Assessing the Treatment of Climate Change Impacts and Adaptation in Project-Level EAs in the Canadian Mining Sector

2014
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With support from Natural Resources Canada through the Adaptation Platform.
Acknowledgments

OCCIAR and RSI would like to acknowledge the hard work and significant contribution of our expert Project Advisory Committee (PAC) in the development of the products associated with this project. The PAC comprises a group of key government, academic and industry stakeholders that specialize in climate change, the environmental assessment process and the mining sector. The expertise provided by the group contributed to a comprehensive review of project-level EAs in the mining sector and to the development of rich findings and recommendations.

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1.0 Executive Summary

Environmental assessment (EA) is a “comprehensive and systematic planning process designed to identify, analyze and evaluate the environmental effects of proposed projects and ensure that these impacts and considerations are factored into project decision making” (FPTC, 2003). In Canada, physical projects of many types, including mining, are subject to environmental assessments. Climate factors significantly shape the baseline conditions of most natural systems and valued ecosystem components. They can impact the health and safety of employees and create challenges for project operation, maintenance and closure (Ford et al., 2011). Climate also affects the performance of project components, which may themselves then affect the environment. As such, it is now generally recognized that environmental assessments (EAs) should consider within their scope the issue of climate change (e.g., FPTC, 2003; NS 2011a, b; Byer et al., 2012). Although Canada is among a small number of nations recognized for encouraging the consideration of climate change impacts and adaptation in project-level environmental assessment, there is reason to believe that in practice the treatment of these considerations may vary in quality (Byer et al., 2004; 2009; 2011), and across jurisdictions (Appendix A).

The purpose of this study was to characterize and evaluate the treatment of climate impacts and adaptation considerations in project-level EAs in the Canadian mining sector. Its specific focus was a subset of six (6) geographically dispersed project EAs, all completed since 2004 in one of four mining sub-sectors (quartz; mineral; bitumen; potash). The study’s specific objectives were:

- To report on actions taken to reduce climate change-related risks at the mining project level;
- To describe, where possible, the strengths and weaknesses of current approaches to factoring climate change adaptation into project EAs in the Canadian mining sector; and,
- To identify other actions that might be taken, by the sector, government, or others in order to advance the role of project EAs in supporting climate adaptation decision-making in Canada’s mining sector.

The review and analysis of the selected EAs generated several key findings with respect to how climate change impacts and adaptation were addressed in mining EAs across the country. These findings were paired with recommendations from the project team and advisors to increase the level of attention to these issues within the environmental assessment process and thus within the industry itself. A summary of key findings and recommendations is presented below:
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<td><strong>1.</strong> Much of the available guidance on incorporating climate change impacts and adaptations into project-level EAs is dated (most relevant guidance published in 2003) and inconsistent across provincial/territorial boundaries.</td>
<td><strong>i.</strong> That the 2003 federal guidance document <em>Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners</em> be updated to reflect developments in climate science, the treatment of climate-related risks in decision-making, and sector-specific examples of best practice drawn from EAs conducted to date.</td>
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<td><strong>ii.</strong> That the appropriate provincial, territorial and federal authorities work towards harmonizing climate change-related requirements for project-level EAs across Canada by establishing clear and common expectations with respect to the steps practitioners should take and methods they should consider when: screening for and analyzing the potential effects of climate change on Valued Ecological Components; evaluating options for managing related risks; and, communicating about related uncertainties.</td>
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<td><strong>iii.</strong> That the appropriate provincial, territorial and federal authorities create or capitalize upon existing institutional mechanisms in order to support efforts at harmonization as described above.</td>
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<td><strong>iv.</strong> That the appropriate provincial, territorial and federal authorities, together with other qualified EA practitioners explore means by which to foster better-coordinated approaches to the consideration of climate change within <em>individual</em> EAs.</td>
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<td></td>
<td><strong>v.</strong> That the appropriate provincial, territorial and federal authorities develop a comprehensive glossary of terms to reduce confusion regarding climate, climate change, engineering and environmental assessment terminology. This work could expand on similar, existing work by Engineers Canada.</td>
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2. None of the evaluated EAs appeared to have been carried out in accordance with Terms of Reference informed by the prior assessment of climate sensitivities, or climate change vulnerabilities among VECs and project components.

| 2. None of the evaluated EAs appeared to have been carried out in accordance with Terms of Reference informed by the prior assessment of climate sensitivities, or climate change vulnerabilities among VECs and project components. |
| vi. That the terms of reference for EAs explicitly identify an initial list of Valued Ecosystem Components (VECs)\(^1\) that could be negatively affected by future changes in climate/weather parameters\(^2\), and require that projected changes in the baseline conditions of each of the identified VECs assume a reasonable, credible range of values for the climate/weather parameters to which they are sensitive, over all main project phases. This should be based on an explicit preliminary climate change vulnerability assessment of the VECs. (See Section 5, best practices 1-4 for further background.) |
| vii. That specific adaptation design and/or management options, and the criteria that would trigger their use, be defined within adaptive management plans for inclusion in EAs. |
| viii. That sufficient financial resources be held in security to ensure that all adaption options defined within proposed adaptive management plans (vii. above) can be implemented as necessary in the future. |
| ix. That guidance be developed to support EA practitioners in the selection and evaluation of adaptation and adaptive management options. |
| x. That EA practitioners explicitly discuss the uncertainties of the climate change projections they use and the implications of these uncertainties for conclusions drawn through the EA. This discussion should be informed to the greatest extent possible by quantitative analyses of the nature described in Best Practice #5, Section 5 of this report. |
| xi. That the appropriate federal, provincial and territorial reviewing authorities consider the role that climate data uncertainty plays in decision-making, so that they are better able to support proponents in identifying and implementing appropriate adaptation measures. |
| xii. That government strengthen efforts to collect and deliver accurate climate data for remote regions of Canada, as well as |

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1 VEC is understood to be “Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern,” (FPTC 2003). The VEC list will continue to be developed throughout the EA and public consultation processes.

2 Climate/weather parameters include variables such as temperature, humidity, atmospheric pressure, wind, and precipitation. Changes in both averages and extremes should be considered.
availability and/or quality of representative historical climate data; the data were often insufficient in either temporal or spatial extent, or both. tools and guidance to help EA practitioners make use of these data.

xiii. That project proponents be encouraged to begin monitoring local climate conditions as early as possible (such as during the advanced exploration phase of the resource extraction process), to ensure the longest and most representative possible climate data record for use in project EAs, regulatory processes, and later decision-making.

6. Across evaluated EAs there were several examples of missed opportunities for the use of key existing tools and methods in the consideration of climate change impacts and adaptation.

xiv. That government authorities provide guidance on how the hazard and risk assessment processes currently undertaken within project EAs might be better used to characterize climate change-related risks, and identify and select among appropriate adaptation measures.

xv. That climate expertise be consistently included in the conduct of project-level EAs, much as EAs currently make use of expertise in multiple other fields.

xvi. That regulatory processes, such as water licensing, be better aligned with EA processes with regard to the consideration of climate change in the planning, design, and management of projects, so that any regulatory requirements directly inform climate change-related analyses within the EA process and vice versa.

7. Information regarding past EAs was sometimes difficult to access.

xvii. That the responsible provincial, territorial, and federal authorities organize project registries to promote easier access to EA documentation.

8. Various key research gaps remain, to be addressed by future studies.

xviii. That additional studies of Canadian mine EAs be conducted in order to gain a better understanding of how the treatment of climate change impacts and adaptation may be changing with time, given the increasing availability of tailored climate information, tools and expertise.

xix. That existing regulations surrounding the reopening of legacy mine sites be reviewed to better understand their implications for associated climate risks (e.g. use, retrofit or replacement of old infrastructure), particularly in the context of environmental assessment requirements.

9. In Canada, consideration of climate change impacts and

xx. That a review be conducted of legislation governing project-level EAs across Canada, to better document any legal
| adaptation options in project-level EAs is suggested (by guidelines) but not required (by law), a situation which may be contributing to clear discrepancies in the extent and quality of climate change-related analyses across EAs. | requirements that may be impeding or could drive the consideration of climate change in environment assessment. |

vxi. That a review of existing regulatory processes and legislation be undertaken to provide a richer understanding of policy barriers and identify opportunities to drive climate change adaptation in EAs.
2.0 Introduction

2.1 Background

In Canada, as well as globally, the impacts of climate change have become increasingly evident. Significant increases in the frequency and intensity of certain severe weather events (e.g., heavy rainfall) and related hazards (e.g., riverine flooding) have been measured in various regions of Canada. Changes in average climate conditions have been measured across most of Canada, with some (e.g., warmer mean winter temperatures) impacting both natural (e.g., permafrost) and manmade (e.g., northern infrastructure) systems (Lemmen et al., 2008). Climate scientists predict that many current climate risks will be exacerbated in the future as climate change accelerates, with significant consequences for industry, infrastructure, communities and ecosystems (Lemmen et al., 2008; IPCC, 2013). The vulnerability of businesses, industries and communities to climate change will depend on a number of factors including: the probability of direct climate impacts and the potential for such impacts to exceed critical (e.g., infrastructure climatic design) thresholds (IPCC, 2012); the sensitivity of the business, industry or community to the impacts of climate on external systems such as supply chains (Lemmen et al., 2008), and the ability of sectors, businesses, and communities to adapt to the potential changes (McBean and Rodgers, 2010; Chiotti and Lavender, 2008; IPCC, 2012). Many municipalities, businesses and industries have begun to undertake adaptation measures to reduce the impacts of climatic change on their operations, assets and people.

The mining industry plays a critical role in Canada’s economy. For example, in 2012, over 200 active mines throughout the country produced $92.4 Billion in exports, approximately 20% of all Canadian exports that year (NRCan, 2013). In 2011, the mining sector contributed almost $63 billion in nominal GDP (NRCan, 2013). In addition to its significant national contribution, the mining industry makes notable contributions to local economies through employment and local spending. Given its size and economic importance, it is essential that operations and long-term revenue generation be maintained in spite of growing climate–related risks.

Many aspects of mining operations are climate-sensitive and hence potentially vulnerable to climatic change. Mining infrastructure such as buildings, platforms, open pits, culverts and tailings ponds can be heavily impacted by climate-related events such as flooding and permafrost thaw. Operations and maintenance schedules can be particularly sensitive to extremes in temperature and precipitation. Supply chains can be vulnerable to a wide array of climate impacts, including freeze thaw cycles, sea level rise and flooding. Health and safety of employees could be affected by extreme weather of any kind, and the natural environment surrounding the mine site (including available water sources, vegetation and wildlife) can be affected by short and long-term changes in temperature and precipitation (Ford et al, 2010).
In addition to creating challenges for the maintenance of stable mining operations, climate-related impacts can affect baseline environmental conditions, which may make certain VECs more sensitive to the presence and operation of a mine. For example, changing precipitation patterns may affect the quantity and quality of nearby water sources, which may be further strained by continued withdrawals during mining operations. These impacts can have implications for the wildlife populations, mine staff, nearby communities and the health and safety of future generations in the region. In light of the climate-related challenges facing the mining sector in Canada there is a growing demand for targeted adaptation measures based on robust analyses of historic and future climate.

Climate change adaptation encompasses adjustments in natural or human systems in response to actual or expected climatic stimuli and its effects, to moderate harm or exploit beneficial opportunities (IPCC, 2007). In the mining sector, owners and operators may choose to adapt to changing climate patterns by designing infrastructure and operations to be more robust and better able to cope with potential climate events. Given the nature of the mining industry and the heavy reliance on infrastructure and equipment, this type of adaptation will be a focal point for many operations (Pearce et al., 2011; Ford et al., 2011). The development of detailed emergency management, adaptive management and contingency plans is another type of climate change adaptation. Planning-based action works to build resilience to climate events in mining operations and staff. As a fundamental part of the adaptation planning process, vulnerability and risk assessment helps to identify aspects of mining operations that require priority attention through adaptive measures. For Canada’s mining sector, it is important that adaptation measures be identified using the most relevant and up-to-date climate data and analyses; be planned or designed to address expected climate risks; be efficiently implemented; and continuously monitored for effectiveness. Considering climate impacts and adaptation options during the environmental assessment process is one way to help ensure that climate risks will be addressed appropriately during later stages of the project.

An environmental assessment (EA) is a “comprehensive and systematic planning process designed to identify, analyze and evaluate the environmental effects of proposed projects and ensure that these impacts and considerations are factored into project decision making” (FPTC, 2003). In Canada, an EA must be submitted prior to commencing work on most large-scale, physical projects. There are several reasons why the project-level EA process could be an excellent vehicle for mainstreaming the consideration of climate change impacts and adaptation measures in the mining sector. First, climate change has the potential to impact mining operations and affect or exacerbate a mine’s impact on the environment. As environmental assessments were designed to account for a project’s impact on the environment, it is logical to consider the enhanced or additional impacts of changing climate as part of the EA process. Second, climate change will have significant implications for a mine’s ability to limit its impact on the environment in the long-term. Mine long-term planning that includes recognition of current and future climate change impacts will ensure full risk disclosure and help to minimize harm in planning, design and implementation phases. Finally, the EA process is mandatory, entrenched and familiar to mining.

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3 Examples include closure planning which is intended to be integrated with environmental assessment according to the Environmental Code of Practice for Metal Mines (Environment Canada)
practitioners. As such, it presents an opportunity to use existing planning tools and processes to bring consistency to the way climate change impacts and adaptation are addressed in large-scale projects in Canada.

The EA process is followed by various regulatory processes (such as permitting, license renewals or zoning processes), which may also be used as vehicles to increase the level of climate change impact and adaptation consideration throughout the mining phases. These processes are outside the scope of this study and will not be explored in depth, but it is prudent to note their potential value in this regard.

### 2.2 Goal of the Project

Despite emerging recognition that climate change impacts and adaptation should be considered during environmental assessments⁴, adoption of this practice across Canadian industries remains largely unexplored. This study sought to explore whether and how climate change impacts and adaptation are being considered in the conduct of environmental assessments by the mining sector in Canada. More specifically, through its review of a targeted set of recently-completed environmental assessments, the study sought to characterize any identified adaptation measures, and to evaluate approaches being used to consider the effects of climate change on projects and projects’ receiving environments.

The study’s specific objectives were:

- To report on actions taken to reduce climate change-related risks at the mining project level;
- To describe, where possible, the strengths and weaknesses of current approaches to factoring climate change adaptation into project EAs in the Canadian mining sector; and,
- To identify other actions that might be taken, by the sector, government, or others in order to advance the role of project EAs in supporting climate adaptation decision-making in Canada’s mining sector.

Although climate change mitigation and adaptation are closely linked, and a dual priority for many industries, this report focuses primarily on climate change impacts and adaptation and addresses mitigation strategies and techniques (GHG emissions reduction) only insofar as they relate to potential synergies with climate change adaptation priorities.

⁴ As evidenced by the development of the 2003 guidebook *Incorporating Climate Change Consideration in Environmental Assessment: General Guidance for Practitioners* by a joint task force including representatives from the Canadian Environmental Assessment Agency, Environment Canada, Natural Resources Canada, the Climate Change Secretariat as well as the provinces and territories.
2.3 Approach

This study was guided by two overarching questions:

- Do recently completed EAs from the Canadian mining sector consider climate change impacts and adaptation, and which adaptation measures have been proposed as a result?
- How could the consideration of climate change in project EAs be improved and are there examples of particular best practices among those which were evaluated?

To answer these questions, the following steps were taken:

**Project scoping and formation of Project Advisory Committee:** A first step was to identify appropriate environmental assessments for review. A comprehensive list of Canadian project-level mining EAs was assembled and screened (Appendix B). A project advisory committee\(^5\) consisting of industry, academic and current and former government experts was formed and consulted regularly throughout the EA selection and analysis phases of the project. At the suggestion of project advisors, public consultation documentation was included in the analysis to better understand the role of the public in driving climate change consideration and adaptation in mining projects.

**Review of earlier scholarship and guidance documents:** Two separate but related literature reviews helped provide the basis for the in-depth EA analyses conducted later in the project. The first review synthesized findings from earlier scholarship on the treatment of climate change impacts and adaptation in environmental assessment, domestically and internationally (a “review of reviews,” Section 4). The second review developed a high-level summary and gap analysis of the treatment of climate change impacts and adaptation in EA guidance of relevance to Canada (Report on Environmental Assessment Guidance in Canada, Appendix A).

**Descriptive analyses:** A descriptive analysis of six selected EAs was conducted, to identify and characterize in objective terms the inclusion of climate change-related content, including proposed adaptations (Descriptive Analysis, Section 6).

**Synthesis of ‘Best Practices’**: Using findings from the review of existing EA guidance, and from key literature in the decision and risk sciences, a synthesis of best practice was developed (Synthesis of Best Practices, Section 5) for reference during critical analysis of the selected EAs.

**Critical review template:** Reflecting main themes of the “Synthesis of Best Practices,” a template was developed to support collection of information of immediate relevance for critical analysis of each of the selected EAs.

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\(^5\) The PAC’s purpose was to provide guidance at every major stage of the project. Guidance was solicited through webinars, conference calls and targeted consultation at regular intervals throughout the year.
**Critical Analyses**: Critical analyses were conducted, to *evaluate* the treatment of climate impacts and adaptation considerations in each selected EA, through structured interrogation and comparison with “best practice” (*Section 7* for further detail). Interviews were conducted with a small set of mining experts and proponents directly associated with the selected EAs (*Section 8*), to supplement findings of the above analyses.

*Section 9* concludes the report with a brief discussion and final recommendations (note that sections 3, 5, 7 and 8 each contain their own set of recommendations).
3.0 Selection of Mining EAs

Selection of EAs was carried out through a two-phase screening process. Phase I served to develop the “long list” of over thirty (>30) mining EAs completed in Canada, on full mining projects since 2004. Phase II served to identify a sub-set of six (6) EAs for in-depth analysis. Both phases are further described below.

