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NUNAVUT REGIONAL ADAPTATION COLLABORATIVE (RAC)

Good Environmental Practices for Northern Mining and Necessary Infrastructure
Task 2 Report

Submitted to:
Government of Nunavut
Department of Economic Development and Transportation
Attention: Jared Fraser, GIS Specialist
Minerals & Petroleum Resources
P.O. Box 2420
Cambridge Bay, NU X0B 0C0
Tel: 867-983-4160
Fax: 867-983-4011
Email: jfraser2@gov.nu.ca

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REPORT

Executive Summary

Introduction

There is widespread evidence from research across the Arctic that climate is changing. Human activities such as resource extraction and associated developments are vulnerable to climate change, but there are knowledge gaps in the understanding potential implications con the mining sector. In response to these knowledge gaps, federal funding support was provided through Natural Resources Canada's Regional Adaptation Collaborative, the *Nunavut Regional Adaptation Collaborative* (RAC) to address these knowledge gaps. The RAC produced two reports. The first report entitled "Vulnerability Assessment of the Mining Sector to Climate Change, Task 1 Report" discussed:

- climate trends and climate forecast models for three communities in Nunavut;
- known impacts of development on permafrost;
- existing and proposed mining infrastructure components in Nunavut;
- vulnerabilities of mining infrastructure components to climate change;
- existing knowledge on adaptation measures to be implement in the planning of mining infrastructure; and
- the facilitation of a Vulnerability Assessment Workshop for key stakeolders.

The second report *Good Environmental Practices for Northern Mining and Necessary Infrastructure, Task 2 Report* is presented here. The Task 2 Report builds upon the results of the Task 1 Report, and focuses on best practices for mining infrastructure in Nunavut with respect to climate change adaptation. The following outline was followed in developing this Task 2 Report:

- describe the phases of the mining life cycle and where climate change and associated Adaption Measures should be considered;
- describe the environmental assessment process and the existing policies / regulations and as it pertains to the planning for mining projects in Nunavut with an emphasis on climate change;
- provide an overview of existing Good Environmental Practices as they relate to the phases of mine development in the North that could be most affected by climate change;
- develop a case study that documents considerations for implementation by stakeholders for planning and development of ports in Nunavut;
- develop a case study that documents considerations for implementation by stakeholders for planning and development of Tailings Management Facilities (TMFs) in Nunavut; and
- provide recommendations for Best Management Practices to address climate change adaptation in northern mining.

Mining Life Cycle

The mining life cycle includes the following phases: exploration and feasibility, planning and construction, operation, and closure.

The **exploration and feasibility** phase includes the identification and assessment of mineralized areas to determine if the development of a mine is economically feasible. Work involved in this phase includes reconnaissance, discovery and sampling work to define the quality and quantity of potential ore bodies, which usually involves developing small-scale mines to collect data. If the results of mineral exploration and feasibility assessments are favourable, and required permits and adequate permits are in place, project proponents may decide to proceed with mine development.

Planning aspects of the **planning and construction** phase of a mine includes scheduling of project components, environmental and social planning, carrying out environmental assessments, finalizing environmental and other permitting requirements, identifying site infrastructure requirements, determining mining and ore separation processes, and closure planning. The scope and complexity of construction varies with the type of mining project, but key activities typically involve site preparation (e.g., involves clearing / blasting / stripping overburden / grading the site), construction of mine infrastructure (e.g., transportation facilities such as roads and airstrips, ore handling / processing facilities, tailings disposal facilities, etc.), and establishing mine workings (e.g., provide access to ore body by drilling and blasting).

The **operation** phase of a mine includes the period of the lifecycle of a mine in which the mine extracts and processes ore to generate a product for market. The mining process produces ore, waste rock and waste water. Waste rock and waste water typically remain on site. Ore consists of minerals that are of value to the mining project, which exist in small amounts, and waste rock. Processing of ore is required to separate these components, and involves activities such as grinding and crushing, ore separation (through physical or chemical methods) and dewatering. The length of time that a mine may remain in operation ranges from years to decades, and may include periods of inactivity (i.e., periods when ore is not extracted and / or processed). A key activity of every operating mine is the transportation of supplies into the mine and transportation of ore or concentrate from the mine trough roads, railways and / or ports.

