate/weather variables and projections need to be interpreted and applied to engineering tools such as return periods of extreme events.

Practitioner Issues

- Environment Canada made recommendations in several cases where it considered climate change could be beneficial. Sometimes the Responsible Authority (RA) directed the proponent to undertake studies.
- A gap exists between needs and expectations from the EA community on the one hand and climate change science on the other. Those who must deal with engineering and design aspects are used to dealing with historical data sets and should consider information expressed in non-traditional ways. Climate change science can provide ranges of future climate conditions but not, as yet, in the form that is useful for proponents. Proponents should consider new ways to take into account available information while climate change scientists should formulate their information in such a way that is most useful to the EA community. Fora to promote interaction between climate change scientists and EA practitioners are required.
- Access to and communication of climate change knowledge among all parties involved in EA could be improved. At present, capacity is concentrated within government and universities. Mechanisms to distribute this knowledge to the consultant and proponent communities might include workshops, seminars and an Internet Web site. All parties involved in the EA process could benefit from this.
- There is support for the development of a formal guide for EA practitioners, proponents, RAs and consultants. Such a guide should:
  - provide links to the CEAA to set the context;
  - contain an education component covering what science is available, a description of climate change temporally and geographically, and a rationale explaining why climate change is important;
  - state the policy on climate change;
  - explain the manner in which climate change information flows through the various agencies and proponents;
  - provide a simplified decision tree to determine when climate change is potentially an issue, what specific (not general) factors and issues to consider and when climate change should be included;
  - include a checklist or step-by-step procedure to take climate change into account including sources of projections, techniques, methods, analyses, procedures, ranges and a list of specific scenarios to be evaluated and sensitivity studies to be conducted;
  - present information on the reliability and uncertainty of projections;
  - list/catalogue sources of climate change on the Web; and
  - prepare an annotated list of resources that are available both within and outside the federal system.

- Interviews were conducted as described in Section 8.2. Aspects that interviewees considered important are presented in Section 9.3. For example, an educational component, a decision-tree approach to determine when climate change should be considered, and information on the reliability and uncertainty of projections are three of the suggestions. A recommended method to apply climate change science to projects subject to EA is presented in Part II, Climate Change Guidance for Environmental Assessments, Section 4.
- Concerns about the appropriate procedures and policies regarding consideration of climate change were voiced and noted, but are outside the scope of this report.

Preface

This exploration of past projects reviews climate science, not EA procedures, processes or decisions. The investigator recognizes EA is a complex process. It determines which elements should be considered and the relative importance to be attached to them in the process, including climate change. There is no intention to cast doubt on or criticize decisions that were made in past assessments.

This investigation is based upon available documentation and recollections of experienced professionals. Except where useful commentary could be made, the investigation did not remark on the level of knowledge and understanding of climate change during the period that each project was underway. Nevertheless, with the benefit of today's knowledge about climate science, the investigator may identify scientific tools or knowledge that, given the same project in today's circumstances, *might* have been beneficial. In discussing such circumstances, future opportunities may be identified.

The author would like to thank the Advisory Committee, comprising representatives from the Agency's Research and Development Program and Environment Canada and two anonymous reviewers for their valuable comments during the preparation of this report.

Review of Climate Change Considerations in Selected Past Environmental Assessments

1. Background

The Canadian Environmental Assessment Agency (the Agency) funded this research through its Research and Development Program, 2000-2001. The Agency's priorities for 2000-2001 are:

- determining the significance of environmental effects;
- follow-up;
- human impact assessment;
- regional environmental effects framework; and
- integrating climate change considerations into environmental assessment (EA).

The research described in this report falls under the priority "integrating climate change considerations into EA."[1] The following paragraph is from the Agency's "Call for Proposals" and addresses Agency goals for this research theme:

> "Some aspects of Environmental Assessments under the *Canadian Environmental Assessment Act* address a project's direct impacts due to emissions of greenhouse gases. Related but different considerations are the biophysical and social changes brought about by climate change and their impact on development. Predictions made in Environmental Assessments are usually based on historical data. These may be rendered invalid due to large-scale climate change phenomena. The effects of long-term climate change may overwhelm the changes associated with an individual project, and may have to be taken into account in making predictions on environmental effects and proposing mitigation measures in Environmental Assessments of individual projects."

2. Research Objectives

The objectives of this research are to assist practitioners to address climate change when preparing EAs by:

- exploring new sources of knowledge on climate change that can assist in assessing potential impacts on projects; and
- developing options and recommendations on the methodology of incorporating climate change and climate scenarios into EAs in Canada.

These two objectives will assist:

- project reviewers within Environment Canada (EC); and
- Responsible Authorities (RAs) for projects.

3. Research Report Structure

This research has two parts. The first part, contained in this document, reviews climate change considerations in selected past EAs.

The second part is a companion document. It deals with the use of climate scenarios in EAs, including the methodologies, options and recommendations. This part uses recent deliberations from climate impact researchers and includes results from the ongoing Canadian Climate Impacts Scenarios Project.

4. Scope

Global climate change phenomena are projected to strongly affect Canada, especially in the North. This research will assist practitioners to better address these changes in reviewing EAs in all regions of the country. The research is needed to improve the consideration of climate change that entails predicting environmental effects, and establishing appropriate mitigation and follow-up in the EA of a project.

EAs of six past projects were reviewed and are reported on in this document. Each was selected in consultation with the Advisory Committee, comprising representatives from EC, and the Agency's Research and Development Program. Each project had a medium to long time horizon. Thus, it could or will be affected by climate change, or was included because climate change had been identified as an issue.

The selected projects are:

- Diavik Diamond Mines: Section 10.1
- Cascade Heritage Power Park: Section 10.2
- Confederation Bridge (Fixed Link – Northumberland Strait Crossing): Section 10.3
- Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake: Section 10.4
- Dredging of the St. Lawrence River between Montreal and Cap à la Roche: Section 10.5
- Little Bow Reservoir/Highwood Diversion : Section 10.6

This research deals principally with the aspect of climate change impacts on the project, not the effects of the project on climate change (i.e. greenhouse gas emissions related to a project are not within the scope of this research). Observations may be made about how project-induced environmental effects could be influenced by climate change; however, this will be of secondary importance.

5. Research Guidance

The Advisory Committee guided this research. The committee have guided the development and structure of this report, but the findings are those of the investigator.

6. Relevance to Past Decisions

This exploration of the six past projects reviews climate science, not EA procedures, processes or decisions. The investigator also recognizes that EA is a complex process – it determines which elements should be considered and their relative importance in any process, including climate change. There is no intention to cast doubt on or be critical of decisions that were made in past assessments.

This investigation was based on available documentation and recollections of experienced professionals. Except where useful commentary could be made, the investigation did not remark on the level of knowledge and understanding of climate change during the period that each project was underway. Nevertheless, with the benefit of today's knowledge about climate science, the investigator may identify scientific tools or knowledge that, given the same project in today's circumstances, *might* have been beneficial. In discussing such circumstances, potential opportunities for the future may be identified.

7. Climate Issues

Projects that have been subject to an EA process have traditionally employed *historical* climate data. Climatologists broadly accept that such a practice is no longer completely appropriate in many parts of Canada when planning for future projects with medium to long time horizons and that are sensitive to certain climate parameters. Understanding the evolution of the climate in recent decades has led to the conclusion that Canada's climate will change significantly in the future.[2]

Climate "normals" or averages are usually computed from the most recent 30-year period that ends with a complete decade (e.g. 1961-1990). While the averages computed in this way represent the recent past, they most likely do not represent earlier or future climates. For example, the average annual temperature in the interior of British Columbia (B.C.) was about 1.0°C colder at the beginning than at the end of the 20th century.[3] In the Great Lakes Basin-St. Lawrence Lowlands Climatic Region the annual temperature increase has been 0.9°C. Minimum temperatures in this region have increased by approximately 1°C while maximum temperatures have increased by 0.1 to 0.2°C.[4] One effect of these temperature trends is that the diurnal range of temperatures is diminishing. Further, the warming has occurred mainly during the winter and spring seasons. Changing average temperatures are usually accompanied by changes in the frequency of occurrence of extremes. An increase in average temperatures implies an increase in the frequency of extreme warm temperatures as well.[5]

These examples illustrate that changes to climate, usually described in terms of changing normals, extremes and variability is an ongoing process and not just something that will occur in the future. These measures of climate change over a period of decades and longer.

For context, during the Little Ice Age, 150-650 years ago,[6] the earth's temperature was, at its coldest, as much as 1°C lower than before its onset. Thus from a climatic perspective, a rise of 1°C in temperature normals over a 100-year period is a major change; this is what many parts of Canada have experienced over the last century. It is likely that average temperatures computed from a 30-year period at the beginning of the 20th century will be different than those computed at the end of the 20th century.

The previous examples illustrate observed climate change. "Climate change" is the term used by the Intergovernmental Panel for Climate Change[7] to refer to any change in climate over time, whether due to natural variability or human activity. The importance of climate change depends on the sensitivity of socio-economic aspects of human existence, physical structures, living organisms or physical processes in nature to changes in climate.

The following two examples illustrate typical issues and concerns of climate scientists that potentially relate to the *future* climate of Canada and to projects in different parts of the country.

1. The climate in northern and central Canada is projected to change in the coming decades. Long-term changes in climate may be important in projects whose *lifetimes* are long enough to experience the effects of climate change, noting that the magnitude and elements of climate change vary geographically. One example of the effects of warmer temperatures might be to reduce the period of the year during which the ground is frozen. This, in turn, will affect the timing and time available for transportation in northern regions.
2. The water balance (comprising the sources, sinks and water stored in the ground, rivers and lakes) is anticipated to be affected in many parts of southern Canada. Warmer temperatures cause higher rates of evapotranspiration. This, in turn, can potentially affect the depth of water cover, soil moisture content and even groundwater storage. In addition, changes to water supply may affect the stability of wetlands with major consequences for their ecology.

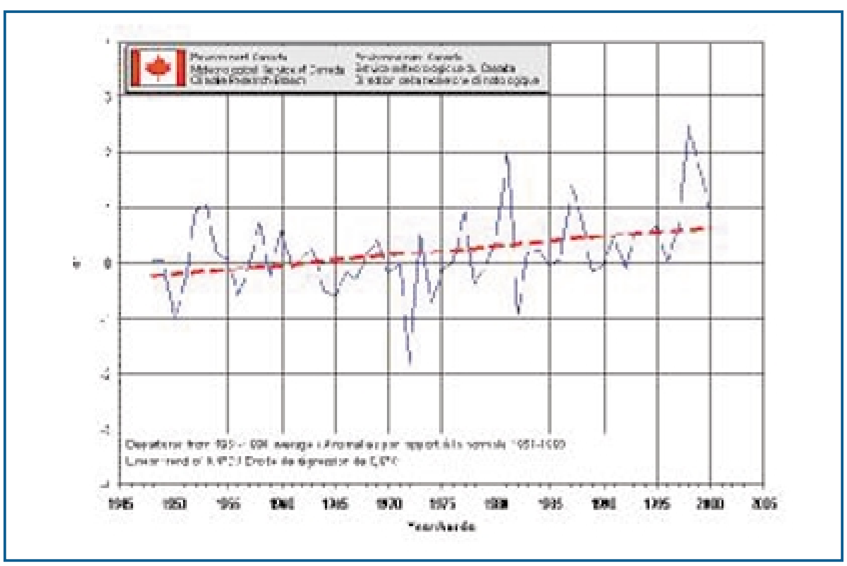

Figure 1. Annual national temperature departures and long-term trends, 1848–2000. Source: Climate Research Branch of Environment Canada.

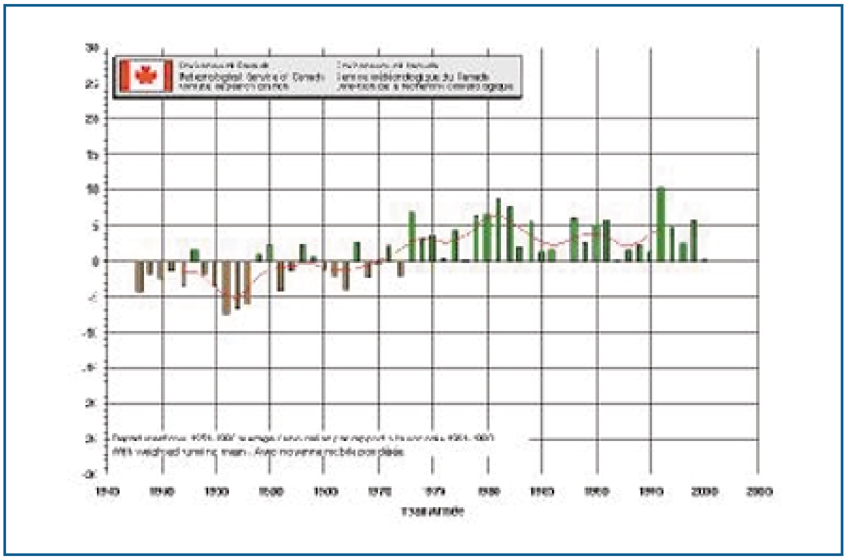

Figure 2. (right) Annual national precipitation departures with weighted running mean, 1948-2000. Source: Climate Research Branch of Environment Canada

The accompanying charts demonstrate climate variability and climate change. Climate variability is the year-to-year fluctuation in the climate record. Climate change is the longer-term change in the average condition. Note that for both precipitation and temperature, for Canada as a whole, the trend is towards more precipitation and warmer temperatures. Rarely has the climate been stable for long periods. Seasonal details can be viewed at http://www.msc-smc.ec.gc.ca/ccrm/bulletin/

8. Methodology

The investigation comprised a review of documentation, a series of interviews and the synthesis of findings. While the time frame for the study was restricted, the available documentation supplied much objective information about how climate change has been considered in past EAs. Interviews also provided an insight into issues related to climate change that may not have been recorded or available in the documents. These interviews are in effect complementary sources of information. For detailed information on documentation and from the interviews, the reader is referred to the appendices to this report. The synthesis of findings is under Section 11.

This investigation does not judge the relative importance of climate change or whether such a change is beneficial or detrimental to a project.

8.1 Documentation Review

For the most part, the Advisory Committee provided the reviewed documents, with the following exceptions:

1. Documents for the Cascade Heritage Power Park were obtained from the Government of British Columbia Web site.[8]
2. EC, Pacific and Yukon Region, supplied two scientific reports regarding hydrology of the Cascade Heritage Power Park project.

3. Diavik Diamond Mines project personnel kindly provided a report on climate change prepared by consultants.

The extent, nature and completeness of documentation reviewed varied considerably from project to project. For some it was quite extensive; for others it was sketchy. This affected the quality of the review.

In general, no attempt was made to check the completeness or to obtain more comprehensive documentation except for items 1 and 2 above, where documentation was particularly germane to understanding how climate change had been considered within a project. Only documentation that was part of the public process was included in this review.

A separate appendix contains a detailed review of documentation from each project.

Diavik Diamond Mines: Appendix B

Cascade Heritage Power Park: Appendix C

Confederation Bridge (Fixed Link – Northumberland Strait Crossing): Appendix D

Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake: Appendix E

Dredging of the St. Lawrence River between Montreal and Cap à la Roche: Appendix F

Little Bow Reservoir/Highwood Diversion: Appendix G

Within each appendix, the available documents are listed in chronological order to provide a sense of the flow of events and interventions. If a document does not appear in the appendices, it was not made available for this review.

For each document, the investigator extracted all points related to how climate change was considered or incorporated into a project. Wherever possible, quotations are made.

Consideration of climate change may not be reflected in the provided documentation for a few reasons. First, climate change may have been considered, but was in documentation that was not available. Second, climate change may have been considered in the EA process, but was not considered important. Where these circumstances arise, the investigator has simply remarked that "no reference to climate change was noted" without judgment about its importance. A rationale is given as to why climate change may have been beneficial in the circumstances.

8.2 Interviews

Interviews gathered experiences, knowledge and suggestions from a range of people who played diverse roles within past EAs; these included proponents, consultants, government officials and one panel member. The goals of the interviews were to (1) explore the role of climate change in selected projects, (2) examine EC's contribution as a federal authority reviewer, and (3) gather input about gaps in climate change guidance, and the types of tools and methodologies that would be useful to proponents and reviewers alike. Interviews in an informal setting allowed these persons to raise points and explain issues that they considered important.

Initially, five to 10 interviews were planned. The Advisory Committee provided an initial list of interviewees. As many names were contacted as possible. In a few cases, persons on the initial contact list recommended persons who were more qualified to answer questions. The appearance of two names on the same line indicates they were interviewed together. A total of 14 persons participated in 12 interviews.

The following persons were interviewed and have been involved either as proponents, RAs, consultants, expert reviewers from government departments, members of panels, or Agency members:

1. Doug Tilden, Acting Senior Program Integration and Strategies, Environmental Assessment Branch, EC.
2. Rob Dobos, Head Assessment Section, EC, Ontario Region.
3. Warren Fenton, Manager, Environmental Assessment, EC, Prairie and Northern Region.
4. Curtis Englot, Environmental Assessment Officer, EC, Prairie and Northern Region.
5. Serge Nadon, Environmental Assessment Coordinator, Meteorological Service of Canada (MSC).
6. Bill Ross, Professor, Environmental Science, University of Calgary.
7. Keith Keddy, Acting Environmental Assessment Coordinator, Ray St. Pierre, Environmental Assessment Coordinator/Policy Meteorologist, MSC, Atlantic Region.
8. Paul Scott, Director, John Mathers, Senior Program Officer, Vancouver Office, Canadian Environmental Assessment Agency.
9. Paul Whitfield, Hydrologist, EC, Pacific and Yukon Region.
10. Harold Belore, Director of Resources, Cumming and Cockburn.
11. Chris Taylor, Program Specialist, Program Management and Environmental Assessment Section, Canadian Nuclear Safety Commission.
12. Gordon MacDonald, Environmental Advisor, Diavik Diamond Mines Project.

The investigator prepared the list of questions, and the Advisory Committee reviewed and suggested changes. All changes were adopted. Time did not allow the use of a written questionnaire. Interviews were conducted by phone and lasted from 30 to 90 minutes.

In all interviews, the same procedure was followed. Questions (see Appendix A) were sent in advance of the phone call by E-mail so interviewees could consider their responses. Each interview started with identification questions and a question that identified projects with which each interviewee was familiar. The questionnaire was a guide; depending on the flow of conversation, some divergence occurred according to the experience, opportunities and concerns expressed by the interviewee. Due to time limitations and the specific experience of some interviewees, the full set of questions was not posed to each interviewee. Instead, interviews were tailored to the areas of expertise of each interviewee. Responses to questions were sometimes recorded word-for-word. However, most answers were paraphrased because of the length and complexity of answers.