3.1 Development of Long List of EAs

A “long list” of Canadian mining EAs was developed by searching federal, provincial and territorial EA registries, then applying a set of five screening criteria to the preliminary results. Screening criteria were selected based on climate risk factors identified by previous initiatives focused on the sector (e.g., Pearce et al., 2009; Nelson and Schuchard, 2011; Stratos, 2011). The original screening criteria (some of which were later modified, as reported in more detail under 3.2) were as follows:

a) Date of completion (2004 or later): The first federal EA guidance to specifically incorporate climate change adaptation was published in 2003 (CEAA). While the presence of CEAA’s guidance post-2003 does not guarantee incorporation of impacts and adaptation considerations among more recent EAs, the study team surmised it would increase the likelihood of such inclusions. Given our interest in evaluating EAs within which climate change impacts and adaptations were expressly considered, 2004 was established as the “earliest date” cut-off.

b) Type of mine: Focus on gold, potash and diamonds. The project team made the simplifying assumption that these three mine types should generally exhibit equal or greater sensitivity to climate-related hazards than other mine types, based on the following considerations among others: gold mines result in acid rock drainage (ARD), requiring careful management of climate-related factors including, most notably, severe precipitation and permafrost thaw; potash mines have relatively long lifecycles compared to other mine types in Canada, suggesting a potentially higher likelihood of exposure to impactful climatic change; and, diamond mines in Canada are generally located “north of 60” where climate change has occurred and will continue to progress more quickly than elsewhere in Canada, and where permafrost thaw can pose significant risks.

c) “Full projects”: Only those EAs addressing full mining projects, including site and access infrastructure, as well as all project life-cycle phases were retained for further consideration. This criterion was used to exclude smaller-scale EAs (e.g., EAs addressing the expansion of an already operational site), based on the simplifying assumption that EAs for new projects, comprising more components and longer timeframes, are more likely than others to address climate-sensitive elements and, therefore, to include climate change impacts and adaptation-related considerations.
d) Duration of operational phase: Minimum of 15 years. Operational phases which were considered relatively short in duration (i.e. ending before expected impacts from climate change come into effect) had been used as justification in previous project EAs for excluding climate change impacts from project considerations (Byer et al., 2011).

e) Highly climate change-sensitive elements: Only those EAs addressing mine projects with one or more of the following “highly climate-sensitive elements” were retained for further consideration:

i. Thaw Sensitive permafrost: Thawing permafrost can fundamentally alter a range of design- and operations-relevant conditions at a site, including the bearing capacity and permeability of soils, and site-level hydrological dynamics.

ii. Tailings facilities, ARD and/or holding tanks: The environmental performance of mines with these components may be especially affected by climate-related assumptions adopted during design, operation, and/or closure (MEND, 2004; 2009).

iii. Complex surface water management conditions: Changing precipitation patterns and extremes are expected under climate change in many regions of Canada, prompting the simplifying assumption that EAs relating to sites with recognized surface water management challenges may be more likely than others to include climate change impacts and adaptation within their scope.

iv. Vulnerable Infrastructure: Did the mine plan include access, power, communication, or other infrastructure vulnerable to climate and weather impacts?

Of the 31 projects identified through the initial EA database search, only 15 met the “full project” criterion. Four of the 31 projects were rejected due to date of completion (criterion “a” for pre-2004 EAs). The remaining screening criteria were not meant to be fully exclusive but were intended to characterize the mine’s potential sensitivity to climate and compare those elements with indicators of climate change consideration.

### 3.2 Selection of EAs for In-depth Analysis

Due to time and resource constraints, the long list of EAs was further honed, ultimately yielding a much shorter list of six (6) EAs for in-depth analysis. Two additional criteria were considered during this final selection process.

a) Adaptation options noted in the EA: Brief word searches were used to identify whether or not climate-related adaptations had been considered (i.e. adaptive management, adaptive engineering, etc.) within each EA. A broad definition of climate change “adaptation” was

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6 As members of the Project Advisory Committee have noted, it is most likely the closure and post-closure phases of the mine are the most important project phases with regards to climate change impacts and adaptation planning. Hence, while this criterion refers to operational phase length, we must emphasize that we do not endorse the concept that short operational phase is proper justification for omitting climate change impacts assessment. See also Stratos (2011).
used to capture the full spectrum of adaptive actions proponents may have identified as options, including planned design and/or management actions motivated by the consideration of change in key climate or related environmental parameters.

b) Geographical/jurisdictional representation: Final selection sought to ensure the greatest possible degree of geographical and jurisdictional representativeness across EAs, in recognition of the variability in climatic hazards and regulatory regimes across Canada.

One of the six selected EAs did not consider climate change. This EA, proposed by the PAC, fulfilled all other selection criteria and contributed to a better understanding of how climate change was considered in northern regions of Canada where climate change impacts can be felt acutely by mining operations. In addition, the review of this EA provided the opportunity for comparison with other mining EAs to evaluate why climate change adaptation was not addressed.

To expand the EA pool geographically, additional searches were conducted using further territorial and provincial databases, resulting in the identification of ten additional “full project” mining EAs. The final list of projects selected for full analysis is provided in Table 3.1.

3.3 Selection Process Results and Recommendations

The majority of “full project” EAs (11 out of the 15) that met each of the selection criteria had no explicit mention of adaptation measures in the main EA documents. The EA screening process, which had initially been intended as a brief exercise for selection of the best-qualified EAs for further analysis, resulted in a number of important findings:

1) In some cases, EAs for projects with proposed operational periods of fewer than 15 years included explicit consideration of climate change impacts and adaptation options. Conversely, in other cases, EAs for mines with planned operational periods of greater than 15 years justified non-consideration of climate change impacts and adaptation based on the “limited duration” of planned operations.

2) Several mines with comparatively long (>50 year) planned operating periods made no mention of climate change in any form in EA documents (e.g. 77 years for the Berger peat mine in Manitoba).

3) Difficulty in obtaining certain EA reports led to concerns regarding access. Archiving practices which required direct requests of company or ministry staff resulted in long delays in acquiring access to key documents. While online archives generally provided access for more recent EAs, potential storage format-related problems impacting access to documents emerged for EAs completed as recently as 2005.

4) Several projects lacked adequate information about the mine site due to company merger or collapse, which resulted in company records becoming lost or compromised and/or loss of “corporate memory” due to staff changes or turnover.

5) Many EAs limited consideration of climate change to the management of development- and operations-related GHG emissions, a finding consistent with those of other studies which have
examined the consideration of climate change in the lifecycle of Canadian mines (e.g. Pearce et al. 2009).

6) It is possible that adaptation actions were considered but not reported in the EA documentation for certain projects.

The 6 EAs chosen for in-depth review are listed in Table 3.1.

Table 3.1: Mining EAs Selected for In-Depth Analysis

| Mary River Iron Mine, Nunavut Territory | Joslyn North Bitumen Mine, Alberta |
| Jansen Potash Mine, Saskatchewan       | Bellekeno Mineral Mine, Yukon Territory |
| Galore Creek Gold/Copper/Silver Mine, British Columbia | Victor Diamond Mine, Ontario |
4.0 Earlier Scholarship on the Consideration of Climate Change in Environmental Assessment

4.1 Introduction

This review was undertaken in order to assess what prior scholarship had determined about the consideration of climate change in project environmental assessments domestically and abroad. The review covered 39 papers and reports from the academic and grey literature, and focused in two main areas:

- Extent and consistency of the consideration of climate change impacts and adaptation in project EAs; and,
- Key challenges for the integration of climate change impacts and adaptation in project EAs.

4.2 Integration of Climate Change Impacts and Adaptation in Project EAs

Many jurisdictions around the world require proponents of physical projects to conduct EAs to characterize and address the potential impacts of these projects on the environment. Local climate conditions have long been considered as part of this process. Addressing the impacts of climate change and the eventual need for project-related adaptation is a more recent practice, but has now been the focus of attention for well over a decade (ClimAdapt, 2003).

4.2.1 Extent of the incorporation of climate change considerations in project EAs

According to Agrawala (2010), progress towards integrating climate change impacts and adaptation considerations in environmental assessment can be described in three phases. While the majority of national and regional EA authorities have indicated their intention (phase I) to effect this integration, far fewer have supported proponents through the preparation of related guidance (phase II), and fewer still can attest to consistent and rigorous implementation (phase III) of the practice among proponents in their jurisdiction. A significant gap remains between those national and regional authorities that have led efforts to ensure actual implementation and the rest of the international community (Agrawala et al, 2010). Canada, Australia and the UK are generally recognized as the three leading national jurisdictions within which the integration of climate change impacts and adaptation considerations in EA has become more regular practice (Murphy and Gillam, 2013; Yohe et al., 2007; Agrawala et al., 2010).

Widely considered a leader in this regard, Canada has stated intention, produced guidance materials and had success eliciting responses within certain industry sectors (Collins, 2008; Adger et al., 2007; Yohe et al, 2007; Agrawala, 2010). In addition, the Canadian International Development Agency (CIDA)
developed a set of guidelines to assist Caribbean aid recipients in incorporating climate change impacts and adaptation considerations into their EA processes (CIDA, 2003). Australia has produced guidance materials and is moving to promote use of EA to address climate change impacts through adaptation (Murphy and Gillam, 2013). A national survey of EA practitioners in Australia indicated that behavioural change is occurring, with almost 64% of respondents believing that the issue of climate change is highly relevant and that the impacts should be assessed as part of the EIA process (Middle, 2012). The United Kingdom has a long history of driving climate change issues forward. A study of UK EIA case studies, demonstrates that select climate change impact criteria are addressed by current EIA practices (Posas, 2011).

In contrast to the above examples, many nations and certain sectors still experience difficulty with obtaining adequate and accurate detail from standard EAs without the additional complexity of considering climate change (Burdge, 2008). For these practitioners, the incorporation of climate change into the process is an added complication that may not be possible at present. Recent examples from Peru, South Africa and Finland demonstrate that many EIAs do not consider the possible impacts of climate change (Rufio et al, 2012; Suopajarvi, 2013). In some cases, particularly in Africa, the perception of EIAs as a ‘green tool’ presents a barrier to the widespread use of a basic environmental assessment in general (Tarr, 2006).

4.2.2 Inconsistencies in the consideration of climate change within project EAs

Even in countries where climate change is incorporated into the EA process, there remain inconsistencies in approach, both across industries and regions (Murphy and Gillam, 2013), and Canada is no exception (Collins, 2008; Murphy and Gillam, 2013). For example, the contribution of climate change to permafrost thaw, a critical consideration for many mining operations in Northern Canada, has been treated in markedly different ways by different proponents (see Section 6).

In Australia, there is a recognized lack of national consistency in the consideration of climate change impacts and adaptation in project EAs (Murphy and Gillam, 2013). For example, in the Australian mining sector climate change vulnerability to impacts and appropriate adaptation measures are rarely considered in project EAs, though climate change-specific mine vulnerability assessments have suggested significant climate change-related environmental risks may exist (Loechel et al, 2013). In the UK, studies have demonstrated increases in the number of EAs with climate change content in their public consultations, but decreases in the number of EAs identifying the need for climate (change)-related monitoring at future project sites (Posas, 2011).

 Disconnects between and among regulators, legal departments, proponents, investors (Murphy and Gillam, 2013; Deloitte Reference from Ian Church) and EA practitioners may be one cause of inconsistency in the integration of climate change considerations across environmental assessments. For example, while municipal governments are arguably “most in tune” with the issue of climate change

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7 Those that do not yet consider climate change.
impacts and adaptation, they may not be reliably consulted with regard to EAs in some relevant sectors, including, most notably, EAs targeting critical infrastructure such as electricity transmission assets (Middle, 2012). Furthermore, in some cases proponents and regulators have competing ideas regarding the best way to address mitigation and adaptation in EIAs (Murphy and Gillam, 2013). The resultant confusion and complexity may be responsible for slowing progress in implementing EAs that consider climate change impacts and adaptation. Engaging key stakeholders (such as regulators, proponents, legal departments and investors), including municipal representatives, to approach EA process more comprehensively is prudent (Murphy and Gillam, 2013).

4.3 Common Reported Challenges to Incorporating Climate Change Adapation in Project EAs

The literature suggests that although comprehensive EA consideration of climate change impacts and adaptation would be valuable for industries and nations, progress has been limited due to various challenges.

4.3.1 Data availability, uncertainty and use

Climate information is a primary requirement for considering climate change impacts and adaptation in environmental assessments. For example, by using projections of site- and project-relevant climate parameters, proponents are better able to design for related conditions, hazards, and risks. The EA and climate change literature reports several specific challenges related to the use of climate information. First and foremost, several articles reported that significant information gaps compromise the ability of practitioners to consider climate change in the EA process (Rufio et al, 2012; Agrawala et al, 2010; ClimAdapt, 2003; Ford et al, 2010). In developing nations such as Peru and El Salvador, a lack of baseline data and climate projections were commonly cited as challenges to addressing climate change within an EA (Rufio et al, 2012, Moran, 2005). Information gaps pose a challenge for many developed nations as well, including Canada (Ford et al, 2010).

Second, significant deficiencies exist in practitioners’ understanding of how to interpret climate projections or where to go for related help. Advances in meteorological technology, computing power and modeling abilities have contributed to increased spatial resolution of climate model output in recent years. However, a certain level of uncertainty will always remain. And though such uncertainties can generally be well-addressed through application of both climatologically- and risk analytically-based techniques, surveys have shown that proponents may be hesitant to “depend too highly” on projections, as they feel the accuracy of adaptation strategies and designs may be compromised if data are faulty or inaccurate (Collins, 2008). In many cases, the uncertainties associated with climate model output have resulted in a lack of adaptation action on the part of the proponent (Tullos, 2009; Carter et al., 2007).

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8 Information gaps most commonly referred to a lack of reliable, long-term climate data.
Finally, several articles suggest that even when climate data are readily available, practitioners may be limited in their ability to interpret and use them (Posas, 2011; Collins, 2008; Pearce et al, 2009). Training in the acquisition and use of climate information for the design and management of adaptation measures within EAs is not yet a priority in most industries. In some industries, including the international mining sector, there is a marked lack of climate expertise at the project level, making it difficult to make use of available climate data during the environmental assessment process without external assistance (Pearce et al, 2009).

4.3.2 Inconsistent approaches

The literature review revealed inconsistencies in approaches for incorporating climate change impacts and adaptation in project EAs. At this time, common standards of practice do not exist, which could result in different approaches being utilized in different sectors or by different proponents (IAIA, 2010).
5.0 Synthesis of Best Practices for Considering Climate Change Impacts and Adaptation in Project-Level EAs

5.1 Purpose

The purpose of this section is to compile best practices to support the evaluation (critical analysis) of completed mining project EAs with respect to their consideration of climate change impacts and adaptation. As such, it is at once a “synthesis of best practice” as well as an analytical tool. As an analytical tool, it is structured to generally align with the main elements of typical project-level EAs. Its content is derived from a range of sources, including existing Canadian and international guidelines for the consideration of climate change impacts and adaptation in EA (Agrawal et al., 2010; Byer et al., 2009; Colombo and Byer, 2012; Byer et al., 2012; FPTC, 2003; CARICOM, 2004; ClimAdapt, 2003; IEEMA, 2010; NCEA, 2010; NSE, 2011a,b; Scottish Government, 2010); authoritative documents regarding climate change vulnerability assessment (Ranger and Garbett-Shiels, 2011; Kwadijk et al., 2010; Dessai and Hulme, 2007; Wilby and Dessai, 2010; Auld, 2008; Lu, 2011; Hallegatte, 2009; Haasnoot et al., 2011; GIZ, 2012; IPCC, 2012), the use of climate and climate change information in decision-making more generally (Auld, 2008; CSA, 2011; CSA, 2010; Dessai et al., 2009; IPCC, 2007(a)(b); Girvetz et al., 2013; Moser, 2009; Moser et al., 2010; New et al. 2007; Suraje et al. 2005); and, seminal pieces on decision-making under uncertainty (Bradshaw et al., 2000; Edwards et al., 2007; NRC, 2009; NRC, 1996). The best practices it outlines should complement other best practices and guidelines for carrying out environmental assessments.

5.2 Effects of Climate Change on the Baseline Environment

1. **Scoping**: The terms of reference for an EA should identify an initial list of valued ecosystem components (VECs) that could be negatively affected by future changes in climate/weather parameters, and require that projected changes in the baseline conditions of each VEC assume a

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9 Scoping, as set out in terms of reference (TOR), might be established by either government or the proponent. If the government provides the TOR, then it should include in the TOR, statements requiring the proponent to do the scoping work as part of the EA.

10 VEC is understood to be “Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern,” (FPTC 2003). The VEC list will continue to be developed throughout the EA and public consultation processes.

11 Climate/weather parameters include variables such as temperature, humidity, atmospheric pressure, wind, and precipitation. Changes in both averages and extremes should be considered.
reasonable, credible range of values for the climate/weather parameters to which they are sensitive, overall project phases\(^{12}\). This should be based on an explicit preliminary climate change vulnerability assessment of the VECs (see #2).

For the VECs identified through the preliminary assessment, the terms of reference should also set out and explain the level of detail and the general approach to be used in the EA for further assessing the character of VEC climate change vulnerability: detailed assessments should be required for those VECs that may be highly vulnerable to changing climate and weather conditions; less detailed assessments may be sufficient for those that would be moderately vulnerable; while no further consideration may need to be given to those that are considered largely resilient to changing climate and weather conditions. For certain VECs, the effects of climate change may be initially unclear or highly uncertain. In these cases, a precautionary approach would suggest additional assessment be required. When time horizons of interest for a VEC are short (i.e. within a decade), assessments of vulnerability to current weather and climate conditions will likely be sufficient.

**Explanation and Guidance:**

Arriving at a “reasonable, credible range of values for the climate/weather parameters” (as indicated above) requires adoption of a defensible set of computational and analytical methods and assumptions, as well as appropriate use of expert opinion, community knowledge and Aboriginal Traditional Knowledge. For key considerations regarding defensible computational and analytical methods and assumptions, and expert elicitation- and traditional knowledge-based approaches, see #4 and #5 (below), respectively.

2. **Preliminary assessment:** Preparation of the Terms of Reference should include an explicit preliminary climate change vulnerability\(^{13}\) assessment of VECs, to identify for each phase of the project: a) VECs that would *not* be substantially impacted by climate change and can therefore be excluded from further climate change impacts and adaptation-related analysis; and, b) VECs that could be moderately-to-highly impacted by climate change and therefore can be considered as priority VECs requiring further climate change analysis.