Mine closure occurs when ore minerals are exhausted or if it is no longer economically profitable for mining operations to continue. Closure can be temporary (“care and maintenance” status), which may occur during times of low commodity prices, and closure can be permanent, which occurs when ore reserves are depleted. Actives that occur in this phase of the mine lifecycle include monitoring / maintenance of the permafrost regime and TMFs.

Environmental Assessment Process

Resource development is an important component of economic activity in northern Canada. In Nunavut, land ownership and management as well as resource development (and associated activities) are administered by territorial government (e.g., Government of Nunavut), federal government (e.g., Environment Canada, Fisheries and Oceans Canada, Natural Resources Canada, Aboriginal Affairs and Northern Development Canada, Canadian Coast Guard, Canadian Environmental Assessment Agency, Canadian Northern Development Agency, Canadian Nuclear Safety Commission, Canadian Transportation Agency, Parks Canada, Transport Canada), land claims organizations and Institutions of Public Government (e.g., Nunavut Tunngavik Inc., Regional Inuit Associations, Nunavut Planning Commission, Nunavut Impact Review Board, Nunavut Water Board, Nunavut Wildlife Management Board, Surface Rights Tribunal). Additional stakeholders with an interest in mining development included intergovernmental agencies and organizations (e.g., Canada-Nunavut Geoscience Office, Mine Environment Neutral Drainage) and Non-governmental Organizations (NGOs; e.g., Canadian Aboriginal Minerals Association, the Mining Association of Canada, NWT and Nunavut Chamber of Mines, the Prospectors and Developers Association of Canada, MiningWatch Canada).

All Environmental Assessments (EAs) for proposed projects for development activities, including mining related projects, are reviewed by the Nunavut Impact Review Board (NIRB) to assess potential environmental and socio-economic impacts. If it is determined that there is a likelihood of environmental or socio-economic impacts, the NIRB issues project-specific guidelines for Environmental Impact Statements (EIS), which have to be completed by project proponents. The EIS is then reviewed by the NIRB to determine whether the mitigation measures to address the potential environmental and socio-economic impacts are adequate. **The EA process is the best opportunity to influence the planning and design of mines to incorporate climate change and build adaptive capacity.**

Existing Guidelines for Good Environmental Practices in Permafrost Regions

The following table summarizes existing Good Environmental Practices developed by Environment Canada as they relate to the different phases of mine development. This Report only emphasizes those practices that were designed for permafrost conditions and that could be implemented as measures to adapt to climate change. Other practices utilized in mine development, engineering design and assessment of environmental effects are discussed in the Task 1 Report.

Good Environmental Practice Considerations in Canadian Permafrost Regions
Exploration and Feasibility
■ Use of off-road vehicles in northern areas should be limited to low-ground pressure equipment to minimize potential impacts on permafrost.
■ Access to mining sites in permafrost areas should occur by aircraft whenever possible.
Planning and Construction
■ Implement an adequate water management strategy. Extreme weather events may increase as a result of climate change, therefore the conventional planning for 100 year flood events may not be considered adequate.
■ Implement the most efficient Acid Mine Drainage (AMD) control strategy for the site (freeze controlled, climate controlled, engineered cover, subaqueous disposal, collection and treatment, segregation and blending). Freezing waste rock and / or tailings in permafrost may be used to prevent or control acidic drainage if designed properly with sufficiently thick cover to permanently encapsulate acid generating waste in permafrost.
■ Planning for the use of permafrost as a method to prevent or control acidic drainage should include considerations such as **potential construction material thaw** in a future warmer climate and **alternative methods that do not depend on frozen materials** to prevent / control acidic drainage.