To allow interviewees greater freedom to express their views, all comments were kept anonymous. This methodology was adopted to gain the most from the interviewees. The investigator has presented all views as objectively as possible. All interviewees were asked to identify the most important point that needed to be reflected in this report. Where possible, all responses from the interviews were incorporated in Section 9.

Comments by interviewees are used to corroborate and supplement the findings from the documentation. Salient points, suggestions, recommendations and observations from these interviews are noted in Section 11.

9. Interview Findings

This section presents the results of the interviews.

The following points were extracted from the database of notes from the interviews of the 14 people listed in Section 8.2. As discussed previously, particular points are not attributed to specific persons. Nevertheless, given the number of EC members interviewed, EC is well represented. The following points represent the views of the interviewees as faithfully as notes taken during the interviews permit. Given the openness of the interviews, the discussion and points of view were wide ranging.

Initially, information was organized by the questions asked; however, while answering them, interviewees often raised other related points. It was decided that, although the process was more complex, the information would be organized and presented in categories related (1) climate science, (2) EA procedures, and (3) a potential climate guide. Sometimes, related points were grouped together where considered useful. Points raised are accompanied by comments by the author, who may be referred to as the investigator or researcher.

9.1 Climate Science

9.1.1 The treatment of the impact of climate change on the projects reviewed in this study varied considerably, ranging from little consideration to embracing climate change as a reality. Sometimes a broad range of climate change impacts were considered from ecological applications to permafrost to hydrology and to fisheries. Examples cited were the Confederation Bridge project where climate change affected the design and the Cascade Heritage Power Park project where hydrology and fisheries were considered. One interviewee noted that the Little Bow Reservoir/Highwood Diversion project considered, but did not incorporate, climate change considerations – leaving some question about the future climate's impact.

9.1.2 Some proponents assume the climate is stationary; changes in historical climate normals are not recognized as a sign of climate change, but of natural climate variability. By way of background, the investigator notes that a long-standing climatological practice of the MSC is to publish what is commonly known as "climate normals" for 30-year periods (e.g. 1951-1980 and 1961-1990). This practice may have led to a perception that there is a "normal" climate and that climate is "stationary." In fact, short-term climate variability is the reality. Climate varies from year-to-year and decade-to-decade. Climate can *shift* abruptly as occurred in 1946 and 1977[9] as well as drift or change over a long time.[10] When a climate drifts, the "normals" increase or decrease over many decades; this is often referred to as climate change.

9.1.3 Interviewees noted that all parties involved in EA could be better informed about climate change. The investigator recorded comments that EC was not communicating the science effectively. In the investigator's opinion, an increased awareness of the degree to which climate changes and its implications for the extremes that accompany climate changes could benefit EA. Workshops to communicate climate change science to the engineering and climate consultants such as the Permafrost Seminar may be a suitable way to disseminate information and raise awareness among the private sector consulting firms who do this type of work.

9.1.4 Interviewees noted they experienced difficulty in incorporating climate change into EA due to the uncertainty and "softness" of the science, both within EC and outside government. Some interviewees involved in EA are not convinced that climate change is a major issue. EC specialists when requested to provide "hard" facts on future climate change, for example to engineers, had difficulty obtaining appropriate scientific information. Similarly they had difficulty translating General Circulation Model (GCM) projections of future climate into practical engineering terms (e.g. converting GCM trends into engineering figures and return periods). The investigator notes that GCM output is not expressed in the terms required by EA specialists. Some interviewees indicated they would be prepared to incorporate future climate conditions if presented as a range of possible values. Some interviewees expressed the view that historical climate variability was larger than future climate change will be.

9.1.5 Many projects will exist in perpetuity – yet, only in one project (and in that case, only one particular area) was climate change considered beyond 100 years (to 1000 years). The investigator notes that projects such as Diavik Diamond Mines and the Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake will physically exist after operations cease, and could have environmental impacts for centuries, if not millennia. Climate models cannot portray the future climate so far in advance because the results diverge considerably after 100 years. The longer a project lasts, the greater the likelihood that the effects of major climate change will be experienced. At present, apart from GCMs, the only tools available are (1) an examination of commensurate periods in the past to establish the full range of climate variation and change, and (2) the use of temporal and geographical climate analogues. Neither of these methods is ideal as they attempt to draw information about the future from the past that may not capture the appropriate variability or the future potential for climate change.

9.1.6 The interviewees noted that in projects where climate change was considered, some in-depth factors were studied, including return periods of extreme precipitation values, hydrology and sea level. Among the projects were Diavik Diamond Mines, Confederation Bridge, and Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake.

9.1.7 The lack of clear guidelines from reviewers of proposals was often cited as a shortcoming. There is an expectation that the RA or EC will precisely state the range of scenarios to be evaluated, a step-by-step guide to follow, the kinds of analyses required and some "policy." On the other hand, some felt it was only necessary to specify what to do, not how to do it. Some interviewees within EC felt that a commensurate level of "hard," forward-looking data was needed to accompany climate change advocacy. The investigator noted that there was a sense that EC could not provide climate change information in engineering terms. For example, the engineering community would be interested in the production of rainfall-intensity-duration tables that have been modified for climate change effects.

9.1.8 At least one interviewee noted the lack of capacity in the private sector to undertake climate change work. Some proponents appear to lack specialized knowledge of climate science, are sometimes hampered by a lack of data and have difficulty obtaining climate science expertise. Interviewees noted that climate science is moving rapidly – "it's a moving target." EC interviewees indicated that proponents approach them for advice on climate change. The investigator understands from information provided by the Advisory Committee that EC reviewers are encouraged to advise proponents and consultants about approaches and methodologies as assessments are being prepared. However, EC reviewers generally avoid actively participating in the preparation of an EA to avoid conflict with their role as federal authority reviewers. The investigator notes that this supports the need for sharing and communicating about climate science between government and the private sector.

9.1.9 The need for atmospheric data to support engineering was mentioned a number of times. This relates to the observational requirements of projects in their early stages, during operations and during monitoring in the post-operational or decommissioning phase. One example is the measurement of the sublimation of snow.

9.1.10 Project engineers are more comfortable dealing with historical data rather than climate trends and the less certain projections. Comments were made that work is needed to integrate hydrologic models to GCM outputs before confidence can be placed in the results. Some respondents were not convinced that hydrologic events were reflected in GCMs due to the scale on which GCMs operate. In

GCMs, even a major project is but a singular point on a large geographic scale. At least one interviewee suggested that techniques to downscale GCM results to point locations or to watersheds are required.

9.2 Comments about Environmental Assessment Procedures and General Comments

Many interviewee comments are related to the consideration and inclusion of climate change within the EA process. The interviewees held a wide range of views. *The purpose of this section is simply to convey those comments; the investigator did not analyze them.*

9.2.1 Climate change is larger than single projects; suggestions were made that it might be better dealt with outside the EA process, perhaps in pre-planning or regional zoning. Some interviewees expressed the view that climate change may be a "force fit" within the EA process. Others believed that EC does not have a climate change policy and this makes it hard to deal within a provincial forum. Some felt a stronger policy statement from EC on the requirement to incorporate climate change is needed. Others felt that climate change was an area that fell between essential and "nice."

9.2.2 Most expertise in climate change and the principal source for data resides in government; therefore, proponents have to obtain data and expertise from the same sources that review the proposals. It was noted that there is a potential conflict between roles of parties insofar as who states "what to do" and where the expertise resides regarding "how to do."

9.2.3 Interviewees noted that the obligation to include climate change in a project is unclear and should be included in the guidelines of the Environmental Impact Statement (EIS); this should be specified clearly to ensure consideration. The view was expressed that the RA ought to specify in the EA guidelines explicitly what is expected. One interviewee noted that when this is included, there is a greater chance of the work being done and not ignored. When the requirement is implicit or weakly documented, uncertain or vague responses are received.

9.2.4 Several interviewees noted that climate change needs to be viewed relative to its significance and impact, not simply because climate change exists. Just because it exists does not mean that it is of major consequence to a project.

9.2.5 In some projects, the RA viewed the impact of climate change on a project to be critical for the economic viability of a project rather than because climate change would impact on the physical structure. This type of impact (i.e. economic) is not of principal concern in EA, but it may affect the operating conditions. Examples cited where such an impact might occur were Cascade Heritage Power Park project whose economic viability depends on stream flow, and Garibaldi and Squamish ski developments that depend on adequate snow packs. The benefit of considering climate change would be of principal concern to the operator.

9.3 Comments about a Future Climate Change Guide

One of the eventual goals of this research is to provide better information for EA practitioners. A specific question was formulated with the assistance of the Advisory Committee to survey those who had been involved in EA previously. "One goal of this [research] project is to undertake the groundwork for the development of a guidance document for the incorporation of climate change into EA. What features should be included in such a guide?" Although it was not always clear who the interviewee thought the target audience should be, many thought all parties involved in the process would benefit. Almost all felt that general guidance was of no use – it needed to be detailed. The following list reflects the collective views of the interviewees about information that should be considered in developing a guide.

- Links should be made to the *Canadian Environmental Assessment Act* (CEAA) to set context.
- The target audiences should include the EA practitioner, proponent, RA and consultant.
- An education component should be included to make climate science more accessible: what science is available, a description of climate change temporally and geographically and a rationale why climate change is important.
- The policy on climate change in EA should be stated.
- How climate change information flows through the various agencies and proponents should be explained.
- The guide should contain a simplified decision tree to determine when climate change is potentially an issue, what specific (not general) factors and issues to consider and when it should be included.
- A checklist or step-by-step procedure should be prepared to take climate change into account including sources of projections, techniques, methods, analyses, procedures, ranges and a list of specific scenarios to be evaluated and sensitivity studies to be conducted. (Some felt that different projects might use different scenarios.)
- Information should be presented on the reliability and uncertainty of projections.
- A list/catalogue of sources of climate change information should be available on the Web.
- A list of resources that are available in the federal system should be included.

10. Review of Projects

The reviews present project summaries in the following standard format:

- Project Description
- Significant Milestones
- Climate Change Issues Addressed by the Proponent
- Environment Canada's Perspective on the Environmental Assessment Documentation

- Recommendations and Decisions Relating to Climate Change Taken by the Responsible Authority or the Panel
- Observations about Climate Change Science in Environmental Assessment
- General Observations

This provides basic information about the project and the time period during which the project was (or is being) undertaken. It reflects how those in principal roles in the EA process addressed climate change in terms of breadth of application within a project and how climate change information may have influenced design as noted from the documentation. Lastly, it allows identification of gaps and strengths of climate data and climate change science.

10.1 Diavik Diamond Mines

This section summarizes the detailed findings in Appendix B and expresses the views of the investigator.

10.1.1 Project Description

The Diavik Diamond Mines project is located at Lac de Gras in the Northwest Territories, about 300 km northeast of Yellowknife. It lies in the Northeast Boreal Forest climatic zone of Canada[11] and is located on an island in the middle of Lac de Gras.[12] The development involves construction of water retention dikes to allow for open pit mining. Underground mining, and construction of a diamond recovery plant, accommodation building and mine support infrastructure will follow. Major ground surface disruption will occur. The mine begins operation this year (2001) and is estimated to have a lifetime of 25 years with reclamation activities following mine closure.[13]

10.1.2 Significant Milestones

Initial Background documents	March 14, 2001
Submission of EIS/Comprehensive Study Report (CSR)	March 14, 2001
Project Decision/Panel Report	March 14, 2001

10.1.3 Climate Change Issues Addressed by the Proponent

The proponent considered impacts of climate change on permafrost, the integrity of facilities and the design of facilities by using a consultant's study to obtain a current scientific opinion. The methodology presented by the proponent, using estimates of temperature warming in its design considerations, was appropriate given the evidence of climate change. Further, the consideration of average as well as maximum values of temperature change illustrates the uncertainty in climate change modelling. While the details of how these figures were employed were not mentioned, they may represent a sensitivity analysis. The importance of snow cover to the maintenance of permafrost was also recognized. Considerations of changes to extreme precipitation were noted in the discussion on changes to the return period for precipitation events. The proponent considered the impact of storm surges on the lake and severe weather on its operation, although no climate change component was noted. Finally, the Government of the

Northwest Territories (GNWT) also raised climate change concerns about the impact on caribou; however, the RAs did not require this information. Taken together, these considerations represent a major recognition of a range of potential impacts of climate change to the project. Other project aspects such as air quality modelling would also benefit from consideration of climate change, even though the effects may be indirect and less dramatic.

The effect of global warming on permafrost, and by extension the effects on dikes that depend on permafrost, are projected to continue well after the mine is closed. While no reference to this post-operation period was noted in the documentation, it may not have been within the terms of reference of the EA process.

10.1.4 Environment Canada's Perspective on the Environmental Assessment Documentation

From the available documentation, EC made several contributions. These included pointing out observed changes to climate, the climate changes projected for the future, the need to reconsider the values used for extreme precipitation and the need for ongoing atmospheric monitoring at the site to validate predictions of climate change impacts.

10.1.5 Recommendations and Decisions Relating to Climate Change Taken by the Responsible Authority

1. Global Climate Change.[14] The RAs concluded that global warming "will not likely cause significant environmental effects on caribou as a result of this project." This deliberation is noteworthy in that the RA recognized that climate change was potentially an issue in an area other than physical structures.
2. Global Warming and Structural Integrity.[15] The RAs directed Diavik Diamond Mines to further consider at the regulatory stage the effects of climate warming on the long-term integrity of frozen structures should the project be allowed to proceed. This example illustrates that the impact of climate warming on structures is a shared concern among the proponent, RAs and EC.
3. Severe Weather. The RAs concluded that severe weather conditions and the impact on mine operation procedures would be incorporated into Diavik Diamond Mine's environmental management system (EMS).
4. Follow-Up Program. The element of the follow-up program related to ambient air quality conditions is to "establish a more sophisticated meteorological station to confirm assumptions and validate predictions." This decision recognizes the need to monitor climate change's effects on extreme events.

10.1.6 Observations about Climate Change Science in the Environmental Assessment

Scientists globally have been studying climate change for decades, and even more intensely during the most recent decade. This project benefited from that research and from the dissemination of that information, to the extent that it has been actively made available. One illustration of distribution of climate information and its interplay with engineering sciences was a workshop on permafrost[16] attended by several government agencies. This workshop appears to have been important as a source of information to this project.

The proponent noted that making climate projections was beyond the scope of its work. The proponent also noted the difficulty in projecting climate change and the uncertainties surrounding the projections. Nevertheless, the proponent, through the work of its consultant, used climate projections. The consultant who was engaged by the proponent approached EC who, in turn, relied on climate models to provide climate change guidance. On one hand, EC comments on a proponent's submission – while, on the other, it gives scientific advice to the proponent. The Advisory Committee noted that reviewers attempt to provide sound advice to the proponents as the assessment progresses, but must ensure that their ability to offer unfettered, objective federal authority reviews is not compromised. While no problem is being suggested, improvements might be achieved by encouraging proponents to seek out independent climate advice whenever possible.

One notable shortcoming in climate science was the lack of information concerning changes in extremes as well as changes in climate averages. This point was also raised during interviews while discussing the Confederation Bridge project. It is noteworthy that EC determined the adjustment of return periods for the Diavik Diamond Mines project through a "logical" process rather than calculating adjusted return periods from an adjusted database that would have taken into account climate change. "Logical" in the above, EC applied its judgement and knowledge of climatology in a sound reasoning manner to arrive at a recommended return period.

The Environmental Effects Report: Climate and Air[17] made good use of linkage diagrams to relate project activities (through a key question) to potential changes in affected areas. For example, Diagram 1-2 related potential changes in air emissions, as a result of project activities, to vegetation and terrain, wildlife, fish and water, and socio-economics (environmental). A similar approach to considering climate change may be beneficial.

10.1.7 General Observations

This project demonstrates that climate change has an impact and, with knowledgeable and willing parties working together, it can be considered. A positive interaction between the proponent and the RA is evident in the exchange of information through the evolution of the project.

10.2 Cascade Heritage Power Park

This section summarizes the detailed findings in Appendix C and expresses the views of the investigator.

10.2.1 Project Description

The Cascade Heritage Power Park is a run-of-the-river hydroelectric project located on the Kettle River at Cascade, approximately 2 km south of Christina Lake, B.C.,[18] within a few kilometres of the Canada-U.S. border. The project is comprised of a powerhouse, weir, tunnels, penstock and other components. Environmental sensitivities relate to stream temperature, species at risk and rate of river flow.

Department of Fisheries and Oceans (DFO) is the RA from a federal perspective. The provincial government of B.C. is participating through a federal-provincial harmonization agreement.

10.2.2 Significant Milestones

Plant start-up is projected for October 2001. Its lifetime is potentially perpetuity.

Powerhouse Energy Corporation (PHE) began the process to gain approval for a power generation facility in 1993. Extensive consultations have led to the current stage of this project including review for climate change and other considerations (January 2001).

10.2.3 Climate Change Issues Addressed by the Proponent

This project, at the time of writing, is still proceeding with pre-project hearings. It is therefore particularly interesting to investigate how climate change has been incorporated. The proponent acknowledged that the hydrological regime had been changing. However, it did not cite any studies it had carried out and concluded that "Hydrological variations in the annual Kettle River hydrograph due to climatic change or to natural annual events will not cause any effect on the method of operating the Cascade run-of-river project."

10.2.4 Environment Canada's Perspective on the Environmental Assessment Documentation

EC undertook a study of the hydrological regime in August 1999. It concluded that it would not be feasible to produce power during approximately 32% of the year, based on historical stream flow data. Further, EC expressed concern that the project would not be viable and recommended that the proponent employ a decade of low stream flow data to demonstrate operational viability.

10.2.5 Recommendations and Decisions Relating to Climate Change Taken by the Responsible Authority

The RA recognized the need to ensure the proponent was aware of the potential issues posed by historical and future climate change. To this end, the RA required the proponent, through Specification #41, to discuss the ramifications of climate change on stream flow and elevated water temperature, among other factors. Further, the RA required the proponent to propose a climate change contingency plan that would be tested against a lower flow regime encountered in the decade 1985-1995. The RA thus took EC's recommendation into account and directed that a historical period of river flow be used as an analogue of future severe conditions.

10.2.6 Observations about Climate Change Science in the Environmental Assessment

This project is ongoing and as such should reflect the current state of climate science.

While climate change was much discussed, few specifics appeared in the documentation reviewed. The historical discussion was well developed but discussion about the future was general. This may have reflected the confidence and level of detail available at the time the comments were made (late 1999 and early 2000).

EC has concluded that changes in river flow in recent decades are consistent with projected changes in climate. Recognizing that the direction of change appears consistent with expectations for the summer, the study also refers to recent decades. Changes during this time may be due to climate variability rather than climate change that occurs over many decades.

Given the sensitivity of fish to water temperature, the temperature in the Fraser River was correlated to atmospheric parameters such as cloudiness and air temperature. A recent study showed that 55% of variations in water temperatures in the Fraser River can be explained by climatic conditions.[19] Similarly, it may be possible to use the projections of future climate from GCMs to estimate the impact on the Kettle River temperatures. This possibility would require further investigation.