**Explanation and Guidance:**

Assessing VECs for probable levels of climate change vulnerability will require a combination of Bottom Up (or “vulnerability threshold first”) and Top Down (or “climate model first”) approaches. In general, top-down climate change vulnerability assessments start with and are driven by climate and climate change models. They often are more time and resource intensive than bottom-up assessments, and are best applied when guided by climatological expertise. Top down approaches are especially important when scoping a range of climate impacts and variables for a region or more

\(^{12}\) Project phases are: construction, operation, closure, and post-closure (reference TBD).

\(^{13}\) Vulnerability refers to susceptibility to harm or negative impacts.
complex system. Bottom up vulnerability assessments typically consider smaller and more localized issues and often focus more on current and short-term time scales, with vulnerability to current climate variability often serving as a starting point for understanding future vulnerability. Particular emphasis is placed on the identification of key thresholds, or climate parameter values which, if exceeded, may result in the condition of particular VECs degrading more rapidly or in especially problematic ways. Once the sensitivity of each VEC has been established for weather and climate-related variables of concern, the assessment must consider the potential for change in these parameters. It is at this point that information from climate model ensembles and trends analyses is required.

Since preliminary assessments are, by design, a precursor to more rigorous assessment later on, analyses supporting this step of the process may be based to the extent possible on pre-existing information and time-efficient methods. However, in order to justify the exclusion of one or more VECs from further climate change impacts- and adaptation-related consideration, a defensible rationale must be provided, including comprehensive descriptions (see #4) of the information, analytical methods, and key assumptions used.

Preliminary assessments should consider climate change scenarios for time periods corresponding to each main phase of the proposed mine and which include the credible worst case or greatest impact levels of the relevant climate variables for each VEC. “Credible worst case” may be defined as a scenario that is not expected to happen, but which nonetheless is something that could happen and should therefore be considered.

For each project phase separately, the Terms of Reference should list and pair the VECs with the climate parameters and thresholds of potential consequence. Using the list, the Terms of Reference should identify those pairs for which the VEC could be moderately-to-highly impacted as a result of the credible worst projected change in the specified climate parameter-threshold condition.

3. **Redefining baseline conditions**: For each VEC that could be moderately-to-highly impacted by climate change (see #1 and #2), the EA should project the future baseline conditions of the VEC as they may be affected by climate change for each phase of the project.

**Explanation and Guidance:**

Projecting future VEC baselines will in many cases require information on, assumptions about, and the modeling of biophysical parameters and systems beyond the initial VEC-climate parameter/threshold pairing(s). For example, to project summertime low flow levels in fish-bearing streams, it may be necessary to acquire or derive information relating not only to the amount, forms and patterns of precipitation within a watershed, but also to the influences of, for example, vegetation and geomorphology as well; site-level water balance or watershed-level hydrological information and modeling could be required. Depending on the VEC(s) and climate change-related impact(s) of concern, requirements for biophysical data, information and models will vary, as will
the challenges of re-parameterizing said models to reflect climate change. Selection and sourcing of data, analytical methods, and tools should be rationalized in accordance with #4 below.

In many cases, it may be necessary to assess environmental change processes at a variety of scales in order to project the impacts of climate change on local VEC baseline conditions. Changes in macro-level ecosystem dynamics and characteristics, as already evidenced by, for example, shifts in certain northern eco-zone boundaries can be expected to affect local VEC conditions over time.

Similarly, the impacts of cumulative effects\textsuperscript{14} on future VEC baseline conditions must be considered.

4. **Methodologies:** For each VEC baseline condition redefined based on climate change (see #3), the EA should provide an explanation and justification for the methodology used to consider future climate conditions, including the use of specific datasets, the choice of models and methods, and the adoption of key assumptions. Credible expertise and the latest, most credible scientific information and climate projections should be used.

**Explanation and Guidance:**

The following interrelated types of information should be provided with respect to the use of data, choice of models and methods, and adoption of key assumptions:

- For each set of *data* used, the following should be documented: (i) the data source(s), ii) periods of record and any other information available on monitoring programs, including instruments used and siting; (iii) whether the data are primary or modified (secondary or extrapolated) data; (iv) whether or not the data are based on an established protocol, theory, or school of thought; and, (v) qualified expert critique of the validity, strengths and weaknesses of the data.

- For each *model* and *method* used, the following should be identified: (i) the source(s); (ii) the degree to which it is an accurate representation of reality (e.g. results of the validation of climate change models in hindcast mode); (iii) whether the model is based on an established underlying theory or school of thought; (iv) whether the model has undergone peer review; and (v) degree of acceptance of the model by the overall scientific community.

- For each key *assumption* made, the following should be stated: (i) the degree to which the assumption is an accurate representation of reality; and (ii) the degree of acceptance of the assumption by the scientific community.

A range of credible climate information types and sources should be consulted, including:

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\textsuperscript{14} I.e., impacts of the proposed mine together with those of other current or future projects, under climate change.
• Synthesized information or existing studies on changes in regional climate and related biophysical conditions, including but not limited to recent climate change-related synthesis reports produced and/or vetted by the Canadian Government, regional climate information-service providers, provincial or territorial government departments; and the Intergovernmental Panel on Climate Change (IPCC);

• Information on historical natural hazards-induced impacts in the region linked to weather and climate;

• Previous EAs on similar types of projects;

• Local experience, proponent/academic studies and traditional ecological knowledge.

If the above information cannot support defensible conclusions, then other information should be sought. Otherwise, given the potential risks from the changing climate, adaptation responses will need to incorporate significantly larger safety margins, more enhanced monitoring, flexible designs and operational programs and other precautionary measures.

Where empirical data is of generally poor quality or lacking, or climate models perform especially poorly in reproducing past measured conditions, expert opinion and local or Traditional Ecological Knowledge may play a larger role. In all cases, clear and defensible protocols for the incorporation of local and Traditional Ecological Knowledge, and expert opinion (elicitation processes) should be used and reported on (see #5).

Further Considerations:

*Climate model ensembles* – Global and regional climate models are key to the projection of future climate conditions. The “de facto standard” when undertaking climate change impact and vulnerability assessments is to consider as many climate model simulations as “reasonable” in order to derive robust impact study results. The use of multiple climate models, known as an ensemble, allows the random errors in individual climate models to cancel out and the steady GHG related global change trends to remain (i.e. after adjusting each climate model for its biases relative to the historical climate period). The benefit of using an ensemble of climate models is to provide a more complete picture of the range of uncertainties among projections. In some cases, fewer climate models can be pre-selected, considering for example skill in replicating the recent historical climate or selected representing a wide range of future climate conditions. The caveat is still that multiple models are used. According to the Australian Bureau of Meteorology (2011), “no one model is the best in representing all aspects of climate, and a range of models should be considered when making projections of future climate”. In essence, “multi-model ensembles sample uncertainties in the emission scenarios, model uncertainty and initial condition uncertainty, and provide a basis to estimate projection uncertainties”.


Climate model GHG scenarios – The future climate projected by the climate models is very sensitive to assumed future GHG emissions, with greater and faster changes generally expected with the higher GHG emission assumptions. In the IPCC’s 5th Assessment Report released late 2013, different possible emissions scenarios are termed Representative Concentration Pathways (RCPs) and incorporate assumptions ranging from ongoing high GHG emissions or business as usual emission trends to low future GHG emission scenarios representing aggressive global GHG mitigation actions.

5. **Uncertainties and confidence in estimates:** For each estimated future VEC baseline condition that incorporates climate change (see #3), the EA should describe the uncertainties and degree of confidence and belief in the estimate based on the degrees of confidence in the models, methods, data and key assumptions that were used (see #4). It should also indicate how these uncertainties and degree of confidence were determined.

**Explanation and Guidance:**

Each estimate of future baseline climate and VEC condition is necessarily based on assumptions about the future climate and on imperfect or uncertain data, models and methods. For example, climate/weather data problems can stem from: lack of climate or impacts data; inadequate or improper measurement instruments and methods; subjective judgments used to establish the data; and, inherent randomness. Uncertainties in climate change model scenarios can arise from a variety of sources including: uncertainties in initial climate conditions input to the models, inadequate understanding of atmospheric processes, and climate gridding and interpolation methodologies. Similar uncertainties will exist in relation to modeled changes in other biophysical parameters (for example, depth of permafrost thaw) and the VECs themselves (e.g., stream flow).

It is important to assess the degree of uncertainty and level of confidence attached to each estimate. A range of techniques can be used to assess this, including: expert elicitation; scenarios-based analysis; sensitivity analysis; statistical approaches; and Bayesian analyses. In choosing among these techniques, a clear rationale should be provided for their choice. Where subjective judgments of confidence are used, they should conform to accepted practice in expert elicitation and be uniformly applied.

The resulting Information should be presented in a way that is relevant and readily understandable to stakeholders and decision makers so that they can judge the reliability of the estimates. Where there is quantitative information, the following types of summary should be presented, where possible: (i) mean values and variances or spreads on the estimates; (ii) confidence intervals of the estimates; (iii) ranges of the estimated values noting possible extreme values in particular; and (iv) full probability distributions of the estimated impacts. For example, “30% of model simulations indicate that future temperatures would cause the soil to remain as permafrost, and the other 70% indicate that there would no longer be permafrost.”
Where the estimates and uncertainties are measured *qualitatively*, they can only be described and presented with considerably less precision, and the following types of summary descriptions should be provided: (i) description of the central tendency of the baseline condition, together with any possible variation away from the central tendency, such as “the soil would most likely remain as permafrost, though there is a moderate likelihood that it would no longer remain as such”; and (ii) ranges of the estimate, such as “low to medium”. Furthermore, when imprecise, qualitative terms and descriptors (such as “low”, “high”, or “significant”) are used, the basis underlying their particular application needs to be clearly explained.

Based on this, summary assessments of the levels of *overall confidence* in the estimates should be provided.

**Further Considerations:**

*Climate model uncertainties* — A significant part of the uncertainty in using climate change models can be linked to the fact that it is not known which sets of GHG emission pathways will be “followed” into the future, although current trends are tending towards the highest possible GHG emission scenario used in the IPCC climate change models. Other climate model uncertainties are linked to limited computing power available to run the climate change models, even though climate models are run using world state of the art supercomputing power and this supercomputer speed has increased by more than a million-fold in the past three to four decades. Other climate model uncertainties relate to still imperfect knowledge of the Earth’s systems, requiring that climate models approximate some of the key climate processes such as thunderstorms and tropical storms. The net result is that different climate models can produce different results, but frequently with consistent trends and patterns between models.

Confidence in climate change model simulations is higher for some climate variables (e.g. temperature) than others (e.g. rainfall and extremes). Climate models have been tested and used successfully for seasonal weather predictions, and tested successfully against past and present climates, including simulation of the Twentieth Century climate. Confidence is generally higher for projected changes in larger-scale climate conditions (e.g. synoptic or large sized storms) than for projected changes in regional and or fine-scale events. While climate models show significant and increasing skill in representing mean conditions and larger scale climate features, they remain less skilled at representing important, smaller-scale processes, such as cloud formation, thunderstorms, tropical storms and rainfall mechanisms which vary significantly at the local scale. Because considerable residual uncertainties will remain for some time, decisions and policies at the regional and local scale based on climate change projections will need to remain robust or flexible into the future.

Global climate model information can be improved in resolution or “sharpened” to better represent the local to regional baseline climate by calibrating the hindcast model simulations for the same climate data period against the historically observed climate data or gridded climate data. This step serves several purposes: (i) calibration against the baseline climate information allows for the
climate change models to be downscaled from their coarse 200-500km grids to provide higher resolution information representative of a more particular locality or region; and (ii) the calibration bias-corrects the initial assumptions and random variability inherent in the climate models, allowing for more credible, reasonable and defensible climate change projections. Downscaling and bias-correcting at both a finer spatial and temporal resolution is needed to better represent the influence of topography and regional climate patterns on both the average and variations in climate, and to more accurately and completely assess future climate scenarios.

It is generally assumed that higher resolution or regional scale climate models should produce more realistic simulations of climate processes and topographical influences, but studies are indicating that increased resolution alone does not reduce certain important biases. Furthermore, the hindcast climate skill of statistically downscaled GCMs compared to use of RCMs or dynamical climate models indicates that often statistical downscaling from GCMs may yield better results for many extremes. This suggests that better understanding of GCM model biases and error patterns and downscaling to account for this can give a better result than focusing only on RCMs.

5.3 Impacts of the Project on the Environment

6. Scoping: The terms of reference for the EA should identify how climate change may affect the impacts of the project and its components on the VECs during each phase of the project, and require that projected impacts assume a reasonable, credible range of values for the climate/weather parameters to which they are sensitive, overall project phases\(^\text{15}\). This should be based on an explicit preliminary assessment (see #7).

For those project impacts identified in the preliminary assessment as sensitive to the effects of climate change, the terms of reference should also set out and explain the level of detail and the general approach to be used in the EA for further assessing impacts with respect to climate change: a detailed assessment should be required for those project impacts that may be substantially worsened by the effects of climate change; less detailed assessments may be sufficient for those project impacts that are likely to be only minimally or moderately worsened by climate change; and, no further consideration may be required for project impacts which demonstrate little sensitivity to the effects of climate change. For certain project impacts, the effects of climate change may be initially unclear or highly uncertain. In these cases, the precautionary principal suggests additional assessment may be required.

Explanation and Guidance:

Arriving at a “reasonable, credible range of values for the climate/weather parameters” (as indicated above) requires adoption of a defensible set of computational and analytical methods and assumptions, as well as appropriate use of expert opinion and Traditional Knowledge. Key

\(^{15}\) Project phases are: construction, operation, closure, and post-closure.
considerations regarding defensible computational and analytical methods and assumptions, and expert elicitation- and traditional knowledge-based approaches are addressed in #4.

7. **Preliminary assessment**: The EA should include an explicit preliminary climate change assessment\(^{16}\) to identify, for each phase of the project: a) the types of project impacts on VECs that would not be substantially worsened by climate change and can therefore be excluded from further climate change analysis; and, b) the types of project impacts on VECs that could be moderately-to-highly worsened by climate change and therefore can be considered as priority impacts requiring further climate change analysis.

**Explanation and Guidance:**

As with #2 above, this assessment will require a combination of Bottom Up (or “vulnerability threshold first”) and Top Down (or “climate model first”) approaches. Whereas #2 results in a preliminary assessment of the vulnerability of VECs to climate change impacts, this assessment requires consideration of project impacts as well.

Since preliminary assessments are by design a precursor to more rigorous assessment later on, analyses supporting this step of the process may be based to the extent possible on pre-existing information and time-efficient methods. However, in order to justify the exclusion of one or more project impacts from further climate change-related analysis, a defensible rationale must be provided, including comprehensive descriptions (see #4) of the information, analytical methods, and assumptions employed. Climate change-adjusted VEC baseline information from #3, #4, and #5 above should be used.

8. **Project impacts**: For each type of project impact requiring further climate change analysis for each phase of the project (see #7), the EA should assess the impact relative to the redefined baseline condition with climate change (see #3).

**Explanation and Guidance:**

In-depth analysis of project impacts considering future VEC baselines under climate change will in many cases require information on, assumptions about, and the modeling of a range of biophysical parameters and systems. For example, to project the impact on fish habitat and survivorship of future summertime water taking from streams under climate change, it may be necessary to acquire or derive information relating not only to the amount, forms and patterns of future precipitation within the watershed, but also, for example, to groundwater dynamics, sedimentation rates, and arctic char phenology. Depending on the VEC(s) and project impact(s) of concern, requirements for biophysical data, information and models will vary, as will the challenges of re-parameterizing said

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\(^{16}\) Among all EA and climate change guidelines reviewed, this practice is explicitly suggested and described only in the CARICOM (2003) guideline.
models to reflect climate change. Selection and sourcing of data, analytical methods, and tools should be rationalized in accordance with #4 above.

9. **Adaptation**: For each project impact worsened by climate change (see #8), the EA should explicitly identify, evaluate and select feasible options for modifying the project to reduce the impact. This should include estimates or explanations of the degrees to which the adaptation options would reduce the impact, and with what level of confidence.

**Explanation and Guidance:**

Adaptation options describe ways the project design and/or operation can be modified now and in the future to adapt to or adjust for a changing climate in order to reduce project impacts. Various approaches should be considered:

- Building robustness into the design of project components to increase their resilience to extreme events caused by climate change; for example, increase the capacity of an emergency spillway to accommodate more intense storms.
- Design and/or operational measures to accommodate a different climate average; for example, increase the capacity of a storage pond to handle an increase in average precipitation.
- Adaptive management that provides for future flexibility including design or operational modifications, such as staged additions or process modifications that can be implemented as we see how future climate change unfolds; for example, design a storage pond to allow for a future increase in its capacity if necessary. These modifications are funded through dedicated funds secured before construction begins.
- New assumptions about maintenance schedules due to more frequent extreme runoff events.

For each project impact, the technically and economically feasible adaptation measures that could be used should be identified. Measures that may initially appear to be too expensive should not be discarded too quickly since they may be inexpensive when compared with liabilities and costs that could occur under climate change. The advantages and disadvantages of the feasible measures should then be estimated quantitatively or, if not possible, qualitatively; this should include their costs, the degree to which they would be effective against climate change, degree of confidence in this presumed level of performance, related uncertainties, and eventual consequences of the adaptation being ineffective.

The feasible measures should then be evaluated on the basis of their advantages and disadvantages in order to determine which options should be implemented. Various decision-making methods can
be used for this, including stakeholder consultations, application of the precautionary principle and no-regrets criteria, and use of decision-analytic approaches.

Further considerations:

Choice of adaptation measures should be informed by, among other things, the degree of uncertainty associated with each anticipated climate change impact requiring consideration. For example, when climate change projections are highly uncertain and the potential consequences of being wrong are high, it is particularly important to adopt flexible or “low regrets” adaptation actions (e.g. good emergency management planning, overdesign of high risk components) that would be at least reasonably effective and offer resilience over a broad range of future climates. (Such an approach is consistent with the “precautionary principle” enshrined in EA practice and law Canada-wide.) Maladaptation can result from, among other factors, over-reliance on too few climate models, misplaced confidence in the capabilities of climate models with respect to a particular location or climate variable, and failures to adjust or bias-correct raw climate change model outputs. In such cases, one must balance the risks of being precise but potentially wrong (i.e., “precisely wrong”) with the risks of being “generally right” but less precise.