Good Environmental Practice Considerations in Canadian Permafrost Regions
■ Mine site geography / vegetation / natural features (e.g., eskers, rivers streams, lakes, ponds, pingos) must be considered in planning of all components. ■ When designing TMFs, site-specific conditions such as permafrost, slopes, seismic activity and site drainage requirements should be considered. ■ On-going monitoring of permafrost conditions is recommended. ■ Additionally, monitoring of conditions specific to the North, such as extreme climate (long cold winters / short summer), thin / sensitive vegetation cover, low precipitation / arid conditions, unstable bedrock conditions with thin / absent soil cover, and wildlife vulnerabilities is recommended.
Mine Operation
■ Implement and monitor AMD strategies designed for the site. ■ Subaqueous disposal is an effective disposal method because the submerged materials have reduced exposure to oxygen and subsequent oxidation reactions. ■ Decreased risk of acidic drainage decreases the risks of associated metal leaching.
Mine Closure
■ Downstream slopes TMFs should be revegetated (e.g., trough encouraging natural revegetation). ■ To establish permafrost conditions, TMFs should be capped and revegetated. ■ If capping cannot be completed, a permanent spillway may be required for a tailings impoundment with a pond to prevent dam overtopping and failure.

Case Study on Ports in Nunavut

The Steensby Port development of the proposed Baffinland Iron Mines Corp. Mary River Project was selected as a case study to examine the vulnerabilities of ports to climate change in the Arctic. These vulnerabilities include sea level rise, storm events and waves, sea ice, coastal erosion, permafrost degradation, and currents. Recommended components for Best Management Practices for ports in Nunavut are summarized in the following table for the identified impacts.

Impacts to Ports in Nunavut / Issues	Recommended Best Management Practices
Sea Level Rise	
■ Reduced top clearance between ships and overhead structures (e.g., bridges, loading facilities). ■ Increased elevation at which wave forces attack a structure,	■ Collect water level data at the site during the planning and design of the port infrastructure and maintain a water level recording station for the life of the project. ■ Adopt a design process for siting key port infrastructure that specifically adopts a strategy or a combination of strategies (e.g., avoid, accommodate,

Impacts to Ports in Nunavut / Issues	Recommended Best Management Practices
potentially increasing the vulnerability of the structure. ■ Increased exposure of dock decks. ■ Increased corrosion rate and the degradation over time of materials that were specifically designed for a particular range of sea level conditions. ■ More wave action / sea spray on navigational installations. ■ An increase in absolute low sea levels allowing greater under-keel clearance for vessels, possibly reducing the need for dredging in low sedimentation areas.	managed retreat, protect) to incorporate projected sea level rise. ■ Plan and design flood elevations and erosion protection using a quantitative risk assessment approach. Determine the highest risk sea level conditions which occur over the duration of the project design life. ■ Plan and design flood elevations and erosion protection to accommodate reasonable levels of climatic variability (e.g. the 1 in 200 year water level). For water levels this would include storm surge. ■ Plan and design the location of port facilities requiring adequate water depth (e.g., vessel draft) based on the lowest sea level conditions which occur over the duration of the project design life.
Storm Events and Waves	
■ Degradation of structures. ■ Increased wave run-up and salt spray impacting structures. ■ Loss of viable industrial land around ports. ■ Reduced regularity of port services (e.g., availability / use). ■ Permanent loss of offshore and onshore sediments (e.g., sand). ■ Retreat of coastal landscapes (i.e., erosion). ■ Reduced capacity of natural systems to recover.	■ Collect detailed bathymetry and topography during the planning and design phases of the project and update at regular intervals over the life of the project. ■ Collect wave data at the site during the planning and design phases of the project and monitor waves on a periodic basis over the life of the project. ■ Plan and design wave loading using a quantitative risk assessment approach to evaluate the combined events of anticipated storm regime, ice-free condition, and sea level condition occurring over the duration of the project design life which yields the greatest risk of wave exposure for the port facilities. ■ Plan and design flood elevations and erosion protection to accommodate reasonable levels of climatic variability in keeping with suitable design guidelines (e.g., the 1 in 200 year storm event or the highest total water level from waves and water levels with a combined probability equivalent to a 200 year return period). For waves and storm events this would include wind speed and direction leading to appropriate wave heights and periods, wave setup and wind setup. ■ Plan and design the port operations to accommodate both the anticipated