In the documentation reviewed, no discussion was noted about the possible use of a watershed model. It may be that the volume of water flow is so marginal that such a model would provide no additional information. In future, when sufficient development work is completed, other projects with larger watersheds might use GCM output to explore the response of a river system to the range of predicted future precipitation regimes.

10.2.7 General Observations

In directing the use of a historical analogue, the RA was satisfied that it would adequately represent the type of conditions the proponent could face in the future. The use of projections of climate change were not recommended, but were rather discussed in general terms. Projections by climate models are based on a grid size that is large compared to the Cascade watershed. For the grid-box within which the Cascade watershed is located, the models predict that lower summer precipitation will occur in future, and by inference, lower stream flows. Even though the models lack real precision for the Cascade watershed and precipitation projections are considered less reliable than the ones for temperature – projections are that precipitation will diminish and thus streamflow will diminish. This is consistent with the observed lower flows during recent decades. Thus, the investigator has concluded that (1) climate change science was inadequately developed at the time, (2) information was not detailed enough for application to the project location, and (3) confidence was lacking to recommend the use of climate science in the assessment.

In this particular EA, historical data were beneficial in raising awareness of the proponent, and federal and provincial authorities to the potential impacts of climate change on the project.

10.3 Confederation Bridge (Fixed Link – Northumberland Strait Crossing)

This section summarizes the detailed findings in Appendix D and expresses the views of the investigator.

10.3.1 Project Description

This project comprised the proposal and eventual construction of a 13-km bridge between Prince Edward Island (P.E.I.) and mainland Canada, i.e. between Borden, P.E.I., and Cape Tormentine, New Brunswick, roughly parallel to the previously existing ferry crossing. The project consists of a high-level two-lane road structure built on piers over the entire crossing of the Northumberland Strait although a tunnel had been considered as a possible alternative. No causeway sections were envisaged and a navigation channel with vertical clearance of about 50 m and a gap-width of some 185 m was planned for passage of ocean-going vessels. The design included a highway access link at either end leading to the bridge structure. This project was subject to the Environmental Assessment and Review Process (EARP).

10.3.2 Significant Milestones

The project planning began in 1985 when the federal government received two unsolicited fixed crossing proposals from the private sector which proposed a causeway and an inter-modal tunnel, respectively. A generic initial environmental evaluation was conducted in 1987 under the EARP Guidelines Order. A Stage II Proposal Call followed. In September 1988, three bridge proposals were found to satisfy environmental criteria and other requirements. A federal Environmental Assessment Panel publicly reviewed the project in 1990. In December 1991, Public Works Canada (PWC) determined that the three bridge proposals satisfied the additional project criteria established by the government's response to the Panel report. In July 1992, PWC selected SCI as the preferred developer. The Panel accepted an environmental management plan on February 26, 1993.

10.3.3 Climate Change Issues Addressed by the Proponent

From the early documents provided, it appears that a 0.3 m per 100 years rise in sea level was considered in the design. No other mention of climate change by the proponent was noted.

EC was involved in the committee that studied ice-out and considered climate change. The documentation does not indicate whether the proponent was involved.

10.3.4 Environment Canada's Perspective on Environmental Assessment Documentation

EC expressed concern that "Considering that the environment may undergo significant changes over the next century … [there is a] degree of risk posed by [meteorological, oceanographic and other physical factors] on the integrity of the structure over the design life of the project (i.e. 100 years)."[20]

EC expressed concern in its position paper that there was a considerable risk to the structural design should climate change not be taken into account, especially considering the lifetime of the project. EC also stated that the rise in mean sea level was largely ignored in the planning of this project, and that it was a "critical oversight that could, in the long run, have negative structural consequences."[21] At some point in the EARP, a rise of 1 m in sea level was adopted as a design standard. No rationale for the specific value was mentioned in the documentation but it appears to have originated at an international meeting. (See Appendix D, D.2.)

10.3.5 Recommendations and Decisions Relating to Climate Change Taken by the Panel

In the final analysis, the Panel was satisfied that climate change had been taken into account where possible. Consideration of climate change with respect to sea level, ice and inundation of low-lying areas near the bridge was assessed.

10.3.6 Observations about Climate Change Science in the Environmental Assessment

When the documents under review were prepared in the late 1980s and early 1990s, in-depth comprehension of climate change and its ramifications were just emerging. Observations of sea level provided the evidence and sufficient data to assess that rising sea levels posed a risk. This is an early illustration of the value of observational data and baselines to detect changes in the environment when considering the impact of climate change.

In the late 1980s, the range of sea level rise was estimated to be between 20 and 140 cm in the next 100 years. A value of 1 m was employed for the design. No reference to sensitivity of the project to greater rise was noted. The Panel was satisfied that reasonable precautions had been taken by taking the 1-m rise into account.

Several references use "climatic normals" for temperature, wind and precipitation. In the most recently dated report, Environmental Evaluation of the SCI's Proposed Northumberland Strait Crossing Project, 1993, tables of extreme values are reproduced for the period 1951-1980. These values appear to have been used in the design.

The way in which climate change was considered in the ice-out delay study is not known, but its consideration is referenced in the documents reviewed.

Interviewees noted some studies were carried out on wind, waves, currents and tides. Whether climate change was factored into these is unknown. Wind is an example of a climatic element that may change with the climate. Not only does wind affect the structure through frequency and severity of storms, but it also affects traffic, ice stress, wave generation, etc.

10.3.7 General Observations

This project was the earliest of the projects reviewed in which climate change was considered in the design of the structure. Interventions by EC influenced the final design standards.

10.4 Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake

This section summarizes the detailed findings in Appendix E. It expresses the views of the investigator.

10.4.1 Project Description

This project involved the decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake that were in operation since the 1950s and closed in August 1990. A range of decommissioning activities was proposed; the most important was the construction of permanent containment ponds for the radioactive tailings. This option required that the tailings remain permanently flooded so that they would not be exposed to air, in order to prevent the generation of acid. The tailings ponds were engineered using a series of dams and dikes to construct a terraced series of water-covered containment cells.

The project falls within the original EARP guidelines, self-assessment process with an initial assessment phase and a public review phase.

10.4.2 Significant Milestones

The original background studies were prepared in the early 1990s. Rio Algom Ltd. submitted the EIS in February 1995 and the EARP panel report was released in June 1996.

10.4.3 Climate Change Issues Addressed by the Proponent

The proponent primarily took climate change into account through the use of drought and flood models by allowing for the possibility of decreasing mean precipitation by *up* to 10% and increasing mean evaporation by up to 10%. In developing models, the proponent analyzed the databases for evaporation and precipitation, concluding that there was no monotonic trend for both precipitation and evaporation. Hence, they may have made an underlying assumption that the climate is not changing and 10% was a reasonable additional measure of safety. These models were based on climate records of 55 years and 18 years, respectively.

Further, the proponent believed that long-term monitoring was unnecessary to assess and validate whether climate change was occurring.

10.4.4 Environment Canada's Perspective on the Environmental Assessment Documentation

EC noted shortcomings of the study in the area of comparing data, as well as in assumptions about evapotranspiration, wind and atmospheric stability. In particular, EC pointed to an International Joint Commission (IJC) study that projected that evapotranspiration for the Lake Huron Basin would be more than 20% higher in 2050 than historic levels. Further, EC noted that there was a need to incorporate the best estimates of the effects of climate change on key climate parameters. However, the proponent countered this claim.

EC recommended that Rio Algom Ltd. re-evaluate the probability and severity of drought in its probabilistic assessment using the best estimates of long-term climatic change and its associated uncertainties. It is also recommended that Denison Mines Ltd. conduct its own probabilistic assessments for the Denison and Stanrock tailings management areas (TMAs).

EC also recognized that uncertainties between projections and performance could be expected and that there would be considerable reliance on the long-term monitoring, maintenance and an intervention program.

10.4.5 Recommendations and Decisions Relating to Climate Change Taken by the Panel

The Panel, in its 1996 report, Decommissioning of Uranium Mine Tailings Management Areas in the Elliot Lake Area, directed the proponent to conduct appropriate risk assessments including consideration of a catastrophic or accidental event based on the current climate and geology as well as on the best estimates of long-term climate changes and their associated uncertainties.

The Panel found that:

1. "The tailings of the Elliot Lake uranium mines present a perpetual environment hazard.
2. Given the nature of the long-term hazards of the tailings, the Panel has set out a number of recommendations that seek to ensure that effective containment is established for the tailings; that an extensive monitoring, maintenance and research program is developed to ensure proper operation and safety in perpetuity …
3. The transitional phase that will follow must be of sufficient duration to permit the effectiveness of the systems to be verified over a range of climatic and other operating conditions, and any desirable adjustments to be implemented.
4. The decommissioned waste facilities will be required to perform their protective functions for millennia, during which time there will be changes to the environmental conditions within which they must operate. Some changes will be external to the facilities, such as climate changes, while others will be internal … ."

The Panel noted that the two potential problems most frequently mentioned were either flooding caused by excessive precipitation events, or the evaporation and subsequent loss of water cover during prolonged droughts. It concluded that the tailings, with suitable arrangements, could be kept permanently saturated either under a water cover or under a dry cover if a sufficient, reliable supply of water was permanently available. Properly designed and constructed, such a system would be both robust and flexible. It could operate effectively over a considerable range of climatic and other conditions, and be modified to adapt to changing conditions or requirements.

The Panel noted that potential climate change makes necessary the capability to keep local weather records in Elliot Lake. It disagreed with the proponent and recommended that a meteorological station suitable for the collection of basic climatic data be set up at Elliot Lake. Further, the Panel strongly urged the Atomic Energy Control Board (AECB) to consider explicitly operating, monitoring and maintenance needs to determine whether they should be incorporated in the approved licensing procedures and plans. The Panel considered the recommendations made by the consultants regarding instrumentation and monitoring procedures to be minimum requirements.

The Panel thus noted that climate change was a real concern, that ongoing monitoring was required in perpetuity, and that the operation would need to be flexible to accommodate climate change when it was detected in the future. Although the Panel did not set specific criteria for action in response to climate change, the ongoing monitoring of water levels in the containment cells would accomplish that, since low water levels would trigger the diversion of water into the cells from nearby Gravel Pit Lake.

In response to the Panel's decisions, the government concluded that "the AECB, with input from the Joint Review Group, will assess the instrumentation and practices to be employed to ensure that all climatic data collected are appropriate, reliable and sufficient enough to be able to detect changes which could potentially lead to change in the integrity of the containment systems over time. The extent of such data collection will be established as requirements in the AECB licensing process."

A further recommendation noted the need to monitor water-cover depth so that prompt remedial action can be taken in the event of a threatened loss of saturation – in particular, " … intensified [monitoring] during the summer because transpiration losses are likely to increase during the growing season."

10.4.6 Observations about Climate Change Science in the Environmental Assessment

Inadequate lengths of recorded atmospheric or climatic conditions appear to be a common issue noted in this and other projects reviewed in this report. Where atmospheric issues are identified in the Guidelines for EIS Preparation or equivalent statements for a project, regular meteorological observations could ideally be maintained *throughout* a project's lifetime so that the meteorological database is maximized during decommissioning studies.

Climate is rarely stationary. This is particularly relevant for projects whose lifetimes, including the decommissioning phase, are 1000 years or more. Computing return periods of precipitation events on more widespread regional statistics or other long proxy records would provide a longer baseline.

For time frames of 1000 years, the scientific tools to assist the design of long-lived programs are clearly wanting. Most climate models only project the climate for 100 years and have large uncertainties. This suggests that at a minimum, the effects of the next 100 years should be taken into account and some additional measure of uncertainty built in for climate change for the subsequent 900 years! While the near-term prospects are for warming, this project could have equally considered a climate flip-flop in which cold, dry conditions become prevalent sometime in the future.

10.4.7 General Observations

This project is possibly the most thoroughly documented process of EA provided for review. In the final analysis, the Panel accepted climate models and climate science as indicative that climate change may occur – but they were insufficient alone due to long-term uncertainties in the projections. Thus, ongoing monitoring must confirm that climate is changing. The Panel noted that other factors come into play when deciding courses of action.

10.5 Dredging of the St. Lawrence River between Montreal and Cap à la Roche

This section summarizes the detailed findings in Appendix F. It expresses the views of the investigator.

10.5.1 Project Description

The project consists of selective dredging the shoals of the navigation channel of the St. Lawrence River between Montreal and Cap à la Roche to maintain in this portion of the channel a minimum depth of 11.3 m below the low-water line (zero on the charts). Currently, the minimum depth is maintained at 11 m throughout this zone; the dredging is thus intended to reduce the height of the dunes, or of the clayey or shaley outcroppings, by 0 to 30 cm.

10.5.2 Significant Milestones

The Montreal Port Corporation (MPC) submitted its EA screening for the project to DFO in April 1996. Consultations were held in June and July 1996 by DFO, and a multidisciplinary interministerial committee was formed to look at the issues that were raised. Based on the consultations and the recommendations made by this committee, DFO submitted comments and a request for additional information to the proponent in February 1997. The proponent responded in August 1997.

10.5.3 Climate Change Issues Addressed by the Proponent

The proponent did not deal with climate change in the initial proposal.

10.5.4 Environment Canada's Perspective on the Environmental Assessment Documentation

The document provided does not allow the attribution of comments on climate change to specific intervenors. The list of intervenors includes 15 individuals, groups and organizations from the three levels of government, among them the following federal departments: DFO, Health Canada and EC.

10.5.5 Recommendations and Decisions Relating to Climate Change Taken by the Responsible Authority

Based on the consultations and on the recommendations made by the multidisciplinary interministerial committee, DFO, which acted as the federal authority under the CEAA, communicated to the proponent the following recommendations and requests for supplementary information:

- Review the justification for the project to take into account a significant reduction of the water levels in the St. Lawrence resulting from eventual climate change.
- Consider, in the evaluation of cumulative impact, the impact of climate change and of the regulation of the waters of the Great Lakes.

The RA also expressed the view that some concerns raised were related to the general and comprehensive management of the St. Lawrence River rather than to the direct implementation of the project.

10.5.6 Observations about Climate Change Science in the Environmental Assessment

The proponent presented a general discussion of climate change and of eventual impacts on water levels. The proponent believed that the issue of climate change lies in the realm of theory and scientific speculation rather than in reality.

The proponent did not consider it worthwhile to investigate or to further discuss the results of GCMs that would lead scientists to suggest reductions in the flow of the river of approximately 20% in the next 30 years.

10.5.7 General Observations

In this EA, everything indicates that more detailed consideration of the impacts of climatic change on water levels and on the eventual need for supplementary dredging was referred to a procedure, yet to be determined, rather than dealing with this issue for this specific project. This future assessment would allow for a more comprehensive and integral management of the river and of other activities on it.

10.6 Little Bow Reservoir/Highwood Diversion Project

This section summarizes the detailed findings in Appendix G and expresses the views of the investigator.

10.6.1 Project Description

The project involves construction in three areas in the High River/Nanton/Stavely area of southwestern Alberta: the Highwood River, in the town of High River; Clear Lake 16 km east of Stavely; and the Little Bow River, 16 km east of Parkland.

The development consists of construction of the Little Bow River Reservoir, enlargement of the Little Bow Canal, construction of the Clear Lake Diversion Canal and implementation of the Highwood Diversion Plan. In this last development, water will be diverted from the Highwood River down the Little Bow Canal into the Little Bow River. Water will be released from the Little Bow River Reservoir for conveyance, irrigation, domestic and municipal purposes. The project is intended to improve in-stream flows in the Highwood River, allow the development of 20 000 new acres of irrigation, stabilize water supplies to a number of municipalities, and facilitate water-based recreational opportunities in the area.

The project falls within the original EARP guidelines, a self-assessment process with an initial assessment phase and a public review phase.

10.6.2 Significant Milestones

This EA started in approximately 1990. The latest correspondence provided suggests the EA process was ongoing as of 1997.[22] The project has an economic lifetime of 54 years.

10.6.3 Climate Change Issues Addressed by the Proponent

The available documentation did not provide any insight into whether the proponent raised the issue of climate change. The proponent did however respond to questions from EC on this matter.

10.6.4 Environment Canada's Perspective on the Environmental Assessment Documentation

EC posed two questions to the proponent and specifically asked if climate change had been considered in the operating plan.

10.6.5 Recommendations and Decisions Relating to Climate Change Taken by the Responsible Authority

No documentation was available relating to this issue.

10.6.6 Observations about the Climate Change Science in the Environmental Assessment

The proponent considered that future climate change would lie within the range of historical variability. How this view was established is unknown. For a project that depends so highly on precipitation, temperature and as evaporation, detailed studies of the potential impact and sensitivity to changes in climate (temperature and precipitation) may have been beneficial.

10.6.7 General Observations

This project is similar to the Cascade Heritage Power Park project in that the impacts of the climate and climate change appear not to affect the project's physical structure but may affect the viability of the project.

10.7 Summary of Climate Change Considerations in Selected Projects

Table 1. Climate change considerations in past projects juxtaposed with scenario capability to provide relevant climatic elements, given the state of climate science in 2001*

Project Name (abbreviated)	**Approximate time of EA**	**Main Focus of Climate Change Considerations**	**State of Climate Science in 2001** Climate scenarios provide projections of the relevant variables listed below at the original GCM grid resolution with a time step of one month to one year for the next 100 years. These variables are considered to be relevant to the issues at each location, either directly or through energy and/or water budget considerations.
Cascade Power Park	Mid-90's to present	Changes in hydroelectric regime (decreased streamflow and elevated water temperatures) potentially affecting viability of operations and fisheries.	Precipitation, evapotranspiration, solar radiation, maximum and minimum air temperature, diurnal temperature range, cloud cover.

Confederation Bridge	Late 1980s to early 1990s	Integrity of bridge structure over design life of project due to a rise of 1 m in sea level, ice-out and inundation of low-lying areas near the bridge.	Sea level, sea ice.
Diavik Mines	Late 1990s to present	Permafrost, integrity and design of facilities in light of changes in air temperature, snow cover and precipitation regime.	Mean air temperature, maximum and minimum temperature, snow water content, rainfall and snow-fall, soil moisture, solar radiation, surface (of ground) temperature.
Dredging of St. Lawrence River	Mid-late 1990s	Maintenance of a channel with a mini-mum depth of 11.3 m below low-water line which may be affect-ed by reductions of water levels and flows in St. Lawrence River arising from lower precipitation and lower Great Lakes levels.	Sea level, evaporation, precipitation, temperature.
Little Bow Reservoir	1990s	Water supply for use in irrigation, municipal water supply and water based recreation as affected by changes to precipitation regime and demand from use of evapotranspiration.	Precipitation, evaporation, snow water content, diurnal temperature range, evapo-transpiration, soil moisture, wind speed, cloud cover, sur-face (of ground) temperature, maximum and minimum temperature.
Decommissionin g of Quirke and Panel Mines	Early 1990s	The permanent (mil-lennium) containment of tailing ponds requiring adequate supply as affected by extremes in precipita-tion, both excessive amounts giving rise to floods and insuffi-cient amounts giving rise to droughts.	Maximum rainfall events, rainfall, snowfall and evaporation, potential evapotranspiration, wind speed, snow water content, diurnal temperature range, cloud cover.