In practice, there is no single recommended approach for incorporating and mainstreaming climate change into adaptation actions, especially since approaches will be highly dependent upon the anticipated service life of a project, the risks and obligations associated with its components, (e.g. tailings storage and post-closure management), and the risk appetites of the regulator, the proponent, and other stakeholders. In some cases, where the planned life of a project is relatively short (i.e., operations lasting a decade or so), it may be sufficient to ensure good adaptation to currently observed climate trends and variability. For longer timeframes and higher risk components (i.e., tailings storage), it is likely essential to develop adaptation options that integrate scenarios of future climate conditions into the project.

10. **Methodologies:** For each estimated project impact without adaptation (see #8) and with adaptation options (see #9), the EA should provide an explanation and justification for the methodology that was used to incorporate climate change, including the choice of models, methods, data and other key assumptions used. Credible expertise and the latest, most credible scientific information and climate projections should be used.

   **Explanation and Guidance:**

   (See #4 above)

11. **Uncertainties and confidence in estimates:** For each estimated project impact affected by climate change, with and without adaptation (see #8 and #9), the EA should describe the uncertainties and degree of confidence and belief in the estimate based on the uncertainties and degrees of confidence in the models, methods, data and key assumptions that were used (see #10). It should also explain how these uncertainties and degree of confidence were determined and how they
affected the conclusions and decisions related to the impact, including the choice of adaptation measures (see #9). Greatest attention should be given to the most severe impacts.

**Explanation and Guidance:**

Similar to the redefined baseline conditions, each estimate of the project impact affected by climate change is necessarily based on assumptions about the future climate and on imperfect or uncertain data, models and methods. It is therefore important to assess the degree of uncertainty and level of confidence attached to each estimate, and to present the resulting information in a way that is relevant and readily understandable to stakeholders and decision makers so that they can judge the reliability of the estimates, as explained further under #5.

An example description of the uncertainties and degree of confidence in an estimate is: “While the effluent of the mine is not expected to increase the stream temperature above the level to support cold water fish, there is some likelihood, conservatively estimated to be 1 to 5%, that future temperatures and stream flows would result in the loss of these fish species.”

Attention should be paid to the potential influence of alternative adaptation options on levels of uncertainty and confidence associated with each of the estimated impacts.

### 5.4 Impacts of the Environment on the Project under Climate Change

12. **Scoping:** The terms of reference for the EA should identify how climate change and its impacts (on the magnitude, frequency and duration of hazard events, and environmental baseline conditions) may affect, directly or indirectly, each project component (elements of the mine and supporting infrastructure) during each phase of the project, *to the extent such impacts may in turn pose a risk to VECs and/or the public*. This should be based on an explicit preliminary vulnerability and risk assessment (see #13).

For the climate change-related vulnerabilities identified through the preliminary vulnerability and risk assessment, the terms of reference should also set out and explain the level of detail and the general approach to be used in the EA for further assessing each vulnerability; a high degree of detailed assessment should be required for those vulnerabilities that pose a high level of risk, less detailed assessments should be required for those that pose a moderate level of risk, and no further consideration needs to be given to those that pose insignificant risks to VECs and the public.

**Explanation and Guidance:**

Arriving at a “reasonable, credible range of values for the climate/weather parameters” (as indicated above) requires adoption of a defensible set of computational and analytical methods and assumptions, as well as appropriate use of expert opinion, community knowledge and Aboriginal Traditional Knowledge. For key considerations regarding defensible computational and analytical
methods and assumptions, as well as expert elicitation and traditional knowledge-based approaches, see #4.

13. **Preliminary assessment**: The EA should include an explicit preliminary climate change vulnerability and risk assessment to identify, for each phase of the project: a) the project components that are not vulnerable to climate and related factors, or whose vulnerabilities are largely inconsequential to VECs and the public, and can therefore be excluded from further, detailed analysis; and, b) the project components that are vulnerable to climate and related hazard conditions, and whose vulnerability is of moderate-to-high consequence for VECs and the public, requiring further, detailed analysis.

**Explanation and Guidance:**

As with #2 and #7 above, this assessment will require a combination of Bottom Up (or “vulnerability threshold first”) and Top Down (or “climate model first”) approaches.

Since preliminary assessments are by design a precursor to more rigorous assessment later on, analyses supporting this step of the process may be based to the extent possible on pre-existing information and time-efficient methods. However, in order to justify the exclusion of one or more project vulnerabilities from further climate change-related analysis, a defensible rationale must be provided, including comprehensive descriptions (see #4) of the information, analytical methods, and assumptions employed.

14. **Impacts on the project**: For each vulnerable project component requiring further climate-change analysis (see #13), the EA should assess how climate change and its impacts may affect the component, and the potential consequence of any identified vulnerability for the wellbeing of VECs and the public.

**Explanation and Guidance:**

The potential vulnerability of mine projects to climate change impacts is of relevance to EA only insofar as an impacted project (component) may deleteriously affect the environment or the public.

In-depth assessment of component vulnerability and related consequences for VECs and the public may require information on, assumptions about, and the modeling of a range of biophysical parameters and systems. For example, to project the likelihood of fish habitat loss associated with tailing pond leakage triggered by rainfall extremes under climate change, it may be necessary to acquire or derive information relating not only to future VEC (e.g., arctic char) baseline conditions and extreme precipitation patterns, but also, in this case, to soil infiltration rates, runoff patterns, flood gate performance, and toxicity statistics. Depending on the VEC(s) and project impact(s) of concern, requirements for biophysical data, information and models will vary, as will the challenges
of re-parameterizing said models to reflect climate change. Selection and sourcing of data, analytical methods, and tools should be rationalized in accordance with #4 above.

15. **Adaptation**: For each project component that is assessed to be vulnerable to climate change (see #14), the EA should explicitly identify, evaluate and select feasible options for modifying the project to reduce its vulnerability to current and future climate conditions and their impacts. This should include estimates or explanations of the degrees to which the adaptation options would reduce the vulnerability and related risks (to VECs and the public).

**Explanation and Guidance:**

The types of adaptation options described under #9 can also be used to reduce the vulnerability of project components to a changing climate. For example:

- increase the capacity of an emergency spillway to accommodate more intense storms;

- design access roads for non-frozen soils rather than for permafrost; and

- adaptive management strategies such as flexible designs to add storage capacity to holding ponds due to increasing precipitation. Further explanations are provided under #9.

16. **Methodologies**: For each estimated climate impact on the project with potential consequences for the environment or public, considering no adaptation actions (see #14) as well as proactive adaptation (see #15), the EA should rationalize the methodology used to incorporate climate change, including the choice of models, methods, data and other key assumptions. Credible expertise and the latest, most credible scientific information and climate projections should be used.

**Explanation and Guidance:**

(See #4 above)

17. **Uncertainties and confidence in estimates**: For each predicted climate impact on the project, with and without adaptation (see #14 and #15), the EA should describe the uncertainties and degree of confidence and belief in the estimate based on the uncertainties and degrees of confidence in the models, methods, data and key assumptions that were used (see #16). The EA should also explain how these uncertainties and degree of confidence were determined and how they affected the conclusions and decisions related to the impact, including the choice of adaptation measures (see #15). Greater attention should be given to the more significant impacts.

**Explanation and Guidance:**

Similar to uncertainties in the redefined baseline climate conditions and project impacts, each estimate of the impact of climate change on the project and, subsequently VECs is necessarily based
on assumptions about the future climate and on imperfect or uncertain data, models and methods. Of particular concern when estimating climate impacts on the project are a shortage of information or evidence on sensitivities of project components to weather and climate, and a lack of information on the frequency of certain extreme events (e.g., severe thunderstorms in remote locations).

It is important to avoid over-interpreting or inappropriately applying climate model results when the results indicate wide variability between outputs. It is therefore important to assess the degree of uncertainty and level of confidence attached to each climate change projection and impact, and to present the resulting information in a way that is relevant and readily understandable to stakeholders and decision makers so that they can judge the reliability of the estimates, as explained further under Best Practice #5.

An example description of the uncertainties and degree of confidence is: “While capacity of the pond has been designed to withstand future storm events, there is a conservatively estimated 5% probability that future climate would cause a catastrophic failure over the course of the mine’s operation, resulting in the loss of fish downstream.”

5.5 Monitoring of Climate Change-Related Impacts and Risks

18. **Monitoring and management plan**: The EA should include a monitoring and management plan that describes the measures that will be carried out to monitor, evaluate, manage (including adaptive management strategies) and communicate each of the following:

   a. how climate change may impact the assumed baseline environmental conditions (see #3),
   b. project impacts considering climate change (see #8),
   c. impacts of climate change on the project (see #14), and
   d. the effectiveness of adaptation measures implemented to address climate change (see #9 and #15). This should include contingency measures that would be taken to address ineffective measures.

**Explanation and Guidance:**

As set out in an operational policy statement under the Canadian Environmental Assessment Act ([http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=499F0D58-1](http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=499F0D58-1)), environmental follow-up programs are required for designated projects in order to:

- “verify predictions of environmental effects identified in the environmental assessment;
- determine the effectiveness of mitigation measures in order to modify or implement new measures where required;
- support the implementation of adaptive management measures to address previously unanticipated adverse environmental effects;
• provide information on environmental effects and mitigation that can be used to improve and/or support future environmental assessments including cumulative environmental effects assessments; and
• support environmental management systems used to manage the environmental effects of projects.”

The policy statement provides useful general guidance on the design of follow-up programs with respect to all types of impacts, and is therefore applicable to project impacts and impacts on the project discussed in the other best practices. Due to the nature and uncertainties of climate change, there are issues related specifically to it and should be included in the design of a follow-up program. These include:

• Identification of climate thresholds at which corrective or adaptive management actions need to be taken. Thresholds need to below levels that exceed the resilience of project components or the acceptable levels of environmental impacts or performance, and that allow time for actions to be taken.
• Collection and evaluation of data for key climate/weather parameters over the lifetime of the project in order to anticipate whether further mitigation or adaptation actions are needed.
• Review and updating of vulnerability assessments of critical project components with respect to changing climate.
• Design of contingency and emergency management plans to address unanticipated problems or events due to climate change.

Best practices have been cross-referenced below in Section 7 when discussing and framing the results of the critical analysis.
6.0 Descriptive Analysis

After reviewing over 40 environmental assessments during the selection process (Section 3), the project team conducted a “descriptive analysis” of each of the six (6) selected EAs. This phase of the project was designed to identify and catalogue instances within each EA where climate or climate change and related topics are considered. It provided the project team with an overarching understanding of the level of consideration climate change received in each of the selected EAs, and contributed to the “critical analysis” (Section 7). This section of the report presents the methodology and findings of the descriptive analysis.

6.1 Methodology

Each of the six selected EAs was reviewed, including summary materials, main report (with particular focus on the most relevant chapters/volumes\(^\text{17}\)), consultant reports/appendices and operational designs. The project team documented the main characteristics and contextual details of each environmental assessment to demonstrate commonalities and differences between and among the EAs in general, and to facilitate comparison across EAs with regard to their treatment of climate change impacts and adaptation. For example, basic metadata such as the name of the mine, its proponent, the year the EA was completed, mine type, geographic location and, type of Review (i.e. Joint, Provincial or Federal) were recorded.

The descriptive analysis then focused on recording and eliciting evidence of climate change context within each mining project. Main topics included:

- Climate or weather-related factors addressed without specific mention of climate change (to flag areas where climate change should have perhaps been considered but was not)
- Sources and character of climate/weather data used
- Source and character of climate change projections used
- Specific phases of the mining project identified in conjunction with climate change or weather related factors
- Decision-making approaches (e.g. scenario weighting schemes, etc.)
- Procedural, legal or policy drivers of climate change adaptation action identified within the EA
- Proposed responses to impacts of climate change and/or extreme weather events (i.e., “adaptations,” including adaptive management, monitoring activities, design measures, and others)

\(^\text{17}\) These include reports that centered on specific aspects of the project. Examples include Air Quality, Noise Pollution and Water Quality reports
A spreadsheet was developed to catalogue these references to climate change within the EAs (Appendix C).

Advice from project advisors led the project team to expand the Descriptive Analysis to include public consultation materials. This analysis helped determine whether or not external forces played a role in driving the consideration of climate change and provided insight into the decision-making processes of the proponent.

### 6.2 Descriptive Analysis Findings

The descriptive analysis yielded insights into the attention (or lack thereof) paid to observed climate trends and projected climate change impacts and adaptation. These findings form the baseline understanding of the degree to which climate change is addressed through the EA process as a factor in mine planning, design, operations and closure. The results of this analysis are explored further in Section 7 to identify practices that line up well with the demands of domestic and international guidance, and to highlight examples of best practices.

Review of the selected EAs generally indicated that future climate change impacts were not consistently considered and that proposed adaptation measures fell largely in the “adaptive management” category. In most cases, strong consideration was given to the current weather or climate of the location, using historical records from Environment Canada, combined with on-site weather observations from recent baseline studies. In one case, the consideration of climate change was limited to historical climate trend analysis only. While this is considered an appropriate approach for certain types of climatic hazards (e.g. short-term projections of extremes; IPCC 2012), in other cases neglecting future climate model projections may be inappropriate, and is counter to current guidance on climate change adaptation planning for mines (FPTC 2003). This method of considering climate change will be further explored in the next section of the report. In another case, climate change was not considered in any fashion, with analysis based solely upon climatic averages derived from historical data, with no assessment of historical trends or climate change projection models.

The different levels of climate change adaptation consideration had implications for the adaptation measures observed in the reviewed EAs. Adaptation measures such as robust design of infrastructure were observed in four (4) EAs; this was coincidentally noted in EAs that considered future climate projections. In contrast, adaptive management techniques and “no/low regret measures” were

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18 The project team notes that the availability of and confidence in climate change projections and impacts information has steadily increased since 2004, with the result that less information on future climate change implications was available for the earlier EAs.

19 From N. Ranger and S.L. Garbett-Shiels, 2011. “‘No-regrets’ does not necessarily mean zero cost or that there will be no trade-offs with other priorities (e.g. whether to build in floodplains); here, it means that the measures will have benefits today and under any future climate. Thus, plans are made robust to climate uncertainties and
observed in all EAs, including those where future climate projections, literature and experts were not consulted.

In EAs for which proponents considered future climate projections, there was little or no documentation or discussion on how this forward-looking climate information was integrated with other analyses critical to decision-makers (e.g., design procedures, cost-benefit analyses, etc.). Furthermore, though the models used for the projections were identified, little if any information was provided about the methods used to select among the various alternative models. Details were also absent on how the information derived from climate model projections was applied in order to support the assessment of VECs, the eventual effects of the environment on the project, and, hence, options for more sustainable and resilient designs, adaptive management strategies and changes to maintenance schedules.

While several EAs provided probable costs relating to different planning options, this type of analysis was not available in cases where adaptation measures were explored. There was no explanation provided as to why costs were considered inconsistently across the sample EAs.

Each of the six selected EAs placed emphasis on ongoing adaptive management practices as a means of addressing uncertain weather/climate challenges. These adaptive management strategies were often tied to existing monitoring and emergency response plans. In a few cases, proponents explicitly stated that, given their short operation phases and the infrequent nature of extreme weather events, preparations already developed to address current extreme weather events were sufficient for future climate impacts as well. This trend will be explored in greater detail during the critical analysis phase of the project.

The project team also found that there was a strong tendency for the governmental review and public consultation processes to highlight climate change as an important factor for consideration. In some cases, these processes resulted in specific requests for additional studies to ascertain the potential impact of climate change on the project.

The following sections provide more detailed results from the descriptive analyses for each of the six EAs. These results indicate whether and how the EAs considered climate change, while the critical analysis phase of the project will assess and discuss the character of the climate change-related analyses, and how these analyses compare to descriptions of “best practice” as conveyed by existing guidelines, the literature, and key informants.

### 6.2.1 Joslyn North Mine (Deer Creek Energy Ltd.), Alberta, Bitumen Mine, Environmental Assessment Completed 2006

then the desirability of their costs, benefits and trade-offs can be weighed up in the same way as any other policy choice.”
The Joslyn Mine occupies 5400ha of the Joslyn Lease in Northern Alberta. As a bitumen mine, the approval process was slightly more complex requiring an integrated application to the Alberta Energy and Utilities Board (EUB), Alberta Environment as well as the Canadian Environmental Assessment Agency and the Department of Fisheries and Oceans.

6.2.1.1 Climate data

Though there were very few explicit references to climate change or use of climate-related terminology\(^{20}\), climate change considerations were embedded throughout the Joslyn EA. Specifically, the EA used a combination of historical climate normals, historical climate trends information, recent on-site weather observations and future climate change projections in the analysis of how the environment might affect the project and VECs. This combination of sources, though thorough, was sometimes applied inconsistently throughout the EA without an accompanying explanation for why the climate data were applied in that manner. For example, although climate projections for temperature and precipitation were considered in the Air Quality Analysis, historical data and current weather observations were used to assess the effects of wind, freeze-thaw, evaporation, relative humidity and other parameters on the project. Despite the noted availability of wind projection data, no explanation was provided for the decision to disregard this data in favour of historical climate data within the Air Quality Analysis. It is noted that at the time the EA was completed (2006), the availability, confidence and use of climate change projections was less than is currently the case (i.e. generally using IPCC 3\(^{rd}\) Assessment Report era results released in 2001).

The EA considered climate change projections for temperature and precipitation using two climate models under five GHG emission scenarios for the 2050 time period (2041-2070). These projections used a range of GHG emission scenarios, from the more conservative B2 assumptions for climate change to the more aggressive and rapid A1F1 assumptions. These projections focused on averages and did not consider extremes, consistent with common practice in the mid-2000s. Despite recognition of the importance of other climate impacts, for planning and design purposes, projections were not developed for parameters such as seasonal thaw, extreme precipitation and extreme wind. In some cases, the proponent consulted literature to access projections for certain parameters (e.g. evaporation) which were then utilized in assessments of climate impacts on VECs, and to inform design decisions. In many cases this literature highlighted projected trends for Canada or the Prairie region which did not pertain specifically to the mine site, sub-region or broader biogeoclimatic zone.

Finally, the risk assessment methods used to assess project impacts on VECs relied very heavily on modeled biophysical conditions obtained using historical weather data.