Impacts to Ports in Nunavut / Issues	Recommended Best Management Practices
	storm regime and waves which could occur over the design life of the project.
Sea Ice	
■ Reduced ice loading on support structures in the water (e.g., bridge piers, dock pilings). ■ Decrease the exposure of a port site to erosion by reducing wave exposure outside of the open-water season.	■ Collect ice thickness and duration data during the planning and design phases of the project. Monitor ice thickness and duration over the life of the project. ■ Plan and design the port facilities to accommodate the ice loading anticipated on the basis of historical data, unless design information is available which supports correlation of reduced ice loading over the design life of the project. ■ Plan and design the port operations to accommodate both the shortest anticipated open water season and longest anticipated open water season which occurs over the design life of the project.
Coastal Erosion	
■ Uncertainties in the future impacts of sea-level rise and storm activities make it difficult to predict coastal bluff erosion. ■ Ports located on erodible soils or soils subject to thaw. ■ Coastal permafrost stability and thaw subsidence can be impacted and result in coastal erosion.	■ Collect shore profile and sediment size data during the planning and design phases of the project. Monitor shore profiles and sediment sizes over the life of the project. ■ Review historical imagery (satellite and air photo) of the proposed site to document observable shoreline changes. Update surveys and imagery on a regular basis, approximately every 5 years, over the life of the project, to evaluate changes to the shoreline. ■ Identify and map the surficial and bedrock geology and collect detailed topography during the planning and design phases of the project. ■ Evaluate the sea level, storm and wave regime, ice regime, and permafrost regime for the site. ■ Plan and design the port facilities to accommodate the extent of coastal erosion anticipated on the basis of historical data unless design information is available which supports correlation of increased coastal erosion over the design life of the project.
Permafrost Degradation	
■ Near-shore thaw subsidence can contribute to increased erosion rates and ground level subsidence, which results in a	■ Collect subsurface profiles of temperature and ice content data during the planning and design phases of the project. Monitor these temperature profiles and ice content of the soils over the life of the project. These samples should be collected both on land and below the sea where feasible.

Impacts to Ports in Nunavut / Issues	Recommended Best Management Practices
decrease in coastal permafrost stability. ■ Docks can be vulnerable to warming and/or thawing coastal permafrost due to the reduced foundation strength of the docks and associated pilings.	■ Plan and design the port facilities to accommodate the potential changes to permafrost anticipated on the basis of historical data unless design information is available which supports predictions of permafrost degradation over the design life of the project.
Currents	
■ Littoral drift in the near-shore zone can be caused by currents or waves.	■ Collect current data during the planning and design phases of the project. Monitor currents over the life of the project. ■ Plan and design the port facilities to minimize impacts to currents within the littoral zone over the design life of the project. ■ Plan and design the port operations to accommodate potential changes to currents over the design life of the project.

Case Study on Tailings Management Facilities in Nunavut

Agnico-Eagle Mines Ltd.'s Meadowbank Project was selected as a case study to examine the vulnerabilities of TMFs in the Arctic to climate change. The vulnerabilities of northern TMFs to climate change include permafrost degradation, frost action and ice, precipitation and water, wind, and extreme weather events. Recommended components for Best Practices for TMFs in Nunavut are summarized in the following table for the identified impacts.