*This table is also presented in Table 6 of Part 2 of the study: Climate Change Guidance for Environmental Assessments.

Many of the above projects are affected by extreme events. It is possible to obtain some information about future extreme events at the *spatial resolution of the GCM* (i.e. over areas several thousand square kilometres in size). Scenarios providing information about changes in the frequency and magnitude of extreme events at this spatial scale are unlikely to be of use to the EA practitioner. Hence, downscaling of extreme event scenarios will be required in the future. This aspect of climate science is in its infancy, with techniques currently being researched and developed.

11. Synthesis of Interviews and Documentation

This section draws out the principal conclusions from the review of documentation and from the interviews and makes some observations about opportunities. Supporting details are in Sections 9 and 10, which summarize the review of documentation and the interviews. No references will be given in this section.

11.1 Findings

- The use of historical climate data in projects subject to EA was widespread, including the consideration of norms, climate variability and extremes. Special studies were undertaken in projects to determine, for example, probable maximum precipitation (PMP). This practice is a good foundation for future use of climate scenarios that depend on the determination of historical climate baselines.
- Some proponents considered the use of historical data as an adequate indication of the future. Others believe that climate change will remain within the range of historical natural variability.
- Opinions differ about the scientific evidence for climate change. Many were of the opinion that the evidence is inadequate, that knowledge about the future climate is insufficiently precise and uncertain on a geographic scale, and that their confidence is insufficient to act upon it. However, considerable evidence indicates that climate change is real. While there may be shortcomings, climate change science cannot be ignored.
- Climate change science did make a difference. Several illustrations exist where proponents and governments believed that enough was known about climate change to include some measure of anticipated response in a project. Except in one project, where climate change was considered, and not pursued further, all other projects considered and incorporated climate change in different ways. Specialized studies were undertaken in some cases. Climate change considerations were noted in many areas including physical structures, aquatic environment, and flora and fauna.
- In some cases where climate change information was considered inadequate basis for making decisions, the need for contingency plans, as well as ongoing environmental monitoring, that would trigger action when required was recognized.

- EC made recommendations in several cases where it considered knowledge of climate change could benefit a project. In some cases the RA directed proponents to respond (e.g. Diavik Diamond Mines Project Comprehensive Study Report, p.169); in others, the RA did not take up EC recommendations.
- Projects used a range of techniques to measure the sensitivity of a project to climate change including statistical modelling and analogue situations.
- A gap exists between needs and expectations from the EA community on the one hand and climate change science on the other. Those who must deal with engineering and design aspects customarily employ historical data sets. Climate change science can provide ranges of future climate conditions but not, as yet, in the form that is useful for proponents. Proponents should to consider new ways to take into account available information, while climate change scientists should formulate their information in such a way that is most useful to the EA community. Fora to promote interaction between climate change scientists and EA practitioners are required.
- Other concerns about the appropriate procedures and policies regarding the consideration of climate change in EA were voiced and noted, but are outside the scope of this report.

12. Concluding Remarks

Six projects subject to the CEAA or EARP were reviewed to explore the consideration of climate and climate change in their design, planning, operation and in one case, decommissioning. These projects represent a decade of impact assessment involving oceanographic, hydrologic, atmospheric and terrestrial circumstances and span a range of possible approaches to the incorporation of climate change into EA.

The projects reviewed were Diavik Diamond Mines, Cascade Heritage Power Park, Confederation Bridge (Fixed Link – Northumberland Strait Crossing), Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake, the Little Bow Reservoir/Highwood Diversion and Dredging of the St. Lawrence River between Montreal and Cap à la Roche. Each of these projects are important because they leave physical remains that could have environmental impacts for centuries; in one case, toxic remains will be a part of Canada's landscape for a millennium or more. All will be subject to climate extremes, climate variability and climate change.

Climate change has been considered in all of these six projects to varying degrees. Such consideration for a decade demonstrates that it is a shared concern with proponent and governments alike. Climate change has affected project design in some cases and not in others. While there was considerable range in the extent to which climate change was factored into these EAs, there was a substantial degree of common appreciation for the impact of climate change. Climate change science is unlikely ever to be able to present climate information in the same manner as historical data to which the EA community is accustomed. This is something that the EA community will have to accept. Climate change scientists on the other hand should start a dialogue with the EA community to determine how their research agenda can accommodate the EA community. Sharing of available knowledge will help build a stronger consensus on the potential impacts of climate change.

Appendix A. Interview Questions

Name?

Current position?

Background in environmental science and EA?

Involvement in major projects with potential climate change implications

We have contacted you primarily in relation to the ______________ project.

What was your role/function in EA in that project?

In what areas of the project was information employed about climate (e.g. air quality, precipitation, run-off containment, socio-economic, ecological)?

Was the project design sensitive to climate change?

What was the time horizon of the project?

Was climate change addressed in the EA?

Were (1) climate trends and (2) climate variability examined?

What approach was taken to represent future climatic conditions?

Did available climate information meet your requirements or were there shortcomings in the availability of climate information/knowledge or the quality of the science? Give examples.

Were any specific studies undertaken to support this approach?

____

Did potential climatic change influence project design or monitoring programs?

____

In your opinion, are there ways in which climate change information might have been applied that would have resulted in improved EA?

____

____

____

____

Do you recall Environment Canada's review comments about climate change for the _____________ project?

Were the comments on climate/climate change scientifically sound?

____

Did the review comments affect project design or monitoring programs?

____

Did they strengthen the overall EA for that project?

____

Do you have any suggestions to enhance the utility and effectiveness of the climate change aspects of these reviews?

____

Is the use of historical climate data still appropriate for project planning and design (for projects with medium- to long-term time horizons)?

____

What scientific "tools" or methodologies could be employed to provide quantitative climate change guidance to a project?

____

Is adequate information available for project proponents and consulting firms to incorporate climate change into EA?

____

If not, what type of guidance is needed?

____

One goal of this project is to undertake the groundwork for the development of a guidance document for the incorporation of climate change into E A. What features should be included in such a guide?

____

Do you have any concerns or caveats about how climate change might be incorporated into the EA process?

____

Do you have any overall comments, perhaps from other projects?

____
____
____
____

Appendix B. Diavik Diamond Mines

This appendix contains the review of specific documentation for the Diavik Diamond Mines project. Documents are cited in chronological where possible. Findings are summarized in the body of the report.

Where required, observations, comments and conclusions made by the investigator are enclosed by square brackets [ ]. Quotation marks are used to refer to material within the document cited in the heading of a section. Where additional reference was thought necessary, the specific reference is provided using a superscript number referring to the source identified in the endnotes. If neither brackets, superscript reference numbers nor quotation marks appear, the information was extracted from the document.

Acknowledgement

The national, and Prairie and Northern offices of EC's MSC kindly supplied the documents contained in this section. Diavik Diamond Mines Inc. (Diavik) provided additional documentation.

Project Description

Diavik and Aber Diamond Mines Ltd. have formed a joint venture to mine four diamond-bearing kimberlite pipes at Lac de Gras, Northwest Territories, about 300 km northeast of Yellowknife. Diavik Diamond Mines is the manager of the project. The proposed Diavik Diamond Mines project is located on a 20-km^2 island in Lac de Gras known as "Ekadi" in the Dogrib language, and referred to as the "east island" in the Environmental Assessment Overview (EAO). The kimberlite pipes are located immediately offshore of the east island. The proposed project is about 30 km southeast of the Ekati Diamond Mine operated by BHP Diamonds Inc.[23] The proposed mine lies in the northeast Boreal Forest climatic zone of Canada.[24]

"The proposed Project facilities would be situated on the east island, with the open pits and their water retention dikes located just offshore, in Lac de Gras. A diamond recovery plan, accommodation building, power generation, and mechanical and administrative buildings would be located on the south east portion of the island providing a view of the lake from the accommodation complex as well as easy access to mine facilities. After the diamonds have been removed, the remaining kimberlite would be stored in a containment structure in the central valley. Country rock removed to access the kimberlite pipes would be placed to the north and south of the processed kimberlite containment area. A water collection system would circle the mine footprint. An airstrip would be located on the northern edge of the island."[25]

The RAs were determined to be the Department of Indian Affairs and Northern Development (DIAND), DFO and the Department of Natural Resources.

Significant Milestones

Diamond-bearing kimberlite pipes were discovered in the Lac de Gras region of the Northwest Territories in 1991. Diavik Diamond Mines began community consultations in 1994. In 1998, Diavik submitted an EAO. In June 1999, a CSR was published. Work began on the project in 2001. The mine has an estimated lifetime of 25 years with reclamation activities scheduled after mine closure.[26]

Documentation Review

B.1 Letter from Nixon Geotech Ltd. to Diavik Diamond Mines Inc. (August 25, 1998)[27]

Diavik, at the request of the investigator, provided this document. It is particularly germane to how the proponent determined geothermal modelling under climate change.

Nixon Geotech Ltd. investigated the question of permafrost and climate warming. This study was not original research; rather it was partly a digest of a Workshop on Climate Change Impacts on Permafrost Engineering Design held in March 1998 by EC's Impacts and Adaptation Group.[28] Thus, EC provided the estimates of climate warming as interpreted by the consultant. It appears that average climate warming rather than extreme possibilities or ranges of potential outcomes were discussed. This report illustrates that a range of possible temperature projections are available. In the investigator's view, rather than assume an average rate of temperature change, some insight can be obtained into the sensitivity of a project to temperature ranges as well as the uncertainty in the range of projections. The same approach could be used with other climatic elements such as precipitation, wind or snow cover, for example.

The consultant's report succinctly illustrates the importance of snow cover to permafrost considerations. "Winter snow cover is also a very important factor in long term predictions for ground temperatures and near surface freeze-thaw depths. Snow insulates the ground in winter and greater snow cover results in warmer ground temperatures. If a reduction in snow cover took place as has been observed for some locations in the Canadian North, then a cooling trend in ground temperatures would take place which could easily offset changes resulting from increasing air temperatures."

In the investigator's opinion, the aggregate effect of reduced snow cover on permafrost depends on a complex interaction of, among other factors, snowfall; timing of rainfall; depth, density and albedo of snow; cloudiness; the intensity of incident sunshine; and the ground's temperature profile. A rigorous treatment of the impact of changing snow cover would require the use of and simulation of surface energy and water budgets.

B.2 Environmental Assessment Overview (September 1998)

The proponent prepared this document to comply with the CEAA.

Section 1.1 Report Summary

In reviewing the Report Summary, the investigator identified the following areas as being potentially impacted by climate change: permafrost[29] (potential thawing), precipitation (flowing into open-pit areas)[30] and surface water (from run-off and seepage).[31] All are related to atmospheric processes and potentially to climate change.

The proponent undertook a four-year study[32] on the environment. Baseline conditions were measured from 1994 to 1998. The proponent refers to the environmental effects report that examined climate and air quality[33] (see B.3).

Under the section, Natural Environment, the Report Summary states, "The climate of the Lac de Gras area is characterized by long, cold winters and short, cool summers. The mean monthly temperatures range from -31.2°C (January) to 10.2°C (July), with a mean monthly temperature of -12°C. Mean annual precipitation is 266 mm, consisting of 138 mm rainfall and 127 cm snowfall. Average wind speeds are about 19 km/hr with a low frequency of calms."[34] In this paragraph, the proponent recognizes the range of climate and potential severe conditions under which the mine will operate.

The EAO report contains several "key questions"[35] related to socio-economics, fish and water, wildlife, vegetation, terrain, heritage resources, climate and air quality. The investigator notes that the physical environment in which the project operates may be affected by climate change, either directly or indirectly through chain mechanisms. For example, air quality is, among other factors, a function of wind speed and atmospheric stability. As the climate changes, a slightly changed temperature and wind regime, and distribution of atmospheric stability classes may evolve. Looking forward, for example, a climate scenario from the Canadian Centre for Climate Modelling and Analysis,[36] for 2010-2039, shows surface temperature increases on an annual average of about 1°C and wind speed decreases of about 5% compared with the 1961-1990 climatic normals. Actual climatic changes may be more or less than this; a sensitivity study would be required to assess the potential sensitivity of dispersion to such changes. In a project whose lifetime was longer and potentially subject to greater climate change, the uncertainty in the climate projections would be correspondingly larger so that a stronger case for sensitivity studies could be made. This effect is indirect and weaker than the impact of temperature warming.

Section 1.2 Appendix III

EA Guidelines regarding the project are contained in Appendix III, pages 1-21, of the EAO. Paragraphs 3235 and 3236, Section 2.3.5, page 17, contain the requirements to consider impacts of the environment on the project.

"2.3.5 Impacts of the Environment on the Project

3235 The EA shall include a discussion of the effects of the environment on the project. This shall consider such things as severe weather events and climate change.

3236 The discussion must specifically describe and assess how the potential for climate change (global warming) could affect permafrost and soils with high ice content in relation to the integrity of the project infrastructure, particularly the tailings (processed kimberlite) containment impoundment, water retention dikes and waste rock piles."

Section 1.3 Effects Assessment[37]

As noted in the following, the proponent considered climate change impacts as required by the EA Guidelines.

Section 4.3.14 Global Warming and Structural Integrity

This section deals with global warming and structural integrity. The proponent examined the effects of global warming on the dikes, processed kimberlite containment (PKC), sediment pond structures and country rock areas. "Temperature changes assumed for this analysis were estimated based upon a review of current scientific opinion (Nixon 1998)." Nixon was a consultant who provided the information to Diavik. In this section, Tables 4-6 contain "Hypothetical Climate Change Scenario Description. Mean Seasonal Temperature (°C) Increases." It cites "Best Estimate Case" and "Extreme Case" for the years 1990, 2020 and 2040. The same section contains the statement, "Neither of these temperature increases is sufficient to thaw the foundation or dam cores." A review of the report referred to as "Nixon 1998" is contained in B.1 of this appendix.

Section 6.2 Climate and Air Quality

Section 6-2 of the EA Overview contained a sub-section entitled Climate and Air Quality. The investigator notes that although the subsection contains the word "Climate," no references to climate change were identified in this section. A more appropriate title could have been selected.

B.3 Environmental Effects Report, Climate and Air Quality (September 1998)

The investigator recognizes that the cited report deals with greenhouse gas emissions and air quality. While the investigator makes no comment on greenhouse gas emissions, there may be some benefit derived for future EAs from the following general observations, which relate to the effects of climate change.

Section 1 Report Summary

The Report Summary[38] states: " … the evaluation itself recognized the expected operating life of the project including construction, closure and post-closure activities which is also consistent with the time period for the climate normal (30 years)." The investigator notes that climate normals are computed from a reference period taken from historical data. It is unclear how the operating life is "consistent" with the time period for the climate normals. Project activities are occurring years after the period for which the climate normals were computed. Climate change is not mentioned; thus, it appears that an underlying assumption in the consideration of air quality is that the climate of the reference period will be representative of the period of operation. Whether or not this is the case, it may be beneficial to consider changes in the climatic conditions that have the potential to alter atmospheric stability, evapotranspiration, the wind regime and precipitation during the project's lifetime.

Section 2 Introduction

While reviewing the Introduction,[39] the investigator noted that a potential tool for the consideration of climate change could be the use of a linkage diagram. This diagram would link climate change impacts to other considerations of a project such as vegetation, wildlife, fish and water quality. Application of climate knowledge in this area may be a secondary effect but may warrant consideration by the Responsible Authorities (RAs).

Section 3 Existing Conditions

The proponent completed a study of existing conditions comprising regional climate, local meteorological conditions and air quality.[40] The early sections contain a general description of the climate in the region between the Mackenzie River and Hudson Bay with an apparent focus on parameters required for air quality considerations. In the section of the report entitled "Climate in perspective,"[41] the investigator noted a quote taken from *Climate of Canada* (1951): "Canada holds none of the world's major weather records. Worse storms and greater extremes of cold, heat, wetness and dryness occur elsewhere." The investigator believes that this statement may be connected to the need to address the Environmental Assessment Guideline to " … consider such things as severe weather events … " While it is possible that Canada's weather extremes are not equal to extremes found elsewhere in the world, this downplays the true severity of the Canadian climate, its extremes and variability. How such a statement assists in placing the climate of the project in context is unclear.

In the section, Length of Records[42], records longer than 30 years have been employed for assessment or evaluation. The investigator notes that given the paucity of data, the author of Diavik's report appears to have made appropriate decisions in its use of longer baseline information; however, it would be a reasonable expectation to test the data for trends. This may have been done but not noted in the report. Further, it would have been beneficial to understand why the Yellowknife 1961-1990 normals were used for wind whereas the 1956-1995 combined Lupin winds were used in Tables 5-1.

B.4 Proponent's Response to Information Requests Made by EC through the Responsible Authority (December 15, 1998)

The following excerpts arose from an information request sent to Diavik Diamond Mines by the RA (DIAND) in November 1998.[43] They are titled Information or Action Required from Diavik Diamond Mines Inc., and are accompanied with citations that are identified by "guideline numbers." They are documents in the public realm and seek clarification before completion of the CSR. The following points that are pertinent to climate change appear in this document and are referenced by guideline number:

Guideline 3235. The question posed was "What are the potential environmental effects on the project as a result of severe weather, including storm surges on the dikes?" The response noted that severe weather effects on the dikes had been addressed in detail in Acres Water Retention Dikes Design Criteria Report. Further, the response noted that storm surges were not an issue as "the lake is too small for tides or storm surges to exist at meaningful magnitudes." The response addresses the physical structure and the proponent included consideration of severe weather in Diavik's EMS.

Guideline 3236. The question posed was "Has climate change effect on dikes, PKC, structure and area, and other infrastructure been modelled?" The investigator believes that the response is well considered and gives a solid rationale of how climate change was included in the dike designs. The response also notes the rate of temperature change was 0.32°C per decade, and discusses the uncertainty in temperature projections and the application of annual versus seasonal trends.

The investigator notes that 0.32°C per decade warming trends were employed and suggests a century-long warming of about 3.2°C in keeping with current (year 2000) estimates of *global warming*; however, regional warming in the Canadian Arctic has the potential to be far greater. Should the project life be decades or a lengthy post-mining phase be envisaged, then sensitivity studies of structural response to climate change may be appropriate. The proponent concluded that: "Climate warming was modeled on the basis of annual mean temperature rather than on seasonal or monthly mean. The reasons for this are twofold. There is always uncertainty in project temperature trends 20 to 50 years into the future and to try to estimate seasonal variations on top of that only compounds uncertainty, and hence raises questions about the precision of the results. Secondly, the long-term thermal modelling is focused on the temperature changes internal to or beneath the mass of the structure and these can be modeled appropriately with annual means." These approaches are well explained and it can be concluded that the proponent has taken into account climate warming.