In 2010, upon assuming responsibility for the mine, the ownership company, Total E&P produced an updated environmental assessment. This updated EA addressed many of the previous concerns,

\(^{20}\) This finding, which occurred early on in the analysis, contributed to a more nuanced understanding of the project’s goal. Instead of simply identifying explicit climate change language and the use of projections, the project team assessed the material to identify more subtle indications of climate change consideration.
responded to reviewer requests for additional information and emphasized climate change as a key issue for consideration throughout the assessment. The updated assessment was better able to integrate climate projections into decision making due to several factors including the release of a new generation of climate change projections (IPCC AR4, 2007), an increase in technical climate expertise within the corporation, and the availability of additional tools to assist practitioners in using climate change projections throughout the planning and design processes. Specifically, the updated EA obtained climate change projections for temperature and precipitation parameters and, using simulation models, determined the level of VEC- and project-related risks attributable to climate change. Using these findings, Total E&P with the assistance of consultants developed a design strategy more focused on preventing climate impacts and building operational resilience to continually changing weather patterns. For example, changes were made to the design of key pieces of infrastructure on site, including an off-stream storage pond and the construction of a new tailings management plant. Changes were also made to the extraction process, planned levels of water withdrawal from the Athabasca River, and the Joslyn Creek diversion system. The fact that the EA was altered so significantly in 2010 is taken as evidence that climate change has a growing influence in the mining sector, and that consideration of it in mining EAs is becoming more prevalent. The updated EA also highlights improvements in climate change projections and the need for regular review and updating of climate change considerations over the lifespan of the project.

6.2.1.2 Public consultation materials

The Joslyn North mine public consultation raised three primary issues: the possible contamination of Ells River due to overland flooding; environmental effects of the planned diversion of Joslyn Creek; and, several general concerns related to water quality in the Athabasca River. These themes reflected an emphasis on water quantity (as opposed to water quality) by Deer Creek Ltd. in the EA studies. In addition to these concerns, there were several specific requests for a greater level of climate change consideration within the EA. Most importantly, the Mikisew Cree First Nations (MCFN) requested additional information in several areas: a) greater understanding of future conditions with regard to the interaction between ground water and surface water sources; b) use of climate change projections that include climate extremes and that project designs be based on the projected likelihood of these events; and c) the types of climate information used and how the information influenced decisions that were made regarding the project design, construction, operation and closure. In addition, government reviewers also asked for further information to clarify the level of climate consideration within the EA.

In responses to the supplemental information requests posed by the Mikisew Cree First Nations, the proponent often referenced guidance materials, international climate literature and the Canadian Environmental Assessment Act to demonstrate that their efforts were in line with required measures. The updated EA (2010) responded directly to requests for supplemental information made by government reviewers. Specific concerns addressed included: drainage issues in the closure plan, tailings ponds coverings, contingency plans for low water seasons and the location of polishing ponds.

6.2.1.3 Adaptation measures
Several climate change adaptation measures were documented in the Deer Creek Energy Limited EA (2006)\textsuperscript{21}. Most measures involved design specifications that were predicted to withstand future climate conditions, create a resilient operation that could be easily adapted or remain robust to different climate conditions. For example, a diversion dam and channel were designed to withstand a 1-in-1000-year flood or Probable Maximum Flood\textsuperscript{22} (creating more resilient infrastructure to withstand future climates). In contrast, flexible adaptation approaches were used for the tailings ponds, which were designed to accommodate additional berm construction around the perimeter should the need arise in the future (creating a more robust condition that is easily adaptable to future conditions). Other examples included:

- Use of management plans to:
  - prevent/minimize adverse effects;
  - respond to expected or unanticipated conditions; and
  - monitor the accuracy of predictions or determine the effectiveness of mitigation plans
- Drainage systems designed to minimize erosion rates and sediment loading in light of expected increases in precipitation and flooding
- Reclaimed areas for development into self-sustaining ecosystems with an acceptable degree of biodiversity in light of future climate conditions
- Provision of an erosion resistant plant cover on tailings dykes and disposal area slopes light of expected increases in precipitation and flooding
- Truck and shovel mining approaches to better withstand all types of weather conditions
- Reservoirs that could cause rapid deterioration of the landscape in the event of an extreme flood were excluded from the closure landscape

The project team observed that most of the adaptation measures explored in the EA pertained to the construction or operation phases of the mining cycle. Although the EA highlighted closure or post-closure phases of the project as most in need of climate change consideration, less emphasis was placed on designs or plans pertinent to these phases of the project.

6.2.2 Victor Diamond Mine (DeBeers Canada), Ontario, Diamond Mine, Environmental Assessment Completed 2005

The Victor Diamond Mine EA was a comprehensive study submitted to a joint panel including the Canadian Environmental Assessment Agency, the Ontario Ministry of Northern Development and Mines, First EA for the Joslyn North Mine (2006)

\textsuperscript{22} This figure was calculated without complex modeling by determining the ratio between the Probable Maximum Flood (PMF) and the 100-Year flood flow. For the Prairie Regions of Alberta, the PMF is generally about 7 -10 times the 100-year flood flow (MCFN, 2007 pg 50). Designing for a 1-in-1000-year flood is considered to be appropriate climate change preparation under the 2007 Canadian Dam Safety Guidelines. In 2006, when the Joslyn Mine EA was completed, this design represented advanced adaptation based on climate change projections and design expertise.
the Ontario Ministry of the Environment, and the Ontario Ministry of Natural Resources. The EA was submitted in this manner to satisfy federal EA requirements related to the construction of an all-season airstrip and the construction of a facility for the extraction of groundwater, as well as provincial level requirements relating to the construction of a power transmission line.

6.2.2.1 Climate data

The 2005 Victor Diamond Mine EA considered climate change primarily through the use of historical climate trends for design and decision-making. Though changes in current local climate were alluded to, and the EA summary document did refer to ‘predictions from global climate models’, the EA did not document consultation of any future climate model projections or reference any specific sources of climate change data. Review of historical climate trends led the Victor mine to identify increasing winter temperatures as a specific threat to the mine’s ability to transport goods, materials and people via the planned winter road. In addition, the review identified an increased possibility of fire caused by increased lightning activity. Specific modeled projections were not consulted or presented in the case of either risk.

The comprehensive report demonstrated that climate change was not factored into the criteria used to evaluate alternatives and most design decisions were made using historical climate trends. In most cases within the EA, this type of climate change consideration led the proponent to assume that most past conditions would represent the future climate, as evidenced by the fact that many of the adaptive design choices were part of pre-existing contingency, adaptive management or emergency management plans that did not explicitly consider climate change but were designed to respond to weather hazards using current probability distributions. For example, infrastructure was designed using cold weather engineering techniques but did not consider specific information detailing future climate scenarios. This tendency will be examined in closer detail during the critical analysis phase of the project.

The EA used weighted scenarios to assess risk from historically based climate-related impacts. Under this strategy, environmental hazards and potential impacts were weighted according to the anticipated frequency and severity with which they might occur. Scenarios considered the potential damage caused by the occurrence of the identified impacts and determined the level of risk they posed to the mine site. It is not known whether the approach used by the Victor Diamond Mine EA to consider climate change was due to a lack of concern over climate change impacts, difficulties in accessing relevant climate change projections, the shorter time frames of mine operations, economic considerations or other factors.

6.2.2.2 Public consultation

There were no explicit uses of climate change or related terminology in the public consultation documents reviewed. Despite this, several inquiries alluded to an overarching concern about the impact of climate change on the project’s operations. In particular, concern was raised over the heightened potential for oil and fuel spills in the sensitive James Bay and Hudson Bay regions given the reliance on winter roads and ice roads for transportation.
In response to this query, the proponent identified seven alternatives to winter roads as means for fuel transportation. Following community consultation, the proponent decided on a strategy that made use of existing roads for transportation, though they decided to maintain an alternative winter road as a contingency measure.

Governmental reviews did not generate any requests for additional studies that considered climate change.

### 6.2.2.3 Adaptation measures

Given the limited consideration of climate change in the EA, it was difficult to assess the proposed responses to impacts of changes through adaptive measures. Of the climate change risks identified (warming winter temperatures and increased risk of forest fires), adaptation measures were only proposed to address the effects of increasing temperatures on the use of winter roads. These proposed measures included:

- Structural changes such as widening winter roads from 6-8m to 10-12m to promote more effective ground frost penetration, construction of all season access roads to the site and the construction of an all-season airstrip;
- Maintenance measures such as optimizing logistical arrangements to ensure that winter road construction and maintenance are carried out in a timely and effective manner or applying water sprays to create an ice road as opposed to a snow road; and
- The introduction of technology such as the use of rig mats at the larger water crossings to provide improved crossing strength, especially at tidal hinge points

To address other environmental risks to operation, the EA proposed a number of no/low-regret measures (e.g. surround coarse stockpiles with natural buffer to trap solids in case of flooding), and a detailed adaptive management and monitoring plan. These measures indicate that despite a limited consideration of the future climate, the proponent took steps to address the uncertainties surrounding the variability of environmental conditions at the site and in the region. These actions provide the additional benefit of contributing to greater operational resiliency to climate change.

### 6.2.3 Bellekeno Mine (Alexco) Yukon, Mineral Mine, Environmental Assessment Completed 2009

The Bellekeno mine is an expansion and revitalization of an historic mine site in the Keno Hill Silver District, Yukon. The mine development program involves the reopening of an existing underground mine, use of existing infrastructure and the reuse of previously impacted historic Mackeno mill site at Christal Lake and therefore the new environmental impact assessment on the site is very limited in scope.
6.2.3.1 Climate data

The Bellekeno Mine EA did not consider climate change, but relied on historical climate averages to establish the environmental baseline, and inform proposed design and operational measures. For example, average precipitation and average evaporation were considered the key parameters in developing the water balance for the site. The climate data was obtained from two nearby Environment Canada climate stations in the Keno Hill area. This data was supplemented with current weather observations and a monitoring and evaluation plan was developed to identify key design issues caused by changing weather. The supplemental information requests issued by Yukon Environmental and Socio-economic Assessment Board advised on the need for a more detailed exploration of current and future climate impacts including a specific request for future-looking wind dispersion modelling, and another for anticipated water levels in surrounding water bodies.

The Bellekeno Mine EA revealed an operational sensitivity to the impacts of extreme weather, due to its reliance on older infrastructure. Aged infrastructure may result in a higher level of vulnerability for two reasons (see also Pearce et al. 2009):

1) It was designed to older or unknown standards and may not be able to accommodate current climate/weather and other environmental pressures
2) Aged infrastructure is often degraded and (under weathering processes) may therefore be more sensitive or vulnerable to climate and weather extremes

Despite this recognized sensitivity, a climatic hazards analysis was not conducted and future climate change projections were not consulted during the EA process. The risk assessment completed by the Bellekeno mine developed risk scenarios for consideration and design purposes. This assessment did not include climate change projections. The risk scenarios were based upon climate normals in the area using recent weather observations.

6.2.3.2 Public consultation

The public consultation process raised strong concerns about the impact of climate change on the aging infrastructure used by this project. Given the potential for significant human and environmental risks and damages from climate/weather events and the minimal level of climate change knowledge incorporated into the EA, the interveners strongly recommended that climate monitoring be maintained at least throughout mine operations, and that the proponent should expand their consideration of future local climate conditions to include the use of climate models, as well as more and different climate parameters. Despite the external pressures to more explicitly consider climate change in decisions on the design and construction process, the Bellekeno mine EA assumed the use of a combination of existing infrastructure (e.g. water treatment plants, roads, etc.) and some new infrastructure. It appears that the new infrastructure and retrofitted older infrastructure was only implemented in cases where existing infrastructure could not meet the needs of the proposed project.

6.2.3.3 Adaptation measures
Several measures were considered which could be defined as adaptation measures. However, given the lack of climate change consideration, most measures were deemed to be part of pre-existing adaptive management, contingency, or emergency management plans. As with other EAs, the lack of climate projections meant that the EA focused on no/low regrets adaptation, monitoring programs and adaptive management strategies. For example: erosion control measures were installed to prevent the entry of sediment into the watercourse during extreme precipitation or flooding situations. In addition, without clear description and discussion of specific adaptation measures, the emphasis on adaptive management plans implied an intention to address emerging climate-related issues as they they arose. This strategy was particularly evident with regard to the Proponent’s continued use of aged and vulnerable infrastructure.

6.2.4 Galore Creek Copper-Gold Silver Project (NovaGold Canada Inc.), British Columbia, Copper/Gold/Silver, EA Completed, 2007

The Galore Creek mine EA involved numerous agencies, with a joint EA triggered both provincially and federally and the mine placement further bringing in US Federal and Alaska State government agencies along with municipalities and first nations communities from both countries. However, the mine site is quite isolated physically, meaning potential direct impacts to populated areas were minimized and no significant trans-boundary concerns were identified.

6.2.4.1 Climate data

The EA evaluated precipitation and temperature projections using GCM data, with a greater focus on the impacts of future changes in precipitation. No details or documentation were provided regarding which models were used, what calibration (if any) was conducted for model biases, or which time periods model projections represented. Other climate change risks, including changes to geo-hazard risks and future climate extremes, were called “unknown”. Climate data collection included the gathering of Tahltan elder council members to discuss traditional knowledge, particularly seasonal rainfall patterns, which was unique to this project.

The proponent also provided an inter-comparison of climate averages from one NOAA and several EC climate stations, but most of these were decommissioned by the time the baseline study was conducted. The study noted in particular a conflict between historically observed climate trends indicating an overall decrease in both temperatures and precipitation for northwestern British Columbia versus projected increases in temperature and precipitation from GCMs. It was suggested that a slight increase in average precipitation should have little effect on operations and could be easily handled by

\[23 \text{ Note that the EA considered future trends in mean/average climate variables and did not explicitly consider climate extremes. Observed and future trends in mean climate variables (e.g. decreased average annual rainfall) can differ in sign and magnitude when compared to trends in extremes (e.g. increased one hour or multi-day rainfall extremes).}\]
the current water management system design (implying this was based on climate change model projections input into hydrological models used for the mine).

Given the mountainous terrain, avalanche/debris flow events were considered in the EA, particularly in scenarios affecting the tailings pond. Snowfalls and accumulations were also indicated as factors that exasperated rock avalanche risks in the east fork Galore Creek, but the EA did not mention potential for any changes in these risks. The presence of a glacier is also particular to this site and was considered from a climate change perspective, with glacial retreat investigated by combining historical photographs with the current climate and future projections. Glacial retreat was to be actively monitored beginning in 2007, representing treatment of a particular climate sensitive element well in agreement with recommended best practices.

### 6.2.4.2 Public consultation

Requests from CEAA and First Nations groups appear to have been the main impetus for consideration of climate change impacts. A local aboriginal assessment organization, the Tahltan Heritage and Environmental Assessment Team (THREAT), specifically addressed concerns about the impacts of climate change on environmental hazards for the project. THREAT also played a direct role in the proponent extending the modeling period for water quality issues to 1,000 years. The assessment team noted the “estimation of impacts from the tailings impoundment needs to be extended to the life of the impoundment which is in perpetuity”.

### 6.2.4.3 Adaptation measures

A number of design measures were explicitly taken to reduce current climate and weather related risks which would produce the added benefit of reducing risks under climate change. For example, a slurry pipeline was chosen over other alternatives partially due to its reduced sensitivity to climatic hazards in comparison to other forms of conveyance. Several additional climate and extreme weather related impacts were identified but no direct adaptation design measures were discussed to reduce future risks. However, climate change was to be considered with respect to the proposed design of specific structures and infrastructure elements (e.g. flood risk assessment for the aerodrome). The discussion and intent to incorporate climate change is commendable given the state of climate change projections at the time of the assessment (i.e. IPCC 3rd Assessment Report, 2001), which featured a limited number of very coarse climate models and far less sophisticated understanding of potential climate impacts than more recent IPCC assessments.

Although climate change impacts were mentioned for a number of hazards, no additional adaptation actions or measures were reported as planned. Justification for this included uncertainty in climate projections, a lack of available methods to assess future climate extremes, and the use of higher (longer) return period values in water and tailings containment (e.g. surface water management infrastructure designed for 1/200 year precipitation event).
Adaptive management was the dominant form of climate change adaption selected, focusing on an environmental monitoring program (including meteorological, surface water and glacial retreat components) as well as the periodic review of infrastructure design criteria. The EA indicated these plans were ISO 14000 (environmental management) compliant. Events deemed “low probability of occurrence” or “catastrophic” were dealt with through emergency management practices rather than forward-looking engineering design measures. A risk assessment was conducted using a weighted scenarios methodology, but climate change related topics were not included among the identified risks.

6.2.5 Jansen Project (BHP Billiton Canada Inc.), Saskatchewan, potash mine, EA Completed 2012

The projected mine life for the Jansen Project was exceptionally long in comparison to other projects in this study, with the operational phase set at approximately 70 years and the post-closure phase (defined by the dissolution of waste piles) estimated at between 250 and 700 years. For this EA, it was very notable that external 3rd party infrastructure was identified and discussed, mainly due to the projects immediate reliance on these elements (e.g. rail line for export from Port Vancouver, WA; SaskPower 138 & 230 kV transmission lines).

6.2.5.1 Climate Data

The proponent used a combination of published climate change literature and GCM output for its discussion of potential climate change impacts. As with several other EAs in this study, the specific GCMs that were used, time periods represented in projections, and emissions scenarios employed were not specified. References specific to Saskatchewan’s future climate included Sauchyn and Kulshreshtha (2008), Barrow (2009), and Sauchyn (2009), as well as IPCC (2007) for more general discussions. The Pacific Climate Impacts Consortium (PCIC) also provided climate projection data (likely consistent with the 2007 IPCC AR4 model results), but no details were provided in the EA regarding which models were employed, the time periods used for projections, whether “raw outputs” or bias adjustments were applied to the projections, downscaling approaches, and so on.

With regards to historical climate data, all adjacent EC climate stations used in the study were listed as inactive at the time of the assessment, including Wynyard, located 40 km from the mine site, decommissioned in 2002 and employed for the discussion of local extremes. The extreme rainfall Intensity Duration Frequency (IDF) curves provided in the report employed data well before the EA was completed.