Impacts to TMFs in Nunavut / Issues	Recommended Best Management Practices
Permafrost Degradation	
■ Permafrost thaw can cause the settlement of structures. ■ Permafrost degradation beneath a dam in permafrost zones can result in both settlement and foundation instability. ■ Thawing and creep or slumping of slopes adjacent to dams can impact dam stability and impoundment performance.	■ Consider potential climate warming in thermal analyses for all components of TMFs. ■ The preferred approach to minimize potential impacts of climate change is to either design TMFs with unfrozen embankments or design embankments that are thaw-stable. ■ Dams on permafrost should be constructed on bedrock or thaw-stable (with minimal ice content) foundations and incorporate traditional seepage control measures such as geomembrane liner or bedrock foundation grouting, so that dam performance is not impacted by future permafrost degradation. Removal of ice rich foundation soils is also recommended to reduce the

Impacts to TMFs in Nunavut / Issues	Recommended Best Management Practices
■ Thawing of permafrost can increase pore water pressure in dams and increase seepage from a tailings impoundment. ■ Thawing of frozen core dams or a dam foundation can increase seepage through a dam and increase the potential for piping. ■ Landslides can occur as a result of permafrost thaw on slopes around a tailings pond.	potential for thaw-related settlement. ■ The use of frozen core dams is not recommended at sites with discontinuous permafrost or where climate change may result in the disappearance of permafrost. Furthermore, reliance on frozen conditions is not recommended in areas with warm permafrost conditions (i.e., ground temperatures above -5°C) or where ground temperatures are expected to increase to near or above 0°C due to climate change. ■ Consider increased thaw depth (e.g., active layer thickness) due to climate change in tailings cover and dam design over the long-term (i.e., post-closure). Both the potential for changes in hydraulic conductivity (e.g., increased seepage) and changes in soil strength properties (e.g., slope instability) should be considered. ■ Thermistors (i.e., ground temperature sensors) should be used to monitor temperature changes in permafrost, frozen core dams, and/or dam foundations. ■ Piezometers can be used to monitor pore water pressure and provide advance warning of related slope instability and/or increased seepage beneath and dam. ■ Survey monuments should be established on dam structures and monitored to identify thaw settlement and/or slope creep. Regular surveys should be conducted.
Frost Action and Ice	
■ Repetitive freeze-thaw action can split soil particles, change the soil structure, increase hydraulic conductivity of dam materials and impact performance or lead to dam failure. ■ Repetitive freeze-thaw of foundation and dam fill materials can result in cracks in dams and impact performance or lead to dam failure. ■ Repetitive freeze-thaw and ice lens development can result in consolidation of tailings and may	■ Climatic (e.g., temperature) and geotechnical (e.g., soil material properties) parameters that affect frost action should be considered when planning TMF structures (such as dams) in order to minimize damage due to frost heave, thaw creep, thaw settlement and other ice-related processes. ■ Installation of thermosyphons, air ducts or convention cooling systems can be considered to maintain freezing ground temperatures to mitigate frost heave and thaw settlement. ■ Provide increased thickness of exposed low-permeability soil elements and/or frost protection to maintain design function with increased active layer thaw and related freeze-thaw effects (e.g., increase till thickness so that the active layer remains above the impounded water level). ■ The entrapment of ice into tailings can be minimized by dewatering tailings prior to deposition, effective beach management and employing appropriate

Impacts to TMFs in Nunavut / Issues	Recommended Best Management Practices
decrease hydraulic conductivity of tailings. ■ Tailings impoundments may not be able to reclaim water if it becomes frozen and permanently entrapped as ice.	operational strategies to reduce ice entrapment (e.g., developing a detailed deposition plan).
Precipitation and Water	
■ Precipitation events increase water flow into a tailings impoundment area, potentially causing overtopping of dams and / or water covered tailings impoundments. ■ Storm events can result in increased water flow into an impoundment and erosion at spillway outlets. ■ Precipitation can cause erosion of exposed tailings surfaces or dam slopes with insufficient erosion protection.	■ Design water retaining dams with conservative assumptions regarding maximum water levels and extreme storm events resulting in increased dam crest elevations. ■ Consider the use of clean water diversion channels to reduce storm inflows to a tailings impoundment and prevent the overtopping of dams and erosion during heavy rainfall events. ■ Spillways and outflow channels should be adequately sized to pass storm flows and, if possible, excavated into bedrock so they are not suspectible to erosion.
Wind	
■ Wind erosion at TMFs can lead to dusting and migration of tailings particles from the impoundment. ■ Dusting and migration of tailings during operations is a potential risk if tailings are allowed to dry prior to discharge of a subsequent layer of tailings. ■ Wave action from wind can cause erosion of upstream dam slopes with inadequate erosion protection and even overtopping of the dams.	■ Planning and design of TMFs should account for potential wind impacts (e.g., dusting, erosion and wave action) and include Adaptation Measures to deal with increased wind speeds. ■ Provide tailings cover to prevent tailings erosion due to wind (e.g., rockfill cover). ■ On-site wind monitoring equipment can aid in establishing trends and observing changes in wind pattern.