The investigator notes that the residual environmental effects of global warming and thus impacts on permafrost and dikes are projected to continue well after the mine is closed. No reference to this possibility was found in the documentation. During one of the interviews with persons involved in past EA projects, this observation was confirmed.

B.5 Environment Canada's Final Report: Recommendations [on] Environmental Assessment of the Proposed Diavik Diamonds Project Draft (March 15, 1999)

This *draft* document summarized departmental recommendations to be included or addressed in the CSR.

EC's Recommendation 4.1 states that higher design criteria be used for the PKC facility during operations and at closure. Also, a 500-year return period should be used as the minimum standard for the PKC facility design criteria. EC's recommendation is in keeping with current climate science in stating that the next 50 years will not be the same as the past 50 years.[44] Further, EC recommended the use of a 500-year return period for rainfall rather than a 100-year return period to compensate for climate change.

EC also suggested the use of the PMP event rather than the 1:1000-year return period for 24-hour precipitation in the emergency spillway. The rationale for this more stringent condition is not explained in the document. However, this condition is consistent with the direction of increased intensity and frequency of projected precipitation events anticipated under global warming.

B.6 Comprehensive Study Report (June 1999)

Following submission of the EA report in which documentation discussed under B.1 and B.2 were included, a CSR[45] was subsequently prepared from Diavik's EA submission. Additional information was derived from technical reviews and public consultations during March and May 1999. The RAs, who were not identified in the report, determined the validity of the proponent's assessment of "significance," the effectiveness of proposed mitigation measures, the need for follow-up and the significance of the residual environmental effects.[46]

Section 8.0 Environmental Effects Analysis

Under the title, Climate and Air Quality, the RAs made statements in two areas relating to climate:

1. Climate and Air Quality. The RAs concluded that no significant effects on air quality by the proposed project would occur with the application of mitigation measures. No statement is made about the effects of climate change on air quality; however, EC[47] commented that "given the probability of climatic change over the life of the project, the establishment of adequate meteorological monitoring stations early in the development would also help confirm the validity of the values used for event return periods." The RAs supported the establishment of a more sophisticated meteorological station. This decision recognizes the need to monitor climate change's effects on the extreme events.

2. Global Climate Change.[48] EC commented that: "over the past 50 years, the Western Arctic has experienced a warming trend accompanied by not only increased annual rainfall but also an increase in the magnitude of daily and longer duration extreme events." Further, EC noted projections of significant warming at high latitudes. While there was no immediate concern of permafrost degradation, EC recommended more stringent design criteria for the facility at closure.[49] The GNWT expressed concern "with respect to wildlife, the effects of global warming were not considered despite the potential for important effects … "[50] The RA concluded that global warming "will not likely cause significant environmental effects on caribou as a result of this project." This deliberation is noteworthy in that the RA recognized that climate change was potentially an issue in an area other than physical structures.

Under title, Effects of Environment on the Project, permafrost, global warming and structural integrity, severe weather, and frost penetration into pit walls are considered.

1. Global Warming and Structural Integrity.[51] The proponent noted that "it is difficult and beyond the scope of this EA to predict if climate changes are likely to occur and what they would likely be." Despite this difficulty, the proponent did evaluate facility sensitivity to temperature changes over a 50-year period employing advice from a consultant who provided a "current scientific opinion" on potential temperature changes. EC expressed the same concerns as noted previously under Global Climate Change. The RAs directed Diavik to further consider at the regulatory stage the effects of climate warming on the long-term integrity of frozen structures should the project be allowed to proceed. This example illustrates that the impact of climate warming on structures is a shared concern among the proponent, the RA and EC.
2. Severe Weather. "Diavik described the severe weather conditions in its Environmental Assessment submission, and anticipates no potential environmental effects." In the same section, the RAs conclude that severe weather conditions and the impact on mine operation procedures would be incorporated into Diavik's EMS. This would " … minimize risk of environmental effects and to ensure the health and safety of workers." The investigator noted no intervention by EC, although it had earlier stated under Global Climate Change that there had been an increase in rainfall in the " … magnitude of daily and longer duration extreme events" during the past 50 years.

Section 9.0 Follow-up Program[52]

The follow-up program describes the specific actions to be carried out by the proponent, should the project proceed, to verify the accuracy of the EA and to determine the effectiveness of measures taken to mitigate adverse effects of the project. The element of the follow-up program related to ambient air quality conditions is to "establish a more sophisticated meteorological station to confirm assumptions and validate predictions." This particular action relates to return periods of extreme weather due to climate change.

No specific global climate change follow-ups were required by the RAs.

Appendix C. Cascade Heritage Power Park

This appendix contains the details of documentation review. Documents are cited in chronological order where possible. Findings are summarized in the body of the report.

Where required, observations, comments and conclusions made by the investigator are enclosed by square brackets [ ]. Quotation marks are used to refer to material within the document cited in the heading of a section. Where additional reference was thought necessary, the specific reference is provided using a superscript number referring to the source identified in the endnotes. If neither brackets, superscript reference numbers nor quotations appear, the information was extracted from the document.

Acknowledgement

The materials cited here were kindly provided by EC, Pacific and Yukon Office, (written documents) and the Government of British Columbia Environmental Assessment Office (Web site http://www.eao.gov.bc.ca/PROJECT/ENERGY/Cascade/) where a publicly available registry of documents can be found. The host agency guided the investigator to specific documents. In addition, federal and other relevant materials were scanned, and copies retained if pertinent and analyzed (see following Documentation Review). As a detailed review of all documents on this site would be an extremely lengthy process, certain relevant documents may be missing.

Project Description

The Cascade Heritage Power Park, a run-of-the-river hydroelectric project located on the Kettle River at Cascade, is approximately 2 km south of Christina Lake, B. C.,[53] within a few kilometres of the Canada-U.S. border. The project is comprised of a powerhouse, weir, tunnels, penstock and other components. This ongoing project should reflect the current state of climate science. Environmental sensitivities relate to stream temperature, species at risk and rate of river flow.

Significant Milestones

Planning documents projected the start-up of the plant in October 2001. Its lifetime is in perpetuity. PHE began the process to gain approval for a power generation facility in 1993. Extensive consultations have led up to the current stage (January 2001) at which this project is being reviewed for climate change and other considerations.

The EA process for this project arises from the CEAA and the requirements of the Government of British Columbia. DFO is the RA.

Documentation Review

C.1 Proponent's Project Approval Certificate Application (May 1999)[54]

Through a keyword search, the following climate-related issues were identified in the electronic registry:

Executive Summary

The issue of river flow is noted in the executive summary. "Under low summer flow conditions, the increased surface area and reduced velocity could slightly increase the water temperature immediately above the weir. Despite record high water temperatures in 1994 … " The investigator notes that water temperature relating to fish is an issue.

Project Description

Under Section 2.1.6 on climate, the proponent cites the climatic normals for the period 1951-1980 "which represent a long-term average." The proponent refers to a Table 7 that contains the climatic normals; however, this table was unavailable on the Web site where the cited document was located.

Cumulative Environmental Effects

Under Section 6 of the proponent's application, the potential effects of climate change on the project were identified as requiring attention. Under Section 6.4.3.5, Climate Change, the proponent discusses the implications of climate change, relying mostly on statements made by EC, some of which were made at a seminar held on March 11, 1999, by the Canadian Water Resources Association. The proponent notes changes in the temperature, dates of peak flow and trends in precipitation. The proponent did not cite any studies it had carried out. The proponent concluded, "Hydrological variations in the annual Kettle River hydrograph due to climatic change or to natural annual events will not cause any effect on the method of operating the Cascade run-of-river project." The proponent noted that river flow may affect the availability of electricity from the plant but will not affect the proposed flow of water that is required for fish. Thus, an initial assessment by the proponent is that climate change will have no effect on the operation.

C.2 Possible Effects of Climate Change on the Cascade Heritage Power Park (August 1999)[55]

The view of EC as of September 1999 on climate change as it applies to the Cascade project was conveyed to the RA in DFO. (This effectively repeated the conclusion conveyed to DFO in a letter of August 5, 1999, by J. Tennant.) The EC conclusion is worth quoting in full. "As a general conclusion it appears that quantifying the potential impact of climate change was not possible given the fact that the issue is relatively new in analytical terms and the available database is therefore limited; however, it certainly does appear that the project's economic feasibility could be significantly affected by flow reductions resulting from climate change. In addition, there may be opportunity costs associated with licensing of the power project in terms of restricting the ability of government to issue licenses for water extraction for future projects upstream, some of which may have comparable or greater socio-economic benefits. We have recommended that the vulnerability of the project from an economic standpoint to potential flow restrictions arising from climate change be studied by the proponent in his own best interests." A research paper attached to this correspondence explored historical climate change relationships between stream flow and precipitation, base flow, glacier melt and snowmelt as sources, and licensed water use and other natural losses.

EC expressed the view that general projections for south-central B.C. are for decreased flows, but that data were insufficient to accurately estimate the likely reduction in the Kettle River at the project location. This conclusion gives the opportunity to point out that GCM projections of precipitation are available but the projections are only at grid points whose spacing are several hundreds of kilometres. To estimate values between grid points, special "downscaling" techniques are required. Such techniques are being developed now (early 2001) to "downscale" the coarse GCMs information to point locations or to finer grids. However, the complex mountainous terrain in B.C. poses additional challenges in developing useful precipitation scenarios.

In the documentation reviewed, the possible use of a watershed model in conjunction with a GCM was not discussed. An interviewee noted that the GCMs do not provide sufficient detail to assist watershed models at this geographic scale. In other projects with larger watersheds, the GCM output may be used to explore the response of a river system to the range of predicted future precipitation.

C.3 Workshop on Climate Change (December 8, 1999)[56]

This public document reports on a workshop held to "discuss climate change and how the effects of climate change should be integrated into the EAs of projects. Only federal and provincial officials attended the workshop. The issue emerged as a result of the federal/provincial review of the Cascade Heritage Power Park project.[57] At the date of the meeting, the project committee had not been able to agree on what should be required of the proponent with respect to potential effects of climate change on the project … "

In the final minutes of the meeting[58] three specific issues were identified and are paraphrased as follows: (1) potential conflicts over water required for power generation and fish protection, (2) reliance on historic flow to represent future flows and (3) the extent to which changes in flow and water temperature affect fish.

This meeting considered the evidence of climate change and potential for changes in stream flow presented by EC, Pacific and Yukon Region. This involved examining changes in the hydrology of streams in southern B.C., the projections of climate models, and shifts in the timing of hydrologic events. Based on historic data, EC, Pacific and Yukon Region stated that changes from one recent decade to the next showed that results were "consistent with expected changes in hydrology that are predicted from climate change scenarios."

The investigator notes that the most recent two decades are a relatively short period to establish a long-term trend. The trends so found, while consistent with climate warming, may also be the results of decadal-long cycles that have been linked to the Pacific decadal oscillation – a periodic rise and fall of sea surface temperatures in the North Pacific Ocean. A comparison of the earliest decade (1936-1945) with the most recent (1986-1995) may have provided additional insight. No mention is made of any study relating to the past century's precipitation record over the watershed, nor specifically how climate scenarios were employed if they were. In this seminar no discussions were recorded on the changes in temperature of the river due to atmospheric conditions, either from a historical or a projected basis. Water temperatures were discussed previously, elsewhere in the Cumulative Effects section of the Proponents' Project Approval Certificate Application.

Under Section 4, Project Discussion, of the minutes, the issue of "risk of low flows" and its impact on the project's viable operation are discussed. Government and the proponent were both concerned over this key item. A suggestion was made to use the last decade of actual river flows in an assessment of the impact of the environment on the project. It was decided that the proponent would be asked through a new specification "to cover climate change and how the proponent is to assess it." The investigator notes that while not explicitly stated and while it may have been apparent to attendees at that meeting, this period (1986-1995) contained extreme low levels of flow. Selecting different periods during the past when flow was both high and low in the extreme may have been useful.

Under Section 4, the issuance of a B.C. water licence was also discussed. It was noted that "a water license would not be issued for a project that is unable to demonstrate that water is generally available based on hydrologic records." The investigator notes that the focus on historical records parallels the use of historical atmospheric records as a proxy for the future. It might be beneficial to consider the use of a hydrologic model incorporating simulations of future precipitation from GCMs to assess future stream flows. Also, given some early understanding on the effects of the atmosphere on stream's temperature, some insight might be obtained about future stream temperatures using GCMs as input.

C.4 Project Report Specifications (January 6, 2000)[59]

This document outlines the project report specifications that PHE is to follow in preparing its project report. PHE's document is to address outstanding issues related to its application for a project approval certificate.

Cumulative Environmental Effects

Section 2.3.6 on cumulative environmental effects briefly noted that PHE "provided information on climate change in south-central B.C." and that "PHE concluded that the cumulative environmental effects were positive (in the case of Total Gas Pressures (TGP) or insignificant (temperature) … Governmental agencies however, have determined that the direct environmental effects of the project require further assessment … ." While this section deals with the project's impact on the environment it *also* requires the proponent to consider climate change's impact on lower flow regimes, in effect requiring the proponent to demonstrate the project is practicable. This requirement appears to be directly due to the meeting of December 8, 1999, noted in C.3.

The proponent was directed to undertake a cumulative environmental effects assessment to "discuss the ramifications of climate change within the context of the above factors," and propose a "climate change contingency plan that sets forth the approach that PHE would take if that anticipated climate change trends develop. This contingency plan should be tested against the lower flow regime encountered in the decade 1986-1995 inclusive to confirm its practicability."

The use of an entire decade of data of generally low flows as discussed above to test is the technique of testing by analogues. While the recommended test period was a period of low flow, it may not represent the most extreme conditions that will be encountered during the lifetime of the project.

C.5 Journal Articles from Environment Canada, Pacific and Yukon Region

In B.C., each region – the coast, the southern Interior and the northern part of the province[60] – has a distinct and different hydrological response to the climate. River flow in some regions depends on glacier and snowfield melt; river flow in other regions responds more rapidly to rainfall. All have different time responses. Therefore, the future climate must be interpreted in the context of a particular region.

Polar Plotting of Seasonal Hydrographic and Climatic Data (December 2, 1999)[61]

This analytical development technique was used to portray hydrologic information for the Cascade Heritage Power Park project. This publication shows the changes in stream/river discharge hydrographs on a polar plot which improves visualization of annual cycles and hence understanding of decadal changes. The paper quotes a previous paper[62] that "the magnitude and timing of run-off events in streams in B.C. have changed over recent decades. Onset dates of hydrologic spring and fall in streams in south-central B.C. are occurring earlier in the year."

Recent Variations in Climate and Hydrology in Canada (February 2000)[63]

This paper compared climatic variations and hydrologic responses between the decades 1976-1985 and 1986-1995 across Canada. The paper describes changes in precipitation patterns in B.C. and changes in the stream hydrograph during the course of the year. Of particular note is that "small variations in temperature and precipitation resulted in significant shifts in stream flow patterns." In the most recent decade, streams in south-central B.C. " … exhibited earlier onset to spring run-off followed by lower flows through the late summer and fall of the year." This research formed part of the input of EC to the Cascade Heritage Power Park project.

The use of an entire decade of generally low flows from the past is a test of the project's operational sensitivity to stream flow.

Appendix D. Confederation Bridge (Fixed Link – Northumberland Strait Crossing)

This appendix contains the details of documentation review. Documents are cited in chronological order where possible. The findings are summarized in the body of the report.

Where required, observations, comments and conclusions made by the investigator are enclosed by square brackets [ ]. Quotation marks are used to refer to material within the document cited in the heading of a section. Where additional reference was thought necessary, the specific reference is provided using a superscript number referring to the source identified in the endnotes. If neither brackets, superscript reference numbers nor quotations appear, the information was extracted from the document.

Acknowledgement

EC, Atlantic Regional Office, kindly provided the materials cited here. Due to the vast amount of material, the documents selected were those that the EC, Atlantic Regional Office, considered germane to this review.

Project Description

This project proposed and eventually constructed a 13-km bridge between Prince Edward Island and the mainland of Canada between Borden, P.E.I., and Cape Tormentine, New Brunswick, roughly parallel to the previously existing ferry crossing. The project consists of a high-level two-lane road structure built on piers over the entire crossing of the Northumberland Strait, although a tunnel had been considered. No causeway sections were envisaged and a navigation channel with vertical clearance of about 50 m and a width of some 185 m was planned for passage of ocean-going vessels. The design included highway access links at both ends, leading to the bridge structure.

This project was subject to the Environmental Assessment and Review Process (EARP. PWC was given the mandate to examine the concept of the fixed crossing in relation to technical and environmental viability. Assuming viability, PWC was asked to select the preferred option.[64]

Significant Milestones

The project planning began in 1985, when the federal government received two unsolicited fixed crossing proposals from the private sector, proposing a causeway and an intermodal tunnel, respectively. A generic Initial Environmental Evaluation was conducted in 1987 under the EARP Guidelines Order. A Stage II Proposal Call followed this. In September 1988, three bridge proposals were determined to satisfy environmental criteria and other requirements. A federal Environmental Assessment Panel publicly reviewed the project in 1990. In December 1991, PWC determined that the three bridge proposals satisfied the additional project criteria established by the government's response to the Panel report. In July 1992, PWC selected SCI as the preferred developer. The Environment Committee accepted an environmental management plan on February 26, 1993.

Documentation Review

D.1 Northumberland Strait Crossing, Initial Environmental Evaluation, Draft (November 1987)[65]

Global warming and sea level rise were principal concerns in this project. This early report recognized that the mean sea level had risen 0.14 m over the 50 years leading up to that time.[66] "Water levels are anticipated to continue rising in the future particularly with an expected global warming."

Section 7.0 of this report dealt with the effect of the environment on project alternatives. Under a subsection entitled Environment on the Bridge, the following environmental factors were identified to have an effect, "ice, wind, fog, erosion, currents, tides, geology, temperature and earthquake risk." It is stated that the Initial Environmental Evaluation reviewed "those environmental conditions with the greatest potential for impacting on the facility." The documentation gave no further details.

A subsequent section, Environment on the Tunnel, dealt with the tunnel alternative. Although the alternative was eventually rejected, high-risk values were identified in one of three categories: "risks of snow and land ice on the utilities servicing the tunnel, on the portals themselves and on the functioning of hazards identification and response system."

The investigator notes that, at the time of the preparation of the cited document, in-depth comprehension of climate change impacts was just beginning. Observations of sea level provided the data and sufficient evidence to assess that there was a risk from rising sea levels. This is an early illustration of the value of observational data and baselines to detect changes in the environment when considering the impact of climate change.