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24 Glacial retreat monitoring was the only one to mention climate change effects explicitly as one of the monitoring goals.
25 The EA did not specify which of the 14000 standards in particular were being followed, although wording refers to environmental “management system and supporting audit program,” implying a reference to ISO 14001.
26 One Project Advisory Committee member noted that Vancouver, BC is also a significant port of export for the site.
27 Baseline studies for this site began in 2008. An auto station at this location this site is still active and data can be found online at ECs climate website.
conducted, with the most up-to-date data being the Yorkton station (ending in 2003) and including several other sets of stations employing data ending in the early to mid-90s. Environmental baseline studies conducted in 2008 and 2009 compared favourably with the historical climate of nearby stations, but it was recognized that these measurement were taken during wetter than average years.\(^{28}\)

### 6.2.5.2 Public Consultation Materials

Climate change does not appear to have been addressed in the public consultation discussion, with much attention focused on the impacts of the mine on the local economy, job opportunities for First Nations and Metis, and land claims. There was some discussion regarding emergency response capabilities with the Township of LeRoy to link to emergency management at the mine site.

### 6.2.5.3 Adaptation Measures

The EA contained tables (Ch.14) the project team recommends for consideration as a template for other EAs. The tables provided a very effective way to present expected impacts and related adaptation measures for atmospheric hazards. These atmospheric hazards were also separated by time scale down into acute (individual weather events), seasonal and long term (climate change) related hazards and impacts with different adaptation responses noted for each time scale. This practice could work well with other EAs.

Ongoing adaptive management and environmental monitoring were again the main adaptive measures proposed here, with a focus on emergency response management measures. These measures were felt to be sufficient for addressing the impacts of climate change. Using long/high return period values for adaptation in water management were considered to be sufficient to address current and future climate risks. As with other mines, tailings design and management employing a design storm of 300 mm in 24 hours, the so-called Probable Maximum Precipitation (PMP) event with an estimated >10,000 year return period, was deemed sufficient to accommodate extreme precipitation. This value is the “industry standard” for potash mines in the province of Saskatchewan and is well in excess of other design rainfall values considered for the mine (e.g. 1/100 year return period event of 114 mm in 24 hours). Other measures included the design of buildings to existing building code values for wind loads and regular maintenance of drainage infrastructure, assuming "existing designs and operational procedures may be able to cope with the changes, although they will need to be reviewed regularly."\(^{29}\)

One of the most significant impacts expected as a result of the mine is ground subsidence (0.8 m average, 1.4 m maximum) due to sub-surface ground water removal, which cannot be prevented. The subsidence will produce changes to local lakes and waterways, increasing the size of Jansen Lake by 300

\(^{28}\) The wet years were determined based on historical data from surrounding climate stations, and not strictly estimated from the only 2 years of site specific baseline study observations.

\(^{29}\) Quote found on p.14-19 of the Jansen Project EA.
ha, and under current rainfall and snowfall processes is expected to take 100 years to reach these maximum lake size and ground subsidence values.

The risk assessment method used for the mine was essentially a weighted scenarios approach augmented by several “risk review” sessions, including, for example, failure mode and effects analysis (FMEA), trade-off studies, and multiple accounts analyses. As in other EAs, hazards were weighted using a combined risk score based on event frequency and the severity of its consequences. So called “major incident events” (MIEs) were then identified, several of which could potentially be triggered by climatic or weather events (e.g. slope failure in tailings pile) although causal factors were not identified explicitly in the EA and climate change was not explicitly mentioned with regards to these hazards.

6.2.6 Mary River Project (Baffinland Iron Mines Corporation), Nunavut, iron mine, EA Completed 2012

The Mary River Project EA consisted of three main sites; the mine site and two ports north and south of main mine site, joined by two long segments of linear infrastructure, rail and road. The rail line and associated port were to be newly constructed for this project. A major climate related challenge and risk for the project is the year round shipping of ore in the Arctic environment using a small fleet of reinforced ice breakers. The proponent specifically noted that the Arctic climate puts the mine at an economical and logistical disadvantage in comparison to other iron mines in warmer climates. It should be noted that, as with other projects, the size and scope of Mary River mine has been “scaled back” and modified since the original EA was published.30

6.2.6.1 Climate Data

Compared to other EAs, treatment of climate change was extremely thorough for this project (see Vol.5 of their report), which included raw (likely non-bias corrected) output from climate change models, as well as published studies addressing specific hazards such as changing sea ice extent. Most notable was an inter-comparison of a 5-GCM ensemble of climate change models with long-term climate observations and trends from selected sites as well as a discussion of relevant future time periods. Unfortunately, the method used to select these particular models was not specified. The use of a multi-model ensemble, as was done here, could serve as an example of best practices for the treatment of climate change in EAs. Changes to sea ice and permafrost were discussed, the former employing the Arctic Impact Climate Assessment Report (International Arctic Science Committee 2005) as a main reference, though the report only focuses on total sea ice extent, rather than localized characteristics.

30 The Mary River Project has been reduced significantly, with estimated project costs reduced from ~$4 billion to $740 million, including shelving of the planned rail line and new port, and change to seasonal instead of year round shipping of ore (Jordan 2013). As with all EAs evaluated here, our analysis is based on the content reported in the EA documentation and has not been modified for additional developments following submission.
All three main project sites have weather monitoring stations. In terms of historical climate data, adjacent climate data near the site had remarkably good temporal coverage compared to other mine site locations (5 of 6 nearest EC stations still active as they are community airports). But, as might be expected in the far north, station distances from the project site are quite significant. The closest is 160 km away from the main mine site, while others are located at 240 to 400 km distance. These climate data records were employed in the GCM assessment.

### 6.2.6.2 Public Consultation

The public consultation and feedback focused on overall socioeconomic impacts to local communities, the effects of the mine on land use (e.g. hunting and other local food sources) and the impacts of year round shipping on these factors, with an overall positive impact expected on local Inuit communities (e.g. mine work schedules were tailored to cultural preferences based on public consultation results).

Environmental monitoring was subject to some discussion, but focused on wildlife rather than atmospheric monitoring, with references to a number of species specific programs which had been put in place. Five key areas of the project were changed due to public consultation, but none were climate and/or weather related. Climate change was identified as a key Valued Ecosystem Component, but this related to GHG emissions rather than adaptation actions.

### 6.2.6.3 Adaptation Actions

Ongoing adaptive management, the precautionary principle and sustainable development were all key terms in the EA, with a cohesive Environment, Health and Safety (EHS) Management System being outlined for implementation.

The main design concern regarding climate change impacts on mine surface infrastructure were the potential negative effects of permafrost thawing and projected active layer depth increases up to 50% based on published studies. Several design measures were proposed to reduce associated risks. It was suggested that, following the implementation of these design measures, site buildings and infrastructure would no longer be “sensitive to changes in climate-related parameters.”

An excellent table discussing the impact of climate change on engineered structures and the associated adaptation measures was provided in the EA, and a similar format could perhaps be adopted for use in “best practices.” This table is somewhat different than those in Chapter14 of the Jansen Project, in that they are strictly related to engineered structures and adaptation responses, rather than management responses more broadly.

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31 There is also a short period of data from 1963-65 at the mine site location, which was used for historical comparison.

It was also suggested that reduced sea ice may be beneficial to the project given its reliance on ocean transportation as the only means of export. Nevertheless, the proponent indicated that current management plans were still based on the assumption that historical sea ice patterns will continue, citing the precautionary principal as the basis for that decision.

Concerns and hazards identified in the risk assessment phase of the project were based on feedback from the public, project personnel, comparable projects, and the experience of personnel on other projects. There were also analyses and studies used for specific hazards identified with the project (i.e. diesel spill, train derailment), some of which considered the effects of climate and weather on response options for these hazards. For example, the shipment of diesel fuel to the mine site will be restricted to the June/July-September time period, specifically due to the negative implications of certain seasonal weather conditions for the management of fuel spills.
7.0 Critical Analysis

Whereas the descriptive analysis served to objectively characterize the climate change-related content of each of the selected EAs, the critical analysis aimed to evaluate the treatment of climate change impacts and adaptation across the same set of selected EAs. Section 7.1 details the methodology used to conduct this evaluation, while Section 7.2 reports the main findings. Section 7.3 pairs findings with recommendations.

7.1 Critical Analysis Methodology

An “Analytical Framework” was developed to ensure consistent and structured analysis across each of the selected EAs. The Framework comprises a nested hierarchy of questions designed to support the evaluation of climate change impacts- and adaptation-related content, and is organized in accordance with the main elements of typical project-level EAs (see Appendix C).

The Framework was applied to each EA using data from the descriptive analysis tables, as well as from further, targeted reviews (for details not captured through the original descriptive analyses). Responses elicited through application of the Framework were then compared against best practices as defined in the Best Practices Synthesis (Section 5).

Throughout the following sections, “BP#” (e.g., BP7) is used to indicate links between particular findings (7.2), or findings and recommendations (7.3) and related best practice from the Best Practices Synthesis.

7.2 Critical Analysis Findings

General findings and their applicability to specific EAs are presented below, in accordance with the following main themes: EA scoping (7.2.1); technical details of climate data (7.2.2); engineering and management adaptation response (7.2.3); hazards identification and assessment (7.2.4); EA format (7.2.5); and, review process (7.2.6).

7.2.1 EA Scoping

The critical analysis revealed several key findings relating to the scope of EAs and how climate change was considered within. Perhaps the most significant was the fact that the terms of reference (ToRs) guiding most EAs did not indicate which of the VECs were most likely to demonstrate climate sensitivities of consequence for the mine (BP# 1 & 2). Without a clear indication of climate sensitivity among VECs, proponents may have difficulty with accurate prioritization and design during the early phases of mine development, potentially resulting in increased vulnerability among built assets. Closely related to this finding was the fact that the environmental baseline used in most EAs was developed using only historical climate data and was not representative of the future environmental conditions
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each mine would have to plan for. In cases where climate sensitive VECs are identified, the use of an environmental baseline developed using climate projections can help proponents to more accurately identify the anticipated impacts that may affect them and prepare appropriately (BP #3). The use of a historical environmental baseline combined with the failure to identify climate sensitive VECs may compound the climate vulnerability attached to each VEC.

Related to the above, certain studies and sections within the EA appeared to have been conducted or written in isolation of one another. These inconsistencies in process, analysis and/or treatment of climate change impacts, may lead to use of different data to inform risks or even oversight of key risks.

Any consideration given to the combined effects of climate change and the project on the VECs tended to be superficial, unsystematic and rare. For example, the Joslyn North EA briefly notes that project impacts on local ecosystems (including the introduction of pollutants and changing hydrologic cycles) may vary under different climate conditions. No further details were provided regarding what these changes might be.

In some cases, guidance materials used to assist with the establishment of terms of reference were outdated, applied inconsistently or applied inappropriately. In one case, the proponent relied upon the Responsible Authority’s Guide to the Environmental Assessment Act (1994), which does not consider climate change, during the development of their proposal and terms of reference in 2006, despite the availability of more recent guides at that time. In another case, although Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners33 (FPTC, 2003) was used to develop the terms of reference for the EA, and the proponent followed the guidance to acquire climate projections for several key parameters, they did not consider these projections equally in their assessment of Valued Ecosystem Components (VECs). It was not clear why certain VECs were included for climate change related analysis and others were not, nor was there any indication of such a selection process taking place (BP#2). This issue was prevalent across most of the reviewed EAs.

Greater consistency in treating future climate change implications within an EA report could result through use of mechanisms to encourage communication and co-operation between those responsible for separate technical components of the EA, with the development of the reference “new baseline” acting as an anchor or focal point for continued coordination throughout the EA process.

7.2.2 Technical Details of Climate Data

The use of historical climate data and future projections lies at the heart of decision-making regarding climate change adaptation. Hence, a detailed assessment of how historical and projected climate information and data were employed within these EAs was conducted.

33 A joint report developed by representatives from all provinces and territories, federal departments such as Natural Resources Canada and Environment Canada, the climate change secretariat and the Canadian Environmental Assessment Agency.
7.2.2.1 Use of Climate Change Projections

As indicated in previous sections, the Bellekeno mine EA did not appear to consider climate change at all, as evidenced by the exclusive use of historical climate *averages* in the development of the environmental baseline and VEC analyses. In this case, the lack of climate change consideration was rationalized by the short operational lifetime of the mine. This rationale for choosing to exclude climate change from the EA process is consistent with findings from previous research, which indicate a general reluctance among proponents to consider potential climate change impacts for projects with relatively short operational periods (Byer et al., 2011). However, this is not to imply that climate change adaption is necessarily binary in nature, as climate change integration for the remaining five (5) assessments was characterized at differing levels of sophistication and detail.

Within the remaining 5 EAs, there were numerous examples that indicated inadequate climate expertise (BP#4, 10 & 16) for the EA development process, particularly concerning the application, evaluation and use of climate change projections. The general practice of considering climate change as an unknown, rather than attempting to quantify the potential range of its effects, greatly restricts the proponent's ability to include it in environmental management planning. One EA specifically stated that no methods exist to estimate future climate *extremes*, which is unfortunately inaccurate. At the time the EA was conducted (2004-07), methods for estimating the behaviour of future extremes were becoming available in the published literature (e.g. Meehl et al. 2000, Palmer & Räisänen 2002, Semmler & Jacob 2004, Cheng et al. 2007), although admittedly these generally addressed extreme temperatures and required climate expertise to apply. Limitations of the use of climate expertise was also revealed through differing levels of sophistication between analyses of climate hazards when compared to other environmental hazards such as geohazards. Even though proponents are not be expected to be fully aware of all details and techniques relating to climate change risks and impacts assessment, utilizing experts in other fields for the purpose of developing an EA occurs, and, by extension, should apply to climate change expertise.

7.2.2.2 Historical Climate Data

EA analyses revealed the need for guidance for the purposes of basic, first order assessment of relevant climate hazards for Canadian mine sites. The Jansen mine used Phillips (1990) as a reference for this, and while it was effective in assisting in properly identifying important climatic hazards for that region, the reference itself is clearly out of date, containing climate normals for 1951-80 period, and extremes data up to around 1985 (Phillips, 1990). It may also be potentially too general in its treatment of climate hazards to be suitable for this purpose. In contrast, the Galore Creek mine (north central BC) described potential impacts from tornadoes and hailstorms within their analysis of the effects of the environment

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34 While this appeared to be recognition of the fact that climate extremes and average require different assessment methods, the EA went on to use projections in climate averages to provide guidance on expected changes in future extremes.
on the project. Current research indicates that two of the hazards are of very low probability\(^{35}\) for the mine’s location (Newark, 1984; Sills et al., 2012). This indicates the need for the development of a climate resource similar to Phillips (1990), updated with recent climate change projections and historical data, which can provide easily accessible information for first order approximation of relevant climate hazards and loads for different geographical regions.

Other examples surfaced within the EAs that signal the need for recommendations on the uses and applications of historical climate data, including minimum data requirements for certain types of analyses. Air quality calculations for one of the projects referred to Alberta Environment (AENV 2009) guidelines, but did not employ the suggested minimum observational collection of data to conduct their air quality assessment\(^{36}\). The mine’s study met only two (2) of the three (3) minimum data requirements specified for air quality modeling in guidance documents (AENV 2009). This also raised concerns about the balance between minimum data requirements and their adequacy. The analysis employed 1 year of on-site surface observations combined with 5 years of 3D meteorological modeling data, while guidelines suggested the additional use of at least 5 years of historical data from the nearest climate station.

For the Victor Diamond Mine, climate change was considered primarily through the use of historical climate trends, without taking into account future climate projections from climate models. Historical data is helpful to understand climate change particularly for the near term future, and can be used for direct comparison to climate model projections\(^{37}\) as well as for complex variables which are not well represented by climate models (IPCC 2012). However, Federal Provincial Territorial Committee on Climate Change and Environmental Assessment guidance clearly indicates that “practitioners should focus upon readily accessible information sources regarding changes to regional climate patterns” (FTCP 2003), including IPCC reports and related climate change model projections.

### 7.2.2.3 Climate Change Model Projections

Climate change models and projections are a part of a dynamic and ongoing scientific process, and hence the climate change-related content of a given EA needs to be placed within the context of the state of this science at the time of the assessment. The EAs completed between 2004 and 2007/08 were undertaken using IPCC Third Assessment (TAR) results, published in 2001, and reflect a time when climate change projections were more difficult to access, when confidence in projections was less, and when techniques for downscaling or regionalizing climate extremes were rapidly evolving.

\(^{35}\)Recent research, which employed population and lightning detection data to adjust for tornado observation biases, indicated return periods of greater than 1-in-10,000 years for tornadoes in this region of northwestern British Columbia. This is in direct contrast to other mine sites, such as the Jansen project, with estimated return periods of less than 1-in-10,000 years for tornadoes of F2 or greater intensity (Sills et al. 2012).

\(^{36}\)Alberta Environment guide to air quality assessment modeling is used as the main reference, including minimum data requirements depending on the needs of different models. The version referred to in the EA was published in 2009 and has since been updated to 2013.

\(^{37}\)Do modeled projections from GCMs correspond well with recent trends in characteristics such as direction (increasing or decreasing) and/or rate of change.
While some EAs identified the climate change models and data sources employed in their analyses, only one conducted any uncertainty or verification checks for these models (BP#5, 11 & 17). Volume 5 of the Mary River EA described the baseline atmospheric environment and employed an ensemble of global climate models to describe potential future changes. The EA also checked for climate model biases by comparing them to relevant historical climate data. However, the respective time periods used for this comparison were different, employing the 1961-1990 time period for GCM hind-cast values and the 1971-2000 observation period for the historical values, meaning the climate model and historical data periods do not match. The methods and/or reasoning used to select the 5 GCMs which were selected (out of the 24 available under IPCC Fourth assessment or “AR4”) for the ensemble was not described. Hence, while a number of best practices were employed in their assessment, the details of their application contained potential errors or omissions.

The Mary River project was also the only EA that contained separate analyses for extreme versus average climate values when considering climate change projections, recognizing the need for using a different assessment method for each (see explanation and guidance BP#5). Other EAs described future extremes as being unknown, while simultaneously using climate change projections of averaged values to diagnose expected future trends in extremes. The Mary River project employed a specific methodology to investigate future temperature extremes, again in recognition of the fact that trends in extremes will not necessarily follow, in sign or magnitude, those of mean values. In many cases, the tendency to treat the behaviour of future extreme events as uncertain, led to the development of no- or low-regrets strategies and/or over-design (robust engineering) to address these risks. There also appeared to be a lack of discussion regarding ranges of uncertainty in climate change projections (BP#5). The only exception was again found with the Mary River Project, which considered the impacts of marine ice on shipping and discussed ranges in projected changes in ice cover (Vol. 9 of that EA). In general, the quantitative discussion of uncertainty in projections was completely absent in any of the EAs.

There were also inconsistencies of climate change projections used throughout the individual EAs. At least two EAs (Mary River and Jansen) clearly contained separate climate change assessments within different sections of their respective reports. The Mary River EA contains climate change discussions in the assessment of engineering hazards (Vol. 9) as well as the description of the baseline atmospheric environment (Vol.5). While findings from both sections are cross applicable, there is no coordination between those volumes, and each uses a different set of models from a different IPCC assessment (TAR and AR4, respectively; IPCC 2001 & IPCC 2007). This inconsistency in the use of model results between different components or segments of the EA reveal the need for mechanisms to ensure that all members of the EA development team are aware of one another’s work and, ideally, coordinate their efforts and analyses. The use of IPCC Third Assessment Report projections for an EA that was completed well after IPCC Assessment Report Four model data had been published also leads to concerns regarding the use of the “latest” climate change projections for evaluation. A mix of eras of climate change projections could be explained or justified mainly in cases where complex climate change downscaling studies were undertaken using previous IPCC assessment results. In relation to these comments, the
selection or scoping of climate related hazards appears to have been done for some EAs (e.g. Jansen; see also BP#14) but was not necessarily transferred to other sections within that EA.

7.2.3 Engineering and Management Adaptation Response

Robust engineering and infrastructure resilience were indicated as adaptation strategies for most mines (Galore Creek, Jansen, Mary River, Joslyn North), and in particular for surface water management structures and facilities. In some cases, this resulted in altered designs (e.g. designing tailings management and diversion dams for 1 in 1000 year flood event to accommodate Probable Maximum Flood as opposed to commonly-used, regional design standards). In other cases this strategy involved building in redundancy or options for future flexibility (e.g. Joslyn North EA, tailings ponds were designed with enough space for the future construction of berms if and when they are required in the future to accommodate flooding). According to international best practice, all of these practices are considered reasonable adaptation options when dealing with high uncertainty climate change projections.

In three other cases, robust design measures were indicated for a number of site facilities, but on the assumption that designs based on long return period or rarely occurring climate events (1-in 100 or 200 year 24 hour rainfall) already provided adequate risk management for absorbing projected climate change impacts. While robust engineering design is indeed a well-established and effective climate change adaptation strategy (Dessai and Hulme, 2007; Wilby and Dessai, 2010; Mastrandrea, et al. 2010; Lal et al., 2012), it was not clear if the impetus behind these designs were in response to general safety concerns under the current climate, or if the extended return periods were first informed by anticipated changes in climate. The wording often described these components as requiring “no action” or “no further action” to address climate changes given the already robust nature of component designs, implying that robust engineering was implemented before climate change impacts were considered. One EA provided no direct rational or quantitative comparison to justify the particular return period used, while others employed academic references (e.g. Dillon 2009) but did not describe the justification or relevant content of those references.

The Jansen mine exhibited both particularly long operational and closure periods (70 and 150-700 years, respectively), and several other mines (e.g. Mary River and Bellekeno Mine) discussed the potential for expansion and extension of mining operations beyond initial estimates (e.g. expansion of mining operations through the opening of new ore bodies). As such, operational and closure periods may extend beyond the design return periods for climatic loads used to design facilities and other infrastructure, therefore increasing risks of failure and subsequent impacts on the surrounding environment. In the case of Jansen, the EA noted that all on site buildings would be designed using current applicable building standards. These standards present snow and wind loads for buildings that employ 50 year return period values (NBCC 2010; NRC 2010). However, the operational phase of the Jansen project is expected to be approximately 70 years (i.e. greater than the return period for design wind and snow storms) which increases the possibility that snow and wind loads may exceed the load-
bearing capacity of those buildings. However, there appears to be no recognition of this discrepancy, and no solutions are provided to address it.

Although every EA described ongoing adaptive management based on environmental monitoring, there was only one instance of a description of either design or management changes or alternatives (i.e. contingency plans, BP#18d; see also BP#9 & 15) that would be implemented if and when climate changes are detected. Such alternatives include specific types of retrofitting for project components that could be constructed to respond to changes in conditions. There was little to no description of the degree of risk reduction generated by any given adaptation actions (BP#9 & 15), the absence of which is again justified by the assumption that design and operational measures already in place should be sufficient to absorb any future changes in climate.

Our analysis also revealed that ongoing adaptive management strategies, emergency management and contingency plans were even more heavily relied upon where climate change consideration was limited to historical trend analysis, or where it was not directly considered in the EA. Both the Victor Diamond EA and the Bellekeno EA placed considerable emphasis on these tools to build operational resilience to current and future climate impacts (regardless of what they might be). In both cases, emergency management and contingency plans were developed to address climate hazards and impacts. For example, the Bellekeno Mine EA used contingency plans and robust engineering were prepare for possible climate hazards. Examples included designing redundant systems to ensure pumping, power and wastewater system operation during extreme weather events.

There was some reliance in several of the EAs (e.g. Jansen, Joslyn North, Galore Creek and Bellekeno Mine) on short-term weather forecasts and warnings for operational response to severe summer and winter weather events. This indicates that there may be an overemphasis on the reliability of said forecasts and weather alerts, particularly for small scale, rapid onset events. In many instances, warnings may not be issued in time to take operational actions described in emergency plans. This is of particular concern for some projects and phases since several structures in use may be of a temporary nature (e.g. work trailers, construction camps) and may not provide suitable shelter under severe and extreme weather and conditions, and the failure of which may also result in impacts to the environment.

Lastly, a systematic listing of both expected impacts and of adaptation measures by project phase (BP#7) tended to be absent from most EAs, again with the exception of the Jansen mine. Chapter 14 of the Jansen EA report clearly elaborates on the effects of the environment on the project and includes within this description the relevant project phase. In all other cases, this was not done.

7.2.4 Hazards Identification and Assessment

In most cases, hazard assessments in the EAs tended to be conducted in the form of a standard weighted risk analysis which used a combination of event frequency and impact severity. The product of these two factors resulted in a score describing the relative level of risk posed by a given hazard. The event frequency component may change significantly over the course of the mine life or extended
closure period, particularly depending on the sensitivity of the hazard to climate, and may require specialized estimates of future extremes (e.g. downscaling, synoptic map typing). Small changes in frequency for high-impact/low probability events could mean the difference between small and large overall risks, hence the need for changes to the hazard to be given further consideration within the EA. Several methods used within the hazard assessments of EAs can easily incorporate climate change information.

In many cases, site hazards were identified that could potentially be driven by climate and weather events, but the explicit connection between these hazards and climatic events was not made or was not quantitatively evaluated. In one case, the mine’s EA noted concerns regarding tailings pile collapses and included this as one of its potential major incidents, but the causes of tailings pile instability were not specifically mentioned. In another case, the Mary River EA noted that a rain-on-snow event during the spring freshet would be the most likely cause of open pit flooding, but no quantitative assessment of this risk was described. This may also be again symptomatic of a lack of integration between EA phases or components or, alternatively, challenges in accessing relevant climate change information or expertise.

### 7.2.5 EA Format

As noted in the descriptive analysis, some EAs contained tables with summaries of the climate driver, expected impacts, and related engineering and management adaptation measures (e.g. Mary River Project’s Vol. 9 Section 2.1, the Jansen Project’s Ch.14). The Jansen Potash mine provided a number of good examples of reporting methods which could help integrate climate change and should be considered as good practices for future EAs and by other jurisdictions. In particular, their Chapter 14 on *Effects of the Environment on the Project* contained tables which describe expected weather, seasonal and climate change related events, their impacts on project elements and operations (further separated by project phase), and associated adaptation strategies employed to respond to those events. The Jansen EA also exhibited recognition of their reliance on external, third party infrastructure. These elements were listed and discussed in terms of the potential impacts of failures to the project (but without discussion of climate change in particular). Consideration of climate change impacts on third party infrastructure could perhaps be considered or integrated as a component of the EA process in general.

Some of the inconsistencies in the incorporation of climate change implications may simply be due to a lack of communication of specific project elements within the EA itself. By virtue of being discussed, a number of processes must have taken place (e.g. selection of specific GCMs or ensembles for projections), but are simply not described in the report. For example, the Galore Creek EA mentioned the use of climate change projections for precipitation and temperatures, but the specific GCMs that

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38 Note that the EA referred to these as impacts “mitigation” measures rather than adaptation measures. The term mitigation is avoided here since it is usually used to describe greenhouse gas emissions reduction strategies and using it in reference to impacts and adaptation has resulted in confusion in the past.
were selected were not described, and neither were the particular climate parameters that were used. Climate change implications may have been treated in this and other EAs but simply not reported or documented.

### 7.2.6 Review Process

The critical analysis revealed that there was sometimes inconsistency with government reviews of EAs. Primarily, reviews and subsequent requests for supplemental information were sometimes inconsistent with federal guidelines on the incorporation of climate change in the EA process. For example, a particular assessment was noted for not considering climate change within the EA process. In this case, the government review also failed to make any requests for additional climate information to be considered during analysis. In other cases, government review was internally inconsistent. There was an acknowledgement by reviewers that climate data used by the proponent to model current climate impacts was too old to be relevant (20 years) and did not adequately consider climate change. The reviewers went on to state that this information was critical to the Project’s calculations because of the strong presence of permafrost on the mine site. Despite these requests and the emphasis placed on climate change, the reviewers deemed a proposed climate resilience-building activity unnecessary. In this case, the proponent had proposed a set of berms constructed to divert surface runoff generated outside the waste rock storage area and to contain any runoff generated within the area. This action was proposed to ensure safety in spite of any climate hazards that occurred (and in the absence of infrastructure designed specifically to handle future climate events).

### 7.3 Summary of Findings and Related Recommendations

The following table provides a summary of findings and a list of related recommendations stemming from the descriptive and critical analyses reported on above. The findings and related recommendations are organized, respectively, under five main headings as follows: legislative/regulatory; climate data and technical expertise; climate change and EA guidance; adaptation measures; and, EA format. The recommendations are meant to be used in conjunction with and to enhance the Best Practices identified in Section 5.

**Table 7.1: Findings and Related Recommendations**

<table>
<thead>
<tr>
<th>Legislative/ Regulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Findings</strong></td>
</tr>
<tr>
<td>1) Including consideration of future climates in closure and abandonment strategies and securing adequate funding to cover anticipated costs may help overcome the</td>
</tr>
</tbody>
</table>
tendency to leave responsibility for future adaptation to the government.

2) Harmonization of government EA review processes may be a key element for encouraging greater consideration of climate change within the EA process as it has the ability to establish climate change as a key factor for consideration across the sector, and may relieve stakeholder concerns of competitive disadvantages stemming from differing expectations on climate change treatment within EAs.

3) In Canada, consideration of climate change impacts and adaptation options in project-level EAs is suggested (by guidelines) but not required (by law), a situation that may be contributing to clear discrepancies in the extent and quality of climate change-related analyses across EAs.

4) Across evaluated EAs there were several examples of missed opportunities for the use of *key existing* tools and methods (e.g. risk and vulnerability assessments) in the consideration of climate change impacts and adaptation.

**Recommendations**

5) That the appropriate provincial, territorial and federal authorities work towards harmonizing climate change-related requirements for project-level EAs across Canada by establishing clear and common expectations with respect to the steps practitioners should take and methods they should consider when: screening for and analyzing the potential effects of climate change on Valued Ecological Components; evaluating options for managing related risks; and, communicating about related uncertainties.

6) That a review of existing regulatory processes and legislation pertaining to key aspects/phases of mining (e.g. water use and management, transportation, closure planning) be undertaken to provide a richer understanding of policy barriers and identify opportunities to drive climate change adaptation in EAs.

7) That the 2003 federal guidance document *Incorporating Climate Change Consideration in Environmental Assessment: General Guidance for Practitioners* be updated to reflect recent developments in climate science, the treatment of climate-related risks in decision-making, and sector-specific examples of best practice drawn from EAs conducted to date.

8) That regulatory processes, such as water licensing, be better aligned with EA processes with regard to the consideration of climate change in the planning, design and management of projects, so that any regulatory requirements directly inform climate change related analyses within the EA process and *vice versa*.

9) That existing regulations for the reopening of legacy mine sites be reviewed to better reflect the implications of using/retrofitting/replacing existing infrastructure and equipment in a changing climate, and the role of environmental assessment in securing these assets.

**Climate Data and Technical Expertise**
**Findings**

10) Hazard identification and risk assessment for the mine site carries particularly strong links to climate change impacts and would benefit from stronger integration with other related components of the EA.

11) A number of methods used for hazard assessment and calculations can easily incorporate climate change information.

12) Averaging periods used for GCM validations using hindcast versus historical data comparisons and other data verification should be equivalent to one another (i.e. cover the same averaging periods).

13) While some of the evaluated EAs identified the climate change models and data sources used in their analyses, only one of the EAs reported having conducted any uncertainty analyses or verifications against historical baselines for the climate change projections they used.

14) All evaluated EAs encountered significant shortcomings in the availability and/or quality of representative historical climate data; the data was often insufficient in either temporal or spatial extent, or both.

**Recommendations**

15) That the terms of reference for EAs explicitly identify an initial list of Valued Ecosystem Components (VECs)\(^39\) that could be negatively affected by future changes in climate/weather parameters\(^40\), and require that projected changes in the baseline conditions of each of the identified VECs assume a reasonable, credible range of values for the climate/weather parameters to which they are sensitive, over all main project phases. This should be based on an explicit preliminary climate change vulnerability assessment of the VECs. (See Section 5, best practices 1-4 for further background.)

16) That the consultation of appropriate climatological expertise be required to guide the considered use of appropriate techniques in the analysis and use of both historical and future climate data.

17) That the appropriate provincial, territorial and federal authorities develop a comprehensive glossary of terms to reduce confusion regarding climate change, engineering and environmental assessment terminology. This work could expand on similar, existing work by Engineers Canada.

18) That climate change projections employed in the development of EAs correspond to

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\(^{39}\) VEC is understood to be “Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern,” (FPTC 2003). The VEC list will continue to be developed throughout the EA and public consultation processes.

\(^{40}\) Climate/weather parameters include variables such as temperature, humidity, atmospheric pressure, wind, and precipitation. Changes in both averages and extremes should be considered.
Assessing the Treatment of Climate Change Impacts and Adaptation in Project-Level EAs in the Canadian Mining Sector

engineering and/or operational management element needs. In particular, extremes should be investigated for elements or impacts relevant to extremes, and averages for elements or impacts related to averages (e.g. seasonal water budgets).

19) That governments strengthen efforts to collect and deliver accurate climate data for remote regions of Canada, as well as tools and guidance to help EA practitioners make use of this data.

20) That where climate models are employed, the documentation of specific GCMs, projection periods, and associated selection methods or justifications within an EA is noted in order to understand and manage uncertainty.

21) That mines consider how design requirements, specifically return periods implicit in baseline values used for climatic load calculations, compare to planned operating periods and potential future expansions. That replacement schedules and/or other contingency plans for mine infrastructure be planned or at least discussed in the EA.

22) That EA practitioners develop new environmental baselines using several climate change projections (i.e. an “ensemble” of models) to be referenced throughout the EA for all project components and phases.

23) That expert knowledge in climatology and meteorology be consulted and utilized as part of the EA process, much as engineering, wildlife and other fields of expertise are consulted for project EAs.

24) That EA practitioners explicitly discuss the uncertainties of the climate change projections they use and the implications of these uncertainties for conclusions drawn through the EA. This discussion should be informed to the greatest extent possible by quantitative analysis of the nature described in Best Practice #5, Section 5 of this report.

25) That the appropriate Federal, Provincial and Territorial authorities consider the role climate data uncertainty plays in decision-making, so that they are better able to support proponents in identifying and implementing appropriate adaptation measures.

26) That project proponents be encouraged to begin monitoring local climate conditions as early as possible (such as during the advanced exploration phased of the resource extraction process), to ensure the longest and most representative possible climate data record for use in project EAs, regulatory processes, and later decision-making.

Guidance

Findings

27) Much of the available guidance on incorporating climate change impacts and adaptation into project-level EAs is: dated (most relevant guidance published in 2003), inconsistent across provincial/territorial boundaries and does not give proper attention to the treatment of climate hazards, climate data management (including hindcasting and downscaling techniques) or best practices.
**Recommendations**

28) That the appropriate Federal, Provincial and Territorial authorities create or capitalize upon existing institutional mechanisms in order to support efforts at harmonization as described above.

29) That the appropriate Federal, Provincial and Territorial authorities, together with other qualified EA practitioners explore means by which to foster better-coordinated approaches to the consideration of climate change within *individual* EAs.

30) That an updated general reference or resource of Canada’s national climate, similar to Phillips (1990) be developed to assist in a first order identification of potential climatic and weather hazards for project sites. Other resources need to become available for consistent treatment of climate hazards or extremes.

31) That additional guidance be developed to help proponents utilize hindcasting and downscaling techniques in environmental assessment.

32) That regular consultation is established with proponents and key stakeholders to develop and improve uptake of new best practices.

33) That government authorities provide guidance on how the hazard and risk assessment processes currently undertaken within project EAs might be better used to characterize climate change-related risks, and identify and select among appropriate adaptation measures.

**Adaptation Measures**

**Findings**

34) Although each of the EAs that were reviewed suggested environmental monitoring and adaptive management as means for addressing the future effects of climate change on the environment and/or project, few of the EAs identified *specific* management options for future consideration, nor the magnitude of environmental change that would trigger the eventual use of such options.

35) In most cases, it was unclear if a particular approach or action (e.g. robust engineering) was employed to generate an overall increase in project safety margins under current climate conditions or specifically due to projected changes in climate.

36) Third party infrastructure may be vulnerable to climate and weather, and damage, outages or other impacts to those components will have a direct impact on the mine and its environment.

37) Identifying climatic drivers for specific mine hazards (e.g. tailing pile collapse, open-pit flooding, etc.) can help to define potential changes in risk posed by changes in climate.