D.2 Climate Change Digest Preliminary Study of the Possible Impacts of a 1-m Rise in Sea Level at Charlottetown, Prince Edward Island CCD 88-02 (1988)

The MSC gave an excerpt from the cited report. In 1988, EC was concerned about climate change.[67] Scientists estimated that global warming in the range of 1.5 to 4.5°C with higher amounts in the Arctic could be expected. As well, an anticipated rise in sea level was a concern, but uncertainty in the estimates and the size and timing were a significant issue then and are still now.

The cited study began with the assumption that a 1-m rise in sea level would occur. The justification for the size of the rise can be found in the citation of a 1985[68] United Nations Environment Programme/World Meteorological Organization/International Council of Scientific Unions (UNEP/WMO/ICSU) Conference entitled "International

Assessment of the Role of Carbon Dioxide and of Other Greenhouse Gases in Climate Variations and Associated Impacts." This conference was the origin of the sea level rise estimate.

In 1988, a rise of between 20 and 140 cm or more in sea level was expected to occur by the middle of the 21st century. The report did not deal with the Northumberland Strait Crossing specifically, but noted that a rise in sea level was considered to physically threaten many aspects of life in Atlantic Canada.

D.3 Generic Initial Environmental Evaluation of the Northumberland Strait Crossing Project (March 15, 1988)

The MSC provided an excerpt from this March 1988[69] report, which addresses a generic initial environmental evaluation of the Northumberland Strait Crossing. It cites the same conference and results for sea level rise as given in reference D.2. A range of impacts on P.E.I. landforms, infrastructure and land were discussed as well as subsidence of the Northumberland Strait.

Concern was also expressed in this report[70] about the impact of the rise of sea surface temperatures on fisheries but not on the physical structure of the crossing.

D.4 Environment Canada's Position on the Northumberland Strait Crossing (February 1990)

A section of this position paper focuses on long-term climate change.[71] EC stated a concern that " … the design of a safe structure and associated facilities to withstand environmental conditions." EC also noted, "Considering that the environment may undergo significant changes over the next century PWC should examine the degree of risk posed by these [meteorological, oceanographic and other physical factors] on the integrity of the structure over the design life of the project (i.e. 100 years)."

In this position paper, EC remained " … concerned that the project design has not adequately considered the effects of long-term climate change on the structure." EC went on to "recommend" that the effects of long-term climate change on the design of the structure be more fully addressed. In this regard, it was suggested that an advisory mechanism could be established, with representatives from government and the scientific community, to ensure that the effects of long-term climate change on the structure be thoroughly evaluated and, if necessary, included in the design of the project.

This particular paper did not specify the basis for its concerns about the design short-comings in considering climate change.

While there was no reference to the scientific and technical paper, the next document reviewed below under D.5 appears to be the supporting document to EC's position.

D.5 Environment Canada's Review of the Northumberland Strait Crossing Project as presented to the Environmental Assessment Panel February 1990: Scientific and Technical Comments (February 1990)

This document contains EC's evaluation of the PWC submission to the Panel reviewing the proposed Northumberland Strait Crossing project. It is a summary document of scientific and technical aspects of the project.

The section dealing with long-term climate change, beginning on page 18, notes that the structure "must be designed to withstand loads (forces) resulting from atmospheric loads including wind, snow, freezing precipitation and stresses due to thermal expansion or contraction of structural components." The discussion also notes that marine loads consisted primarily of currents, waves and sea ice.

The report continued, "Existing standards used by designers to estimate environmental or climatic loads are based primarily on historic data. Evidence is emerging that while these standards may still be reliable indicators of what to expect in the short term, they may not be appropriate for projects with long life expectancies. Long-term climate change is predicted to be of a cumulative non-linear nature, in that the rate of change during the coming half century will probably be much less than in the 50 years which follow. In other words, environmental conditions at the end of year 35 of the structure's life … may not be markedly different from those which exist now, but there is a high probability that those at the end of year 100 (design life of the structure) will be."

EC's major concern was "that the project design may not adequately account for the long term climate change which [then] appeared probable." These statements illustrate that even a decade ago, when GCMs were more primitive and comprehension of climate change less advanced, scientists were sufficiently concerned about climate change to intervene. EC gave other examples from the Bridge Concept Assessment, "This suggests that present temperature data are sufficient for future planning, whereas temperatures may increase by 5 or more degrees Celsius over the next 100 years. Other examples can be found throughout the various assessment documents."

On page 19, referring to standards existing in 1990, EC expressed concern that the present standards may be inadequate to "withstand future environmental forces," and further noted that the structure must last for 100 years. In its view, "the design standards for this project as well as others of similar duration are adequate to protect the safety and financial interests of future generation of Canadians."

Also on page 19, EC stated that the rise in mean sea level was largely ignored in the planning of this project, and that it was a "critical oversight which could, in the long run have negative structural consequences."

The AES noted that the proponent acknowledged sea level rise but estimated the rise would be 0.3 m per century and further, "Any design will incorporate this anticipated increase over the structure's 100 year life." AES recommended that "Designs incorporate a minimum mean sea level rise of 1 metre/100 years."

EC's view was that an advisory mechanism could be developed to deal with the problem of determining design parameters, which take long-term climate change into account. The investigator noted that, although virtually all of the section previously quoted focused on sea level rise as an example, the general wording, without specific mention of sea level rise, suggests that the advisory mechanism would be broader.

D.6 The Northumberland Strait Crossing, Final Report of the Ice Committee (December 20, 1991)[72]

This report dealt with the risks associated with "ice-out delay" – the delay of ice clearing from the strait due to the bridge structure. The standard that was apparently suggested in 1990 by the Panel was "a maximum ice-out delay of two-days in any year in a 100-year period." The Ice Committee's major focus was to determine whether such a criterion could be met. A model was developed and tested against historical data, the main ice decay [not delay] being due to factors beneath rather than above the surface. The report refers to Table 5.1 that "describes the parameters and environmental data required to execute the simulations" and how each input is selected.

Under Section 5.2, the committee reported that it had weighed many considerations. The Ice Committee deliberated over several "what if" questions to assess whether the results were especially sensitive to various inputs and aspects of the methodology. One question was "assessing the effects of global climate change." This cited summary report did not present the detailed results of deliberations but it did note that "none of the sensitivities examined lead to significant changes in the ice delay caused by the bridge."

Under Section 7.0, page 28, the committee concludes, "the effect of the bridge on ice-out date needs to be judged in the context of the 65-day range of natural variability [in ice-out date] which can occur from year to year, as well as potential long-term climate trends … that these natural swings and trends will mask any effects of the bridge on the date of ice-out."

This illustrates the consideration of climate change as an indirect but potentially important impact on project design. It appears that climate change was not considered to be an important factor.

D.7 Environmental Evaluation of the SCI's Proposed Northumberland Strait Crossing (April 22, 1993)[73]

"The objective of this report is to provide a Specific Environmental Evaluation of SCI's proposed project, including an evaluation of any potentially adverse impacts of the project on the environment, and an assessment of the mitigability of these impacts."

One of the first references to the effects of climate change is found on pages 1-8. In this particular section, the Panel's concerns over ice-out were elaborated. " … the Panel concluded that an ice-out delay of one to two weeks could result, which would pose unacceptable risks to the marine environment. Such a delay could cause physical interference with important fisheries and alter the coastal micro-climate upon which coastal agriculture depends. The Panel expressed the belief that the ice modelling results would be more dependable if a safety factor to allow for possible climatic shifts were adopted, if corroborating observations were available, and if ice jams of all probability classes were included."

Further, on pages 1-10, the federal government "responded to the Panel's major concern regarding ice-out delay by accepting the Panel's criterion of a maximum ice-out delay of two days over a period of 100 years, and by agreeing to several improvements in the predictive tool of the ice model … " The government went on to appoint an Ice Committee to advise PWC whether the specific bridge proposals of the three developers would meet the Panel's criterion of a maximum two-day delay in ice-out over 100 years.

The next reference to the effects of climate change is found in Section 2.1.1, Bridge Structure. A 1-m sea level rise has also been incorporated into the design due to the potential effect of global warming over the design life of the project (100 years). Reference is also made to the incorporation into the design of "Potential 'environmental' (external forces) loadings from wind, waves, ice, currents and earthquakes … " In the last example, the investigator noted no reference to changes in loadings due to climate change.

Section 4.1 presents an overview of the biophysical environment that "may interact with project activities." Section 4.1.1 presents material on the climate. The period 1951-1980 was used as the reference period for which statistical information was presented. The investigator did not identify any mention about changes in the future values of weather or climate elements of the area, including extreme values arising from climate change.

Section 6.4 discusses cumulative effects, in which climate change is broadly discussed. The Panel had earlier noted several areas of concern, which "included potential cumulative effects on marine biota and the fishery as a result of the presence of a bridge and increased sea level, ocean temperatures and climatic variability due to global warming (FEARO 1990a)." The effects on fish and fisheries as a result of global warming were "not known and that marine species will be faced with adaptation to the new habitat conditions or relocation to a more suitable environment should global warming occur (FEARO 1990a) The Panel considered that the effects of global warming on sea level, changes in ocean temperatures and climatic variability could be dramatic. Although some scientists suggest that there could be global warming of 3 to 5°C by as soon as the year 2030, they cannot accurately predict local or regional change (FEARO 1990a)."

The Panel noted, " … the possible consequences of global warming and a bridge were beyond its ability to resolve. The Panel believed however that climatic changes could synergize with bridge effects. In response to the Panel (PWC 1990), the Government of Canada committed, when deemed necessary, to optimize the use of icebreakers to clear ice build-up around the bridge. Further the Ice Committee (1993c) concludes that the bridge design is such that a significant delay in ice-out will not occur due to bridge design characteristics. Should global warming result in an increased ice thickness in the Strait, as speculated by the Panel, the clearing of ice from the Strait will be governed by non-bridge factors."

In a further paragraph, the report states, "The Panel believed that if a bridge concept proceeds, a safety factor will be required to ensure the maximum ice-out delay was not exceeded in the event of climate shifts due to global warming (FEARO 1990a). In regard to this, the SCI bridge has been designed to withstand a 1-m sea level rise during the life of the bridge. This is considered to be a reasonable safety factor. Shoreline erosion and scour protection in relation to possible sea level rise has also been incorporated into the final design. If realized, a sea level rise could be further mitigated through additional protection or modification."

The previous citations show that climate change was clearly a major consideration in bridge construction. A review of references also indicated that wind, tide and other effects were studied.[74] However, the degree to which the impact of climate change was incorporated or that it influenced the design cannot be assessed as full documentation was unavailable for review.

Appendix E. Decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake

This appendix contains the details of documentation review. Documents are cited in chronological order where possible. Findings are summarized in the body of the report.

Where required, observations, comments and conclusions made by the investigator are enclosed by square brackets [ ]. Quotation marks are used to refer to material within the document cited in the heading of a section. Where additional reference was thought necessary, the specific reference is provided using a superscript number referring to the source identified in the endnotes. If neither brackets, superscript reference numbers nor quotations appear, the information was extracted from the document.

Acknowledgement

The materials cited here were kindly provided by EC, Ontario Office.

Project Description

This project involved the decommissioning of the Quirke and Panel uranium mines near Elliot Lake that had been in operation since the 1950s and were closed in August 1990. A range of decommissioning activities was proposed, the most important being the construction of permanent containment ponds for the radioactive tailings. This option requires that the tailings remain permanently flooded; this would prevent exposing the tailings to the air and the generation of acid. The tailings ponds were engineered using a series of dams and dikes to construct a terraced series of water-covered containment cells.

The project falls within the original EARP guidelines, "a self assessment process with an initial assessment phase and a public review phase."

Proposals for decommissioning of four uranium tailings management areas near Elliot Lake, Ontario, were referred to the federal Minister of the Environment for public review by an independent panel.

Significant Milestones

The background studies for this assessment were prepared in 1991-1993. Public meetings were held in 1993, Rio Algom Ltd. submitted the Environmental Impact Study in February 1995 and the Panel decision was rendered in June 1996.

Documentation Review

E.1 Report to Rio Algom Limited on Probabilistic Assessment of the Long-Term Performance of the Quirke Mine Waste Management Area (July 1992)[75]

In 1992, Golder Associates Ltd., a consulting company, undertook a study for Rio Algom Ltd. on the long-term performance of the Quirke WMA.

The potential hazard is the release of mine tailings due to, for instance, excessive rainfall, ice blockage or breach of dike retention systems.[76] Studies were based on the "Regional Storm, in this case the Timmins Storm (7.6 in. (193 mm) of rainfall in 12 hours). This corresponds to the largest observed rainfall in Northern Ontario and has been assigned a return period of 350 years."

While six storm events were considered in the assessment, " … the facility is designed to pass the Probable Maximum Precipitation (PMP) storm event."[77] "The Probable Maximum Precipitation (PMP) event (16.8 in. (426.7 mm) of rainfall in 12 hours). This is a theoretical maximum rainfall for the region of northern Ontario and, for modelling purposes, is assumed to have a return period of 10,000 years."

Under Section 5.4, for the PMP, assuming no change in blockage potential (floating debris or ice jams), the proponent calculated a chance of 2.4% that in the next 1000 years a dike breach and water/tailings solids release may occur. The proponent notes that 1000 years is "considered to be the maximum period of time for any rational assessment of the performance of civil engineering structures and for the extrapolation of precedent and/or historical data."

The investigator noted that statistics of occurrence of extreme rainfall such as PMP are based on historical data. The occurrence of climate change could result in a changed database and a new PMP. Similarly, climate change might potentially modify the conditions that affect blockage.

Under Section 6.1, Model Concepts and Assumptions, in the report to Rio Algom Ltd., Golder Associates Ltd. noted that if "a significant drought occurs, natural inflow into the facility could be insufficient to maintain saturated conditions in the tailings area."

The potential for exposing the tailings was assessed by Golder Associates Ltd. using a drought model that "synthesizes the hydrologic cycle in the waste management area by randomly generating monthly rainfall and evaporation values based on historical observations." The report[78] states that the procedure allows for the "possibility of decreasing precipitation by up to 10% and increasing evaporation by 10%." The rationale for a 10% deviation in precipitation and in evaporation was stated to provide an "additional degree of conservatism and to allow for sensitivity testing of climate change, an additional model parameter was incorporated to reflect climate variations." The report stated that no monotonic trend over time was detected for either recorded precipitation or evaporation.

Section A2 discussed meteorological data and statistics. The investigator's main observation about this analysis is the length of the record on which calculations are based. It is a discontinuous record of 55 years of precipitation data from 1915 to 1989 (missing 20 years) and 18 years of evaporation data from 1968 to 1985. Although this may be all data that were available, this is relatively short climatological period. For example, the standard to characterize the climatology of an area was 30 years of data. This is now recognized to be inadequate in portraying the future state of the climate for time periods extending more than 30 years into the future or for areas presently undergoing rapid change. Thus, the 18 years of evaporative data appear to not meet this standard.

On page A4, "the following assumptions were undertaken in order to develop a suitable Markov model: i) Precipitation and evaporation are stationary stochastic processes and ii) they are normally distributed random variables." On page A5, the report goes on to note "there is no monotonic trend for both precipitation and evaporation." While no trend was evident, making allowance in the models for lower precipitation and higher evaporation recognizes potential climatic change. EC commented on the adequacy of the allowance.

E.2 Federal Environmental Assessment and Review Office Panel on the Decommissioning of Uranium Mine Tailings Management Areas in Elliot Lake, Ontario: Final Guidelines for the Preparation of an Environmental Impact Statement (August 1994)[79]

This document "contains guidelines for the preparation of an Environmental Impact Statement (EIS) and identifies issues which the panel determined should be addressed in the EIS."

These guidelines were prepared to permit "any interested parties, the public and the Panel to," among other objectives "d) understand how the nature and extent of past, current and/or environmental impacts has been considered by the proponents, in the development of a site decommissioning strategy … ." In addition, on page 2 of this document, a list of major topics to be included in the EIS are laid out, including "6. Identification and assessment of short- and long-term environmental effects." In Section 6.0, Environmental Effects of the Proposed Decommissioning Option, the proponent is directed on page 16 to conduct appropriate risk assessments, including "c) consideration of a catastrophic or accidental event on the current climate and geology as well as the best estimates of long-term climate … and their associated uncertainties."

Section 9.0 specifies the consideration of a proposed monitoring program including air and water.

The issue of climate change is clearly identified as a concern of the Panel.

E.3 Environmental Impact Statement: Decommissioning of the Quirke and Panel Waste Management Areas prepared by Rio Algom Limited (February 1995)[80]

The Final Guidelines for the Preparation of an Environmental Impact Statement[81] August 1994 specified the material that was to be covered.

After the closure of the mining activities, Rio Algom Ltd. proposed to deal with waste management areas by flooding. The tailings would be contained in a stable condition within natural rock-rimmed basins with engineered dams closing off low areas of the natural basin perimeter and engineered dikes constructed as necessary to maintain internal water levels. This treatment was believed to include the virtual elimination of acid production, release of waterborne radioactive elements into the downstream watershed and the release of airborne radiation (radon and dust release, and elevated gamma radiation).

Section 3.1.3 Climatology and Meteorology of Elliot Lake

Section 3.1.3 presents climatological information and analysis. As the object of this investigation is to focus on climate change, the researcher will make no detailed comments on this section. However, as a general observation, the length of the observed record appears very short and no discussion of climate trends was noted (but it was noted in other places in the documentation). The researcher also noted that inadequate lengths of recorded atmospheric or climatic conditions appear to be a common issue noted in this and other projects reviewed. Where atmospheric issues are identified in the Guidelines for EIS Preparation or in similar requirements, it would be ideal if regular meteorological observations could be maintained throughout a project's lifetime so that the meteorological database is maximized when decommissioning studies must be undertaken. Even this step may not be fully adequate, but it certainly would be of assistance.

The document addresses issues surrounding adequate water coverage of tailings. "The tailings basins must be designed to ensure that water loss due to seepage and evaporation are more than offset by precipitation and/or run-off into the basin. In Elliot Lake, rainfall exceeds evaporation by 60%; therefore, all basins should have a positive discharge of water."[82]

Section 6.4 Long-Term Performance of the Waste Management Areas

The section opens with a comment that the purpose of the assessment was to determine the potential effects of non-routine effects such as large earthquakes and floods on the performance of the waste management areas (WMAs). It refers to a number of reports among which is the Golder Report reviewed under Section E.1 and in which probabilistic studies were undertaken. "Probabilistic analysis techniques were used to estimate the frequency and magnitude of an [extreme natural] event, and to accommodate some uncertainty associated with the potential long term environmental effects … " The discussion focuses on events that could occur at the facilities over the next 1000 years.

Section 6.4.1.1 Performance Models

The Drought Model is discussed. It "considers:

- Statistical data on meteorology (i.e. rainfall, evaporation);
- A range of values for potential seepage losses; and
- Potential impacts from the greenhouse effect.

… Expert opinion is used however, to factor in such phenomena as the potential effects of future climate change as a result of the greenhouse effect." Documentation provided did not specify what "expert opinion" was obtained either here or in documentation provided for the Golder 1992 reports.

Later in the same section, the Flood Model and the Integration Model are mentioned. The latter determines the potential releases that cumulatively could occur over a simulation period of 200 years and 1000 years. "The 200 year period is the minimum design period proposed … for the development of closure plans for mines. The 1000 year assessment represents the outer bound for extrapolation of precedent or historical data." It was unclear to the investigator what was being extrapolated for 1000 years. However, this procedure, if it assumes a "stationary" or "unchanging" climate for the coming 1000 years, could be strengthened by incorporating the range of climatic variations over a similar period of time, for example, the past 1000 years.

Section 9.0 Proposed Environmental Monitoring Program

"The primary goal of the monitoring and inspection program is to confirm the performance of the reclaimed WMAs and the monitoring needs."

According to the document, a "transition phase" was to end in early 2000. This phase was to have been used to adjust the monitoring programs as a "result of discussion with the regulatory agencies, experience and information obtained, periodic review of the data, and actual performance of the facilities." Based on this assessment the report concludes, "The anticipated requirements for 'long-term' monitoring (i.e. post-Transition Phase) are minimal."

In Table 9.2.1, the proposed monitoring program shows that a Long-term Meteorological Program for the Quirke WMA is "not required." Section 9.2.2.1 further clarifies that the meteorological program refers to " … wind direction and speed, precipitation, evaporation, and minimum/maximum daily temperature. The station is not required in the long term." The intent of the transition phase was to use the monitoring data to verify the performance of the hydrological models used for the site.

The investigator believes that, given the relatively short length of observational records, it would be unusual to expect that statistics derived from this record to represent a subsequent period of 1000 years. It may be beneficial to compute return periods on more widespread regional statistics or other long proxy records that would provide a longer baseline.

The researcher notes that climate change may mean more than just temperature and precipitation change impacts on major projects. It may involve all meteorological parameters to some extent. For example, evaporation depends predominately but not entirely on temperature and wind. It can also be affected by the radiation balance – which can be affected by cloudiness, and by water and ground temperatures. Changes in atmospheric humidity should also be anticipated as climate change becomes more pronounced. The mix of rain and snow as well as the seasonal timing changes need to be taken into account. Processes concerning the sublimation of snow may need to be addressed. In short, it may be beneficial to consider more than historic values.

E.4 Preliminary Review of Quirke and Panel Environmental Impact Statement Submission Atmospheric Issues Division, Environment Canada, Ontario Region (July 27, 1995)[83]

This document contains a note stating the comments were to be submitted as part of a comprehensive review by EC, Ontario Region, to the Panel. This review focused on Rio Algom Ltd.'s Quirke and Panel EIS submission dated February 1995 (see E.3).

The Atmospheric Issues Division (EC, Ontario Region) (AID) reviewers note shortcomings of the study in comparing data, assumptions about evapotranspiration, wind and atmospheric stability. Comments concerning climate change, or climate variability are noted in Section 6.0, Environmental Effects of the Proposed Decommissioning Option. The review notes that, while studies are limited, "evapotranspiration for the Lake Huron Basin will be more than 20% higher in 2050 than historic … levels" and further points out the need " … that the Probabilistic Assessment models incorporate the best estimates of the effects of climate change on key climate parameters."

When discussing flood models, the AID review points out that the system of dikes must last for over 1000 years and that historical precipitation should be replaced by "a reasonable attempt to incorporate future climate conditions into the heavy rainfall and resulting flood statistics."

The researcher notes that climate change occurring over 50 years described elsewhere in this document appears to illustrate the need to incorporate climate change. But for time frames of 1000 years, the scientific tools to assist the design of such long-lived programs are clearly wanting. Most climate models only project the climate for 100 years into the future. This suggests that at a minimum, the effects of the next 100 years should be considered and some additional measure of uncertainty built in for climate change for the subsequent 900 years.

E.5 Response to Environment Canada's Comments on Rio Algom Limited's Environmental Impact Statement (October 27, 1995)

This paper contains the proponent's response to EC's concerns about climate change and long-term monitoring. Pages 26 to 30 were provided for review.

Section 6.0 (iii) Risk Assessments

EC had noted that there was "no discussion of long-term climate change." The proponent countered by claiming that it had been taken into account in the model that investigated reduced precipitation due to climate change as well as drought.

Section 9 (i (b)) Extent in Time and Space (EIS 9.2.1 Inspection Programs) Water Level Monitoring

The proponent concedes that under drought conditions the monthly monitoring of water levels would be important after the transition period.

Section 9 (i (c)) Parameters to be Monitored (EIS 9.2.2 Routine Monitoring)

The proponent provided the meteorological information sought by EC.

The investigator suggests that this exchange indicates that the proponent was comfortable with its analysis regarding the risk of climate change while EC was not.

E.6 Technical Evaluation of Decommissioning of Uranium Mine Tailings Waste Management Areas Based on Environmental Impact Statement Documents of February 1995, submitted to the Federal Elliot Lake Environmental Assessment Panel by Environment Canada, Ontario Region (November 1995)

This evaluation, one of a series of submissions made by EC to the Panel, included comments regarding the decommissioning in the context of climate change.

Section 2.1.4 Physical Environment

Department of Environment (DOE) stated that: "several areas … such as drought/water level modelling, require representative, long-term meteorological databases containing key parameters such as temperature, wind direction and speed and precipitation. However long-term records of these parameters are generally unavailable for the Elliot Lake Waste Management Areas. Therefore, it is incumbent on the proponent to carefully compare on-site data to that from nearby, long-term sites to determine whether the regional data (i.e. Sudbury) is representative or will need adjustment." DOE provided an example concerning wind speed and direction. It ended Section 2.1.4.1 with the following recommendation: "Environment Canada recommends that the proponents compare at least one year of temperature, precipitation and wind data from the Quirke WMA site to data for the same time period for a nearby long-term site such as Sudbury. This comparison would determine whether the Sudbury data is representative of conditions in the WMAs or requires adjustment before being used for other components of the assessment."

This example illustrates that the brevity of observational data records was an issue in the decommissioning. Future steps might be taken to monitor climate during a project that has long post-operation lifetimes to maximize data on which studies are based.

Section 2.2.1.1 Extended Drought

This section begins by noting, "Maintaining the water cover is crucial." The section goes on to note a difference between the rate of evaporation used by the proponent and that recommended by the IJC for the middle of the 21st century. "Environment Canada recommends that Rio Algom re-evaluate the probability and severity of drought in its probabilistic assessment using the best estimates of long term climatic change and its associated uncertainties. It is also recommended that Denison Mines Limited conduct their own probabilistic assessments for the Denison and Stanrock TMAs."

Section 4.2 Climate and Weather (EIS Section 3.1)

DOE outlined concerns in Sections 4.2.1 (Wind: no consideration of wind speed), 4.2.2 (Atmospheric Stability: need to see direct comparisons between sites) and 4.2.3. (Water Issues: water losses should have included evapotranspiration). In these areas, no recommendations regarding climate change were made.

Section 4.17.4 Flood Conditions and Section 4.17.5 Maintenance of Watercover or Water Table in Waste Management Areas

EC noted the need to consider future climate conditions given that "these containment systems are expected to last over 1000 years, a reasonable attempt should be made to incorporate future climate conditions into the heavy rainfall and resulting flood statistics." As well it noted, "global warming, for example, could cause the flooded tailings to be exposed more often than predicted using present-day meteorological data." EC made similar notes about the drought and flood models in Sections 4.17.5.1 (Drought Model) and 4.17.5.2 (Flood Model), and especially the concern over the 1000-year lifetime.

E.7 Department of the Environment Elliot Lake Panel Presentation (November 17, 1995)[84]

These speaking notes were used in DOE's presentation before the Elliot Lake Panel. A separate Technical Evaluation dated November 1995 (see E.6) was the basis for this presentation. This paper raises several concerns, among them the following issues that related to climate change:

1. DOE believed that Rio Algom's simulations of the risk of [tailings] exposure under future drought conditions used the current evaporation rates … not supported by the IJC estimates which place the evaporation rates for the Lake Huron Basin 20% higher than historical rates by the middle of the next century [21st century].
2. DOE went on to recommend that: "Rio Algom re-evaluate the probability and severity of drought in its probabilistic assessment using the best estimates of long term climatic change and its associated uncertainties."

3. DOE recognized that "uncertainties between prediction and performance can be expected." DOE went on to note that there would be considerable reliance on the long-term monitoring, maintenance and intervention program.

E.8 Letter from the Atmospheric Issues Division to the Agency (November 22, 1995)[85]

The IJC paper on Great Lakes Basin hydrological impacts projected under a doubled CO_2 scenario (see E.9) was forwarded to the Agency Panel Manager under this cover letter. The letter noted some key findings of the IJC paper including:

Annual average air temperature over the land area increased by 5°C.

Annual precipitation was nearly unchanged (2% less).

Evapotranspiration from the land portion of basin increased 24%.

Over-lake evaporation increased 32%.

Snow pack storage reduced by 79%.

Soil moisture reduced by 26%.

The letter cautions the use of these data since the results are based on doubling of CO_2 by the middle of the 21st century or possibly as late as the year 2100. The results depend on the outputs of GCMs that use doubled CO_2 steady state that still have large uncertainties.

E.9 Hydrological Impacts on the Great Lakes using Canadian Centre for Climate Modelling and Analysis, General Circulation Model Doubling of CO_2 (undated)

This paper prepared by the IJC Working Committee 3, Task Group 2, on the Water Levels Reference Study, by T.E. Croley II provides key findings that support the letter discussed under E.8. The abstract concludes, "This study indicates a 20 to 100% reduction in net basin supplies to each of the Great Lakes. The basin's various moisture storages become dryer and the lakes are warmer with associated hydrological impacts."

E.10 Decommissioning of Uranium Mine Tailings Management Areas in Elliot Lake Area: Report of the Environmental Assessment Panel (June 1996)[86]

The executive summary, and Sections 6.0, 7.0 and 8.0 were provided for review. Certain sections of this lengthy document will be presented here to illustrate pertinent points.

In the executive summary, the Panel notes it reached many conclusions and formulated several recommendations. Those that pertain to the climate change issue follow:

- "The tailings of the Elliot Lake uranium mines present a perpetual environment hazard."
- "Given the nature of the long-term hazards of the tailings, the panel has set out a number of recommendations that seek to ensure that effective containment is established for the tailings; that an extensive monitoring, maintenance and research program is developed to ensure proper operation and safety in perpetuity … "

- "The transitional phase that will follow must be of sufficient duration to permit the effectiveness of the systems to be verified over a range of climatic and other operating conditions, and any desirable adjustments to be implemented."
- "The decommissioned waste facilities will be required to perform their protective functions for millennia, during which time there will be changes to the environmental conditions within which they must operate. Some changes will be external to the facilities, such as climate changes, while others will be internal … "

Section 6.2.2 Stability and Longevity of Water Cover

The Panel noted that "under existing climatic conditions in the area, precipitation exceeds the water loss caused by evapotranspiration. Under "normal" conditions, this ensures that more water will be replenished than will be lost due to natural processes. However, concern was expressed in several presentations about the impact of a possible long-term climate change on the proposed water-cover decommissioning program. The two potential problems most frequently mentioned were either flooding caused by excessive precipitation events, or the evaporation and subsequent loss of water cover during prolonged periods of drought. The Panel noted that "An extensive modelling program by Environment Canada indicated that there are adequate water resources available to maintain the water cover under foreseeable drought conditions"[87] and that "The potential climate change makes it necessary to have the ability to keep local weather records in Elliot Lake. This will allow observers to spot whether or not a trend is developing … " The Panel concluded this section by stating, "Climate variations represent just one factor of many which, when combined contribute to a slow but constant change of natural ecosystems."

Section 7.0 Facility Operations and Management

Under Section 7.1.1, the Panel noted that [the proponent believed] "on-site meteorological data are indicated as being "not required" in the long term." "The Panel does not agree with this stance and recommends that a meteorological station suitable for the collection of basic climatic data be set up at Elliot Lake." In a further sub-section, the "panel strongly urges the AECB [Atomic Energy Control Board] to consider explicitly each comment regarding operating, monitoring and maintenance needs with a view to determining whether it should be incorporated in the approved licensing procedures and plans."

Section 8.0 Conclusions and Recommendations

The Panel's main conclusions relating to climate change are presented in this section. Those that pertain to operations in the context of climate change are also noted here.

"C8. Tailings can, with suitable arrangements, be kept permanently saturated either under a water cover or under a dry cover, provided a sufficient, reliable supply of water is permanently available."

"C.10 Properly designed and constructed, such a system is both robust and flexible. It is capable of operating effectively over a considerable range of climatic and other conditions, and can be modified to adapt to changing conditions or requirement."

"R6. Because of the impact that climatic change may have on the performance of the containment systems, it will be important to monitor climatic behaviour closely with a view to early identification of possible trends. Current arrangements for acquiring timely, accurate and site-specific weather data are inadequate. An appropriate weather recording capability should be permanently established in Elliot Lake."

"R14. … In particular, the recommendations made by the consultants regarding instrumentation and monitoring procedures are considered by the panel to be minimum requirements."

The Panel thus noted that climate change was a real concern, that ongoing monitoring was required in perpetuity and that the operation would need to be flexible to accommodate climate change when it was detected in the future. Although the Panel did not set specific thresholds for climate change action, the ongoing water level monitoring will accomplish that, in that low water levels would trigger diversion of water from Gravel Pit Lake.

E.11 Government Panel Response to the Panel Recommendations of Uranium Mine Tailings Management Areas in the Elliot Lake Region YR-1996-022-1, Natural Resources Canada et al. (April 1997)[88]

The Government of Canada noted that the policies pertaining to mining, that is to say, the Minerals and Metals Policy recognizes that " … the operations of the mining industry involve the need to integrate environmental, economic and social considerations in decision-making. The sustainable development challenge is to ensure that each of these three elements is taken into account fully in the decision making process."

The Government of Canada response to Panel Recommendations contained recommendations on climate change and the recognition that over the period considered in the decommissioning, climate change may affect the performance of the containment systems.

Recommendation 6

The government concluded, "the AECB, with input from the Joint Review Group, will assess the instrumentation and practices to be employed to ensure that all climatic data collected are appropriate, reliable and sufficient enough to be able to detect changes which could potentially lead to change in the integrity of the containment systems over time. The extent of such data collection will be established as requirements in the AECB licensing process."

Recommendation 7

This recommendation notes the need to monitor water-cover depth so that prompt remedial action can be taken in the event of a threatened loss of saturation. In particular it notes the need for " … intensified [monitoring] during the summer because transpiration losses are likely to increase during the growing season."

The investigator notes that, in the final analysis, climate models were accepted as indicative that climate change may occur, that steps must be taken to confirm that climate change is occurring but that GCMs and climate science alone are insufficient evidence to warrant specific action.

Appendix F. Dredging of St. Lawrence River between Montreal and Cap à la Roche

This appendix contains the details of documentation review. Documents are cited in chronological order where possible. Findings are summarized in the body of the report.

Where required, observations, comments and conclusions made by the investigator are enclosed by square brackets [ ]. Quotation marks are used to refer to material within the document cited in the heading of a section. Where additional reference was thought necessary, the specific reference is provided using a superscript number referring to the source identified in the endnotes. If neither brackets, superscript reference numbers or quotation marks appear, the information was extracted from the document.

Acknowledgement

The documentation referred to in this appendix was kindly provided by EC, Quebec Region. Since the Canadian Institute for Climate Studies does not have a French language capability, Serge Nadon, EC, agreed to review the materials using the same format that the Institute has used elsewhere in this study.

Project Description

The project consists of dredging the shoals of the navigation channel of the St. Lawrence River between Montreal and Cap à la Roche to maintain in this portion of the channel a minimum depth of 11.3 m below the low-water line (zero on the charts). Currently, the minimum depth is maintained at 11 m throughout this zone; the dredging is thus intended to reduce the height of the dunes, or of the clayey or shaley outcroppings, by a thickness of between 0 and 30 cm. Downriver of Cap à la Roche to Quebec City, the minimum depths are 10.7 m. Navigation in this sector could, nevertheless, benefit from tidal movement. Consequently, the selective dredging of shoals does not appear to be necessary. Beyond Quebec, the depths are greater than 12.5 m.

Review of the Documentation

F.1 Addenda to the Environmental Study (August 1997)[89]

This document is the response of the proponent: the Montreal Port Corporation (MPC), to the comments and the request for additional information made by the RA (DFO) under the CEAA. It provides supplementary information on some aspects of the environmental study that was conducted in 1996.[90]

Following this 1996 EA screening, DFO conducted consultations and received comments on the project and on the environmental study from 15 bodies, ministries and individuals. DFO formed a multidisciplinary interministerial committee to carefully look into these comments. One of the views expressed by the committee was that three levels of comments or concerns had been made: comments related to the EA process, comments that directly concerned the implementation of the project and more general comments related to the comprehensive management of the St. Lawrence River.

To follow up on these comments, DFO submitted, in February 1997, a request to the MPC for additional information. This request appears as Appendix 1 of the addenda; the elements related to the impacts of climate change are highlighted in the next section.

Appendix 1

In the introduction to this appendix, DFO mentions, "the multidisciplinary interministerial committee also recognized the need for a more comprehensive management of activities related to maritime transport, including dredging, and recommended concrete action to that end. On the other hand, the committee agrees that this matter exceeds the framework of the present project and, in that context, a delay in the application of the recommendations should not hinder the realization of the project to dredge the shoals."

Section II-2 deals with the justification for the project. DFO mentions that "altogether, the justification for the project is not in doubt, although certain points may have to be reviewed. Some interveners … questioned the rationale of the project in the perspective of a significant reduction of the water levels of the St. Lawrence as a result of climate change."

Section II-10 concerns the cumulative impact. DFO notes, "numerous interveners mentioned in their comments that the impact of former dredging as well as the impact of climatic change and of the regulation of the waters of the Great Lakes should be taken into consideration in the assessment of cumulative impact." In the final paragraph of this section, DFO recognizes the importance of pursuing the development of new predictive models for water flow and recommends that the development of satisfactory forecasting instruments be continued. However, it clearly states that the results of these studies should not delay the realization of this project.

Body of the Addenda

Section 2.3 of the document deals with the question of climate change. The first paragraph discusses the limits to predicting future climate patterns from knowledge of those of the past. "It is impossible to extrapolate the future from known climatic tendencies, particularly considering that the forces influencing future change may be very different from those in the past."