**Recommendations**

38) That the impetus behind specific adaptation measures or actions be clearly
articulated within the main body of the EA.

39) That specific adaptation design and/or management options, and the criteria that would trigger their use, be defined within the EAs adaptive management plan.

40) That adaptive actions also be accompanied by a description of the degree of risk reduction associated with their implementation.

41) That operational response measures acknowledge that rapid onset of severe and extreme weather events may occur without adequate warning time for response, and plan accordingly.

42) That sufficient financial resources be held in security to ensure that all adaption options defined within the proposed adaptive management plan can be implemented as necessary in the future.

43) That guidance be developed to support EA practitioners in the selection and evaluation of adaptive management and adaptation options.

**EA Format**

**Findings**

44) A number of issues noted in the analysis may simply be rooted in a lack of reporting within the EA documentation. This can be avoided by better reporting of technical details or aspects of climate, and of operational management and engineering design specifications used for the mine.

45) Information regarding past completed EAs was sometimes difficult to access.

**Recommendations**

46) That a standard format or suggested screening structure be developed for reporting on the climate vulnerability of VECs.

47) That EAs have a systematic breakdown of adaptation measures with respect to project phases, which can likely be done in conjunction with the “new baseline” concept described above and in the Best Practices.

48) That mechanism(s) be put in place to better coordinate the analyses and writing of different EA segments. This includes the need for consistency in the nature of climate projection data used throughout the EA.

49) That the responsible Federal, Provincial and Territorial authorities reorganize project registries to promote easier access to EA documentation.

50) That additional studies of Canadian mine EAs be conducted in order to gain a better understanding of how the treatment of climate change impacts and adaptation may be changing with time, given the increasing availability of tailored climate information, tools and expertise.

51) That examples of table formats and analysis methods from some of the EAs in this study (Jansen Ch.14; Mary River Vol. 5 & 9) be adopted and expanded.
Many of the above recommendations can be implemented as a continuation or expansion of elements that are already part of the mining EA process, rather than new and potentially unfamiliar elements which need to be considered in addition to an already time and effort intensive activity. A number these recommendations also confirm several of the Best Practices described in Section 5 and provide guidance on how these best practices can be effectively implemented within Canadian mining EAs.
8.0 Practitioner/Expert Interviews and Results

In order to corroborate main findings of the descriptive (Section 6) and critical analyses (Section 7) above, and pose follow-up questions where possible, interviews were conducted with company representatives and technical experts familiar with one or more of the selected EAs.

8.1 Interview Methodology

Technical experts in the areas of climate change, mining or environmental assessments, and company representatives directly involved in the development of the selected EAs were deemed to be most suitable to provide additional context to the results of the analysis. Project advisors were asked to offer potential interviewees, and that list was supplemented with additional contacts at each of the companies that developed the selected EAs.

A total of four interviews were conducted over three months, two with technical experts and two with stakeholders directly involved in conducting the selected EAs. An interview guide was developed for each interview with questions tailored to interviewee’s area of expertise and reflective of their level of familiarity with the EA in question. The questions covered common challenges relating to climate change and mining operations, specific climate change impacts on the mine, primary drivers of climate change adaptation action and level of regulatory support for climate change adaptation among other questions specifically related to the descriptive and critical analysis findings. The additional information and clarification provided by the interviewees informed the critical analysis.

8.2 Findings

A number of common themes were identified in each of the interviews and are explored below.

Three of the interviewees identified the importance of available climate change expertise, either within the mining company or their consultants, as a key component to the incorporation of climate change into the EA process. Interviewees suggested that although detailed change projection data may be available in many regions, proponents find it difficult to utilize it in their decision-making without expert assistance. The identification of relevant climate parameters, acquisition of climate data and manipulation of said data to project potential climate impacts on the mine site requires a high level of specialized climate knowledge. Two of the interviewees also suggested that acquiring external expertise was a costly investment that many proponents would be reluctant to make unless it were legally required.

Current and detailed guidelines that identify specific sources of climate information were cited as important tools to support the consideration of climate change in an EA. Although the 2003
Incorporating Climate Change Consideration in Environmental Assessment: General Guidance for Practitioners is considered to be a good resource for practitioners, two issues were raised with regard to its use in completing an EA that considers climate change. The first was the large challenge of integrating climate change into all the other studies required during the EA process. More specific and consistent guidance on how best to incorporate climate change into each part of the EA was deemed helpful. Secondly, some interviewees expressed that the guidance was dated and sought an updated version for use in EA process.

Two interviews also suggested that the expectations of government reviewers played a key role in determining the level of consideration given to climate change within an environmental assessment. Motivated by compliance with Provincial/Territorial (and Federal) guidance, environmental assessment reviewers use those guides to establish the standard of climate change consideration within an EA and ensure that they are followed. Thus the presence of proper guidance ensures that climate change risks are properly accounted for throughout all phases of an EA, and it allows reviewers to justify criticisms where it is not included in EAs. Interviews suggested that the difference in the treatment of climate change in EAs across Canada could be partially attributed to differing expectations in regional review processes.

Interviews also suggested that legislation and regulation held the most influence over the degree of attention to climate change within EA development process. As regulations progress to more, and defined attention to the impacts of climate change, so too will mining and other sectors move to comply with the regulations.

Stemming in part from inconsistencies in the various regional guidance documents, differing levels of attention to climate change impacts and adaptation in EAs in different regions at times evoked perceptions of competitive disadvantage among proponents. Resources spent conducting vulnerability and risk assessments and the address of climate risks were seen as ones better spent elsewhere. As the overarching guidance piece, Federal legislation can relieve this issue by clearly communicating expectations with regard to the consideration of climate change and establishing a sector-wide standard that can be enforced. Similarly, regulations and permitting, zoning and licensing processes may be used to ensure more comprehensive consideration of climate change impacts and adaptation in project EAs and evaluation of climate risk. These actions, if appropriately enforced, could support greater climate change consideration within EAs and resultant adaptation measures, contingency planning, adaptive management and emergency management efforts.
9.0 Conclusions

There is a growing body of evidence that demonstrates that climate change impacts such as flooding, declines in permafrost and extreme heat stress already impact Canadian mines throughout phases of development, operation and closure (Pearce et al, 2011; Nelson and Schuchard, 2011). As climate continues to change, these impacts will likely be enhanced, increasing related risks for mine owners and operators (Lemmen et al., 2008; Ford et al., 2011). Consideration of climate change impacts and adaptation measures during the design and planning phases of a mining project can significantly increase the ability of a mine to prepare for these emerging risks (FPTC, 2003). Incorporating recognition of climate risks into environmental impact assessments affords mine owners and operators the opportunity to assess, disclose and plan for climate change risks. Adaptation can also derive financial savings through cost avoidance and also protects against declines in reputational risk. Proper analysis of weather and climate change data and information through an EA process can also identify risks to surrounding communities in areas of critical infrastructure. Although results of this analysis are sector-specific and based on the review of a small sample of EAs, observations, lessons and recommendations are appropriate to environmental assessments conducted in other fields or sectors.

The current approach to environmental impact assessment focuses primarily on the pending project’s impact on the environment and lacks emphasis on the implications of changing environmental baselines or the impact of changing environment on the project. The presence of attention to climate change impacts and adaptation within these mining EAs was limited and inadequate, with inconsistencies and un-systematic approaches to addressing the risks. Data availability, data quality, climate science expertise, uncertainty in model results and differing regional expectations were noted as challenges within EA development. The manner in which climate change adaptation was considered and applied throughout the selected EAs appeared to be largely focused on enhancing the resiliency of mine site infrastructure, predominately for operational periods, and seldom as part of closure and post-closure phases.

The reliance on adaptive management, contingency planning and emergency planning as a means of managing future weather- and climate risks was apparent in all six EAs. Although adaptive management is encouraged in the context of climate change, specifically as a means of continuously evaluating weather and climate risks and measures used to manage them, utilizing specific climate information and conducting risk assessments comprises significantly more robust methods of climate change risk management.

In addition, and supplemental to, environmental impact assessments, modification of existing regulatory tools such as licensing, zoning, permitting may be one way to generate additional attention to
climate change risks. These compliance-related processes afford a degree of clarity for mine proponents, and evaluation of uptake and enforcement for regulators.

Though Canada is considered to be an international leader in the consideration of climate change within EAs, this analysis highlights some of the deficiencies and challenges on addressing climate change impacts and adaptation within the EA process. Stemming from the analysis, we identified numerous recommendations and several “next steps” to advance recognition of climate change risks in EAs and for the mining sector as a whole. This information can help to build on existing regulation, guidance and support to encourage still greater climate change impact and adaptation consideration in decision-making among EA practitioners.
Appendix A – Report on Environmental Guidance Within Canada
(Report attached)

Appendix B – List of Completed Mining EAs

All “full” completed mining project EAs identified in phases I and II of the selection process described in Section 3. The six (6) projects which were subject to detailed analysis are in **bold italic**.

**Table B: All “Full” Mining Projects Identified in EA Search**

<table>
<thead>
<tr>
<th>Project Title</th>
<th>EA Completion Date</th>
<th>Province/Territory</th>
<th>Type of Mining</th>
<th>Length of Project (operational period)</th>
<th>GHG mitigation discussed?</th>
<th>1+ climate change adaptation decisions?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joslyn North Mine Project</td>
<td>2006</td>
<td>AB</td>
<td>Oil sands, surface mine</td>
<td>20 years</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Kearl Oil Sands Project</td>
<td>27-Feb-07</td>
<td>AB</td>
<td>Oil sands, surface mine</td>
<td>50 years</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Muskeg River Mine</td>
<td>12-Dec-06</td>
<td>AB</td>
<td>Oil sands, surface mine expansion</td>
<td>~20-25 years</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Brule Mine Project</td>
<td>09-Jun-06</td>
<td>BC</td>
<td>Coal, open pit</td>
<td>11 years</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Galore Creek Project</td>
<td>Feb-07</td>
<td>BC</td>
<td>Copper/Gold/Silver, open pit</td>
<td>25 years</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hermann Mine Project</td>
<td>10-Oct-08</td>
<td>BC</td>
<td>Coal, open pit</td>
<td>10 years</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Mt Milligan Project</td>
<td>25-Feb-09</td>
<td>BC</td>
<td>Copper &amp; Gold, open pit</td>
<td>15.3 years</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Red Chris Porphyry Project</td>
<td>22-Jul-05</td>
<td>BC</td>
<td>Copper &amp; Gold</td>
<td>25 years</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ruby Creek Project</td>
<td>25-Jul-07</td>
<td>BC</td>
<td>Molybdenum, open pit</td>
<td>22 years</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wolverine (Coal) Project</td>
<td>13-Dec-04</td>
<td>BC</td>
<td>Coal, open pit</td>
<td>11 years</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Project</td>
<td>Date of Planning</td>
<td>Province</td>
<td>Commodity</td>
<td>Life Span (Years)</td>
<td>Climate Change Impacts</td>
<td>Adaptation Actions</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------</td>
<td>----------</td>
<td>--------------------</td>
<td>-------------------</td>
<td>------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Hay Point Peat Mine Development</td>
<td>October, 2011</td>
<td>MB</td>
<td>peat</td>
<td>45</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Touquoy Gold Project</td>
<td>Nov-07</td>
<td>NS</td>
<td>gold</td>
<td>5 to 7</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Donkin Export Coking Coal Project</td>
<td>Jul-12</td>
<td>NS</td>
<td>coal</td>
<td>n/a (Full production to begin 2017)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Meadowbank Gold Project</td>
<td>05-Nov-11</td>
<td>NU</td>
<td>gold</td>
<td>8 to 10</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mary River Project</td>
<td>Feb-12</td>
<td>NU</td>
<td>iron</td>
<td>21</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Detour Lake Gold Mine</td>
<td>Nov-11</td>
<td>ON</td>
<td>gold, open pit</td>
<td>16</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Victor Diamond Mine</td>
<td>2004</td>
<td>ON</td>
<td>diamond</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Projet minier aurifère Canadian Malartic (Canadian Malartic Gold Mine Project)</td>
<td>Aug-08</td>
<td>PQ</td>
<td>gold</td>
<td>14.3</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Golden Heart Mine Project</td>
<td>29-Aug-11</td>
<td>SK</td>
<td>gold, underground &amp; open pit</td>
<td>4</td>
<td>Yes</td>
<td>(Discussed but &quot;no action&quot; decided)</td>
</tr>
<tr>
<td>Jansen Project</td>
<td>Dec-10</td>
<td>SK</td>
<td>potash, underground</td>
<td>70</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>The Legacy Project</td>
<td>Aug-10</td>
<td>SK</td>
<td>potash</td>
<td>40 to 100 years</td>
<td>Yes</td>
<td>(Discussed but &quot;no action&quot; decided)</td>
</tr>
<tr>
<td>Yukon Zinc Wolverine Project</td>
<td>01-Oct-05</td>
<td>YT</td>
<td>Lead, zinc &amp; copper</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bellekeno Mine</td>
<td>2009</td>
<td>YT</td>
<td>mineral mine</td>
<td>5.5</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Appendix C – Descriptive Analysis Spreadsheet

(Spreadsheet attached)

Appendix D – Analytical Framework for Critical Analysis

(Spreadsheet attached)

Appendix E – Examples of Adaptation from 6 Mining EAs

<table>
<thead>
<tr>
<th>Adaptation Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Change Analyses for Decision Making</td>
<td>• Consultation of climate change model projections (Joslyn North, Jansen, Galore Creek, Mary River)</td>
</tr>
<tr>
<td></td>
<td>• Analysis of historical climate data to determine direction and magnitude of recent trends (Victor, Galore Creek)</td>
</tr>
<tr>
<td></td>
<td>• Comparison of climate model “backcasted” values to historical climate data (Mary River)</td>
</tr>
<tr>
<td></td>
<td>• Comparison of recent historical trends with climate change model projections (Galore Creek)</td>
</tr>
<tr>
<td>Engineering Actions</td>
<td>• Systematic identification of specific climate vulnerabilities for engineering design elements and components conducted during the planning stages of the mine (Jansen, Mary River)</td>
</tr>
<tr>
<td></td>
<td>• Flexible/Adaptive engineering: design facilities and infrastructure to allow for expansion or modification if and when changes occur; design of tailings ponds containment areas to accept additional berms in case of greater future precipitation (Joslyn North)</td>
</tr>
<tr>
<td></td>
<td>• Robust engineering: design structures for higher loads or longer return period events (e.g. floods) for greater resilience, load bearing capacity; design of tailings containment area using 1/1,000 year or “PMP” flooding event (Joslyn North, Jansen); increasing safety margin for bridges to prevent mine waste spills and other transportation accidents using 1/200 rather than 1/100 year flooding event (Galore Creek; Jansen); design drainage systems to prevent erosion due to increases in precipitation (Joslyn North); design or placement of foundations and footings to allow for increased active layer depth changes (Mary River); design port infrastructure to allow for changes in sea level (Mary River)</td>
</tr>
<tr>
<td></td>
<td>• Strengthening or modification measures to extend the operational season length of climate sensitive: seasonal elements or structures; rig mats for winter road water crossings (Victor), conversion of winter roads to all season roads (Mary River)</td>
</tr>
<tr>
<td></td>
<td>• Design alternatives: choice of alternative which are less sensitive to climatic hazards; slurry pipeline selected as alternative to surface</td>
</tr>
</tbody>
</table>
transformation due to reduced sensitivity to climatic hazards for roads and vehicles (Galore Creek)

- Identification and consideration of 3rd party infrastructure: analyses to include considerations of infrastructure external to mine site which may affect mine operations; identification of transportation, power and communication infrastructure which is both critical to mine operation and sensitive to climatic hazards (Jansen)
- Building redundancy into mine operations: Construction of all-season airstrip and all-season access roads to mine site, and adjusted maintenance and construction of winter roads to ensure transportation opportunities during all seasons (Victor)

<table>
<thead>
<tr>
<th>Monitoring Activities</th>
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</thead>
<tbody>
<tr>
<td>Ongoing/specialized monitoring of climate elements with known sensitivities to climate change: glacial retreat monitoring (Galore Creek)</td>
</tr>
<tr>
<td>Monitoring climate to determine accuracy of climate change projections/predictions (Joslyn North, Jansen)</td>
</tr>
<tr>
<td>Regular review of standards: using meteorological on-site monitoring data to track for changes in climatic elements, planning to respond to important changes through engineering and/or management actions when necessary (Galore Creek, Jansen)</td>
</tr>
<tr>
<td>Instrumented monitoring of mine infrastructure components: annual inspection of railway with “suspect” components being fitted with instruments for further monitoring (Mary River)</td>
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<table>
<thead>
<tr>
<th>Management Actions</th>
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<tbody>
<tr>
<td>Systematic identification of specific climate and weather vulnerabilities for operational activities: anticipating impact of sea ice extent and thickness on arctic shipping and developing response plan (Mary River)</td>
</tr>
<tr>
<td>On site storage of critical components: additional construction materials and equipment held on-site for rapid response to high impact climate and weather events (Jansen)</td>
</tr>
<tr>
<td>Optimization of seasonal activities: in recognition of potential changes to length of suitable conditions for certain types of operations; ice road construction optimized in anticipation of warming temperatures and shorter ice road seasons (Victor)</td>
</tr>
<tr>
<td>Use of emergency response procedures, equipment, employee training, sprinkler systems and foam fire suppression systems to reduce the risk of forest fire (Victor)</td>
</tr>
<tr>
<td>Emergency management and response planning for extreme weather events which take into account specific characteristic impacts of those hazards: blocked or lost transportation routes from bridge washouts due to flooding (Galore Creek); specific types of damage to equipment and buildings such as removal of building cladding due to high winds (Jansen); and determining corresponding response to these impacts, such as strategically located snow removal equipment to clear roads during heavy snowfall events (Jansen, Galore Creek)</td>
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<table>
<thead>
<tr>
<th>Additional Data Collection</th>
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</thead>
<tbody>
<tr>
<td>Continued on-site monitoring and archiving of climate and hydrological information (all mines)</td>
</tr>
<tr>
<td>Documentation of impacts and response: recording impacts from climate and weather events, response to these events, and effectiveness of response</td>
</tr>
<tr>
<td>Additional Study</td>
</tr>
<tr>
<td>------------------</td>
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Appendix F - Bibliography


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