The second paragraph deals with the uncertainty of climatic models in the following terms: "As mathematical techniques and computer capability are limited, it is impossible to simulate in detail all the processes that play a part in the climatic system. Moreover, even the most sophisticated models provide, in fact, only an extremely summary description of the actual climatic system. It is therefore difficult to establish with any acceptable degree of certainty the importance of the greenhouse effect on climatic change. Most scientists consider that it is too early to conclude that an increase in the greenhouse effect is already affecting the global climate."

The last paragraph refers to the State of the Environment Report (no. 95-2) published by EC in 1995 and entitled *A State of the Environment Report, Understanding Atmospheric Change: A Survey of the Background Science and Implications of Climate Change and Ozone Depletion*. The following passage is quoted: "Typical scenarios suggest that water levels in the Great Lakes could fall by 0.5 to 1.0 m or more on average, while the amount of water flowing out of the St. Lawrence River could be reduced by up to 20% within the next thirty years." The paragraph concludes, "These consequences could certainly have a significant impact on maritime transport in the St. Lawrence River system. However, as mentioned previously, it is not possible at this time to conclude that such a situation will occur." The investigator notes that reference is made to the above 1995 report when the Intergovernmental Panel on Climate Change 95 report was also apparently available. The latter, more recent report, states a more forceful position on climate change than the former.

Section 10.3.5 deals with the cumulative impact that could be anticipated on currents and levels. The following point is noted: "With regard to the future, one of the factors that could affect currents and levels in the river is global warming, which could, in turn, modify the flow available and the constraints related to the management of the waters of the Great Lakes and the St. Lawrence." On this point, the MPC concludes, "With a change in speed [of the current] of less than 0.1 cm/s and levels of less then 1 mm and taking into account, on the one hand, the numerous causes, natural and artificial, that can affect currents and water levels and, on the other hand, the customary variations of these parameters on a daily, seasonal, annual or interannual basis, these variations could be considered imperceptible. Thus, even in a cumulative context, it is impossible to conclude that there would be any tangible effect on future currents and water levels."

Appendix G. Little Bow Reservoir/Highwood Diversion

This appendix contains the details of documentation review. Documents are cited in chronological order where possible. Findings are summarized in the body of the report.

Where required, observations, comments and conclusions made by the investigator are enclosed by brackets [ ]. Quotation marks are used to refer to material within the document cited in the heading of a section. Where additional reference was thought necessary, the specific reference is provided using a superscript number referring to the source identified in the endnotes. If neither brackets, superscript reference numbers nor quotations appear, the information was extracted from the document.

Acknowledgement

The Prairie and Northern Region of Environment Canada kindly provided the documents referred to in this appendix.

Project Description

The project involves construction in three areas in the High River/Nanton/Stavely area of southwestern Alberta: the Highwood River, in the town of High River; Clear Lake, 16 km east of Stavely; and the Little Bow River, 16 km east of Parkland.

The development consists of construction of the Little Bow River Reservoir, enlargement of the Little Bow Canal, construction of the Clear Lake Diversion Canal and implementation of the Highwood Diversion Plan. In this last development, water will be diverted from the Highwood River down the Little Bow Canal into the Little Bow River. Water will be released from the Little Bow River Reservoir for conveyance, irrigation, domestic and municipal purposes. The project is intended to improve in-stream flows in the Highwood River, allow the development of 20 000 new acres of irrigation, stabilize water supplies to a number of municipalities and facilitate water-based recreational opportunities in the area.

The project falls within the original EARP guidelines, "a self assessment process with an initial assessment phase and a public review phase." The Natural Resources Conservation Board and the Agency formed a Joint Review Panel.

Significant Milestones

This EA review started in approximately 1990. The latest correspondence provided suggests the EA was ongoing as of 1997.[91] The project has an economic lifetime of 54 years.

Documentation Review

G.1 Terms of Reference for the Proposed Little Bow Project/ Highwood Diversion Plan: Environmental Impact Assessment (September 6, 1991)[92]

There appears to be no obvious consideration of climate change at this early stage of the project, although it may be implicit in the terminology used in the terms of reference.

G.2 Letter to Mr. R. Morley Christie 4186-NW4930 from Environmental Protection, Environment Canada, Prairie and Northern Region (December 8, 1994)[93]

This correspondence identifies the DOE interests in the Little Bow/Highwood Water Management Project. It provides comments on the terms of reference for the preparation of an Environmental Impact Assessment (EIA). Climatic trends are discussed under Section 4.1, Atmospheric Environment, noting the relevance of climatic conditions to the assessment. "The predictions of climatic conditions, events and trends are in turn critical to [the] predictions of [the] impacts on hydrology and associated effects on wildlife … These predictions would also be important with respect to probability and consequences of dam failure which could be caused, for example, by overtopping during an extreme hydrological event or … "

The section further examines the climatic factors that the applicant should determine relative to water demand and availability including:

- frequency and effects of dry years, singly and of several years in succession, and of very wet years singly and in succession;
- frequency and combined effects of heavy precipitation and snowmelt events on water containment and conveyance systems leading to possible overflow and flooding;
- monthly evaporative losses from the reservoirs and water conveyance structures, and associated effects in reducing water supplies; and
- worse-case scenarios and their impacts on water management procedures and on containment structures.

Section 4.2 contains statements about the need to examine the local and regional climate. Under Section 4.3, reference is made to the potential effects of global warming, "The potential impacts of global warming on the hydrological scenarios which are basal to the design and operational planning of the project should be assessed."

G.3 Volume 5, Environmental Impact Assessment 1995[94]

A review of this document reveals one reference to climate change. In Appendix B, climate change appears in a list of requests by participants at a public meeting for specific information.

G.4 Draft Letter Mercer to Woodward[95] Conveying Environment Canada's Review Comments for Alberta Public Works' Environment Impact Assessment for the Little Bow Project/Highwood Diversion Plan 26 (November 1996)

This letter notes that EC's role was to give expert or specialist information or knowledge on the EIA. The comments in the cited reference (i.e. the draft letter) refer to Volume 3 of the EIA dated 1995.

Under the section Climate and Air Quality- Existing Conditions and Impacts – a note is made that "The potential effects of global change on various hydrological scenarios, which could affect aspects of the proposal's design and operation, were also not discussed. The proponent should provide information on extreme events and explain how these were incorporated into the design and planning. The proponent should discuss the potential impacts of global change effects on the operating plan."

G.5 Environment Canada's First Draft Submission (October 1997)[96]

This document describes EC's outstanding issues relating to water quality and wildlife and habitat. No reference to climate change was noted although it is possible that other correspondence dealt with this issue identified in document G.1.

G.6 Little Bow Project/Highwood Diversion Plan: [Proponent's] Response to Federal Government January 6, 1997 Request for Supplemental Information (February 20, 1997)[97]

This document responds to concerns identified by federal agencies related to the scope of the study for the proposed Little Bow Project/Highwood Diversion Plan.

Under the section, Environment Canada – Climate and Air Quality, the proponent responded to EC's recommendation that the proponent should "discuss the potential impacts of climate change effects on the operating plan." The response states that computer modelling was conducted using climate and flow data for the 1950 to 1999 period. The data encompass a wide range of conditions including flood events and the extreme drought of the 1980s. The effects of these variations on water supply and demand throughout the study area are reported in detail throughout the EIA.

The next issue raised by EC was "The proponent should discuss the potential impacts of climatic change effects on the operating plan."

The proponent replied, discussing what GCMs suggested, based on references from the year 1993. From a global perspective of temperature and precipitation, the proponent then focused on Alberta and noted predicted increases of 3 to 7°C and increases in annual precipitation of 7 to 30% quoting a reference from the Hydrology Branch of Alberta Environment dated September 1991. This latter document was unavailable for review by the investigator so the time frame is unknown; however, the Canada Country Study[98] published in 1995 discusses various GCMs and their range of projections for $2XCO_2$. It includes more recent information. In Table 10 (p. 17, Vol. III), which deals with the Prairies, a diverse range of climate scenarios with considerable seasonal variability in precipitation was projected in some seasons. For future summers, the range of projections was, on the one extreme negative precipitation anomalies and on the other precipitation anomalies as high as 50% above normal. Temperature projections ranged from 0.5 to 8.0°C depending on which model, and the season under consideration. The proponent focused on a time frame of one-half century whereas $2XCO_2$ usually equate to about a century.

The proponent noted, on page 18, that "the predicted changes would not significantly affect the operating plan as the magnitude of change is within the range of natural variation … " The investigator noted that it is not evident that an increase in the mean temperature or in the mean precipitation with accompanying changes in the frequency and magnitude of extremes would fall within the "range of natural variability."

The proponent had clearly considered the question of climate change on the operating plan. By using computer simulation models and historical data, the proponent had considered a wide range of climatic conditions from floods to droughts, but the investigator found no mention of climate change in this context.

Glossary of Acronyms and Abbreviations

$2XCO_2$	Atmospheric carbon dioxide levels double those prevailing in the pre-industrial age
AECB	Atomic Energy Control Board
AES	Atmospheric Environment Service (renamed Meteorological Service of Canada in the year 2000)
the Agency	Canadian Environmental Assessment Agency
AID	Atmospheric Issues Division, Environment Canada, Ontario Region
AQ	Air Quality
B.C.	British Columbia
CEAA	*Canadian Environmental Assessment Act*
CSR	Comprehensive Study Report
DIAND	Department of Indian Affairs and Northern Development
DOE	Department of the Environment (now known as Environment Canada)
EA	Environmental Assessment
EAO	Environmental Assessment Overview
EARP	Environmental Assessment and Review Process
EC	Environment Canada
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
FEARO	Federal Environmental Assessment Review Office
GCM	General Circulation Model
IJC	International Joint Commission
IPCC	Intergovernmental Panel on Climate Change
MPC	Montreal Port Corporation
MSC	Meteorological Service of Canada
PHE	Powerhouse Energy Corporation
P.E.I.	Prince Edward Island
PKC	Processed Kimberlite Containment
PMP	Probable Maximum Precipitation
PWC	Public Works Canada
RA	Responsible Authority
TGP	Total Gas Pressure
TMA	Tailings Management Area
WMA	Waste Management Area

Endnotes

1 http://www.ceaa.gc.ca/rd/proposal_e.htm

2 Environment Canada, Canada Country Study, National Summary for Policy Makers, 1997, p. 2.

3 BC Ministry of Lands, Environment and Parks, BC State of the Environment 2000 Report.

4 Environment Canada, *Adapting to Climate Variability and Change in Ontario*, 1998, p. 20.

5 Environment Canada & Ministry of Supply and Services, *Climate Change Digest. Extreme Weather and Climate Change*, 1998, p. 21.

6 Ibid., p. 13.

7 IPCC Draft Third Assessment Report, p. 1.

8 http://www.eao.gov.bc.ca/PROJECT/ENERGY/Cascade

9 Gedalof and Smith, *Interdecadal Climate Variability and Regime-scale Shifts in Pacific North America*, 2001, Geophysical Research Letters 1999GL000000.

10 IPCC WG1 Third Assessment Report.

11 CCRM Web site: http://www.msc-smc.ec.gc.ca/

12 Diavik Diamond Mines Project Overview, p. vii.

13 Ibid., p. viii.

14 Ibid., p. 102, 8.2.2.

15 Ibid., p. 169.

16 http://www.msc-smc.ec.gc.ca/airg/pubs/permafrost.pdf

17 *Environmental Effects Report, Climate and Air Quality*, Diavik Diamonds Project, Sept. 1998, Linkage Diagram 1-2: Air Quality, p. 3.

18 Cascade Heritage Power Park Project Committee, *Project Report Specifications for the Powerhouse Energy Corp. – Cascade Heritage Power Park Project*, Jan. 6, 2000.

19 M.G.G. Foreman, D.K. Lee, J. Morrison, S. MacDonald, D. Barns, and I.V. Williams, *Atmosphere-Ocean*, 2001, In press.

20 Environment Canada's Position on the Northumberland Strait Crossing Project, Feb. 1990, p. 2.

21 Environment Canada's Review of the Northumberland Strait Crossing Project as presented to the Environmental Assessment Panel Feb. 1990 – Scientific and Technical Comments, Feb. 1990, p. 19.

22 Memo, Assessment Clerk, EACC Secretariat, EIA Coordination, Departmental Affairs DOE, Prairie and Northern Region, Oct. 26, 1994, enclosing Pre-Screen Report.

23 Diavik Diamond Project Environmental Assessment Overview, Sept. 1998, p. iii.

24 CCRM Web site: www.cmc.ec.gc.ca/

25 Diavik Diamond Project Environmental Assessment Overview, Sept. 1998, p. vii.

26 Ibid., p. viii.

27 Letter, Nixon Geotech Ltd. to Diavik Diamond Mines Inc., Aug. 25, 1998.

28 http://www.msc-smc.ec.gc.ca/airg/pubs/permafrost.pdf

29 Diavik Diamond Project Environmental Assessment Overview, Sept. 1998, p. ix.

30 Ibid., p. x.

31 Ibid., p. ix.

32 Ibid., p. xi.

33 Ibid., p. xvi.

[34] Ibid., p. xvi.

[35] Ibid., p. xvi.

[36] http://www.cics.uvic.ca/scenarios/data/select.cgi

[37] Diavik Diamond Project Environmental Assessment Overview, Sept. 1998, p. 6-1.

[38] Ibid., p. iii temporal boundaries.

[39] Ibid., pp. 2 and 3.

[40] Ibid., p. 37.

[41] Ibid., p. 39.

[42] Ibid., p. 39.

[43] E-mail message A.-M. Henry to D. Broadhurst, April 4, 2001.

[44] Environment Canada Final Report, Draft Mar. 15, 1999.

[45] Comprehensive Study Report, CEAA, June 1999.

[46] Ibid., p. 97.

[47] Ibid., p. 98 iv.

[48] Ibid., p. 102, 8.2.2.

[49] Ibid., p. 103.

[50] Ibid, p. 103.

[51] Ibid., p. 169.

[52] Ibid., p. 229.

[53] Cascade Heritage Power Park Project Committee, *Project Report Specifications for the Powerhouse Energy Corp. – Cascade Heritage Power Park Project*, Jan. 6, 2000.

[54] CASCADE HERITAGE POWER PARK, Project Approval Certificate Application www.eao.gov.bc.ca/PROJECT/ENERGY/Cascade/appl_apps/casapp.html Section 6 cumulative effects – Proponents statements.

[55] J. Tennant, *Possible Effects of Climate Change on the Cascade Heritage Power Park*, Environment Canada, Aug. 1999.

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Recommendations for Future Work

Introduction

In the conduct of the project, a number of areas worthy of consideration for future work were identified. Many recommendations are drawn from the Project Reports – Part 1: Review of Climate Change Considerations in Selected Past Environmental Assessments and Part 2: Climate Change Guidance for Environmental Assessments. As well, many points that were raised during the Peer Review process and that lay outside the original scope of the project, have been included. Recommendations have been gathered and grouped into the following areas without prioritization:

Data Related Issues

- Observational records were inadequate in many projects examined. For projects sensitive to climatic elements, where nearby or adequate climate observational data do not exist, the establishment of atmospheric observing systems should be considered when projects are started. Such observing systems should be operated during the operational lifetime of the project so that during decommissioning phases the data may be used with that of high-quality, long-running reference climate stations to provide a baseline and for appropriate correlation studies.
- The projects in this study considered historical climate normals, variability and extremes in at least some aspects of their planning. This is a necessary step in considering the application of climate change scenarios. It would be beneficial to know to what extent this is a current practice or could be strengthened. An examination of the details of past projects could prove useful.

Scientific Issues

- A recommended method to apply climate change science to projects is contained in Part II of the Report. Future work should develop and refine the methodology through application to a range of selected projects.
- No immediate "climate" tools are available for use in projects whose lifetimes are greater than 100 years. Consideration of climate change from the past using periods commensurate with the lifetime of the project may be the only way now to assess the potential range of climate that might be experienced in the next millennium. Given the virtual certainty that climate is changing, the dual issues of advice from climate change science on the one hand and operation and safety in perpetuity on the other, warrants a further investigation and should be the subject of a future study.
- Recognizing that projections of human activities on which projections of future climate and climate scenarios are based will remain uncertain for the foreseeable future, uncertainty expressed as a range of possible outcomes will always surround climate projections. Shortfalls in climate change science in meeting the needs of the EA community are recognized. A need clearly exists for improved knowledge about climate change. The portrayal of the future climate needs to be defined on

as fine a scale as possible (given the limitations of the science). Uncertainty must be addressed and a range of probable futures made available to support sensitivity studies in those projects where climate change is considered an issue.

- Projections from general circulation models need to include more climate/weather variables and projections need to be interpreted and applied to engineering tools such as return periods of extreme events.
- There is a likelihood that uncertainties in climate change science will remain a permanent feature of this discipline. The application of climate change in EA is a case of decision-making under uncertainty. Uncertainty analysis and risk analysis, well developed disciplines, need to be explored for application of climate change in environmental assessment.

Practitioner Issues

- The importance of the climate change science in EA varies project to project. Future research should consider the characteristics of projects that make climate change impacts most relevant or important with a view to assessing the degree to which climate should be considered.
- A gap exists between needs and expectations from the EA community on the one hand and climate change science on the other. Those who must deal with engineering and design aspects are used to dealing with historical data sets and should consider information expressed in non-traditional ways. Climate Change Science can provide ranges of future climate conditions but not, as yet in the form that is useful for proponents. Proponents should consider new ways to take into account available information while climate change scientists should formulate their information in such a way that is most useful to the EA community. Recognizing that the environmental assessment process has different levels of assessment as reflected by the extensiveness of the process (Screening, Comprehensive Study, Panel Review), there is a need to adapt the proposed methodology to these different levels of assessment. Fora to promote interaction between climate change scientists and EA practitioners are required.
- Access to and communication of climate change knowledge among all parties involved in impact assessment could be improved. At present, capacity is concentrated within government and universities. Mechanisms to distribute this knowledge to the consultant and proponent communities might include workshops, seminars and an Internet Web site. All parties involved in the Environmental Assessment process could benefit from this.
- There is support for the development of a formal Guide for the EA practitioner, proponent, RA and consultant. Such a Guide should:
    - provide links to the *Canadian Environmental Assessment Act* to set context;
    - contain an education component covering what science is available, a description of climate change temporally and geographically, and a rationale explaining why climate change is important;
    - state the policy on climate change;

- explain the manner in which climate change information flows through the various agencies and proponents;
- provide a simplified decision tree to determine when climate change is potentially an issue, what specific (not general) factors and issues to consider and when it should be included;
- include a checklist or step-by-step procedure to take climate change into account including sources of projections, techniques, methods, analyses, procedures, ranges and a list of specific scenarios to be evaluated and sensitivity studies to be conducted;
- present information on the reliability and uncertainty of projections;
- list/catalogue sources of climate change on the Web; and
- prepare an annotated list of resources that are available both within the federal system and outside.