Impacts to TMFs in Nunavut / Issues	Recommended Best Management Practices
■ Wave action can cause turbulence in a tailings water cover, which increases the oxygen concentration, re-suspends tailings particles, and allows oxidation of sulphide tailings.	
Extreme Weather Events	
■ Extreme storm events (e.g., flooding) can exceed the discharge capacity of an impoundment spillway and result in dam overtopping and possibly dam failure. ■ Extreme precipitation events, including flooding, could cause increased erosion in drainage ditches and / or increased water levels in tailings impoundments	■ TMFs should be designed to withstand more frequent and intense storm events. ■ Design adaptations may include a larger spillway capable of passing larger storm flows and higher dam crests so that tailings impoundments can store increased precipitation volumes from more intense storm events.

In addition to the above recommended practices, it is suggested that a risk assessment be completed and undertake precautionary actions to reduce identified risks, including the incorporation of the required Adaptation Measures.

<u>Recommendations for Guidance and Standards Related to Engineering and Mine Operations</u>

The published guidance materials including the current Environmental Good Practices documented by Environment Canada do not identify all of the Adaption Measures that are outlined in the Task 1 Report. These practices were developed for all of Canada and with no specific focus on climate change or the Arctic environment. Some of the commenting agencies in the Environmental Assessment process have stated climate change goals and the effects of climate change may impact their respective regulatory mandates (Task 1 Report). However, there is no single process that identifies all of the climate change risks.

Despite the lack of formal guidance, the case studies examined in this Report are good examples of how climate change and Adaptation Measures can be incorporated in a project and documented. The Best Practices identified in the case studies along with Adaptation Measures identified in the Task 1 Report should be formalized in guidance documents produced by NIRB.

Additionally, as part of the Environmental Assessment process, a risk assessment should be conducted to document that the climate change vulnerabilities have been identified and the appropriate Adaptation Measures or monitoring programs are planned. A number of risked-based screening tools or assessment protocols have been developed. A documented risk assessment framework should be developed so that developers can demonstrate that they have incorporated climate variability and change into their project proposals that can be used by the NIRB and the commenting agencies.

Plain Language Summary

Past studies have shown that the climate in the Canadian Arctic is changing. This *Regional Adaptation Collaborative (RAC): Good Environmental Practices for Northern Mining and Necessary Infrastructure Task 2 Report* was completed to complement the report *RAC: Vulnerability Assessment of the Mining Sector to Climate Change Task 1 Report*. The Task 1 Report described how changes in the climate can affect infrastructure in Nunavut, in particular infrastructure used in the mining sector such as: roads, airstrips, railways, ports and tailings management facilities (TMFs). The Task 2 Report builds on the results of the Task 1 Report by:

1) describing existing policies / regulations and the environmental assessment process as it pertains to the planning for mining projects in Nunavut with an emphasis on climate change;
2) providing an overview of existing Good Environmental Practices as they relate to the lifecycle phases of mine development in the North and climate change;
3) developing a case study that documents considerations for implementation by stakeholders for Best Management Practices in planning and development of ports in Nunavut;
4) developing a case study that documents considerations for implementation by stakeholders for Best Management Practices in planning and development of Tailings Management Facilities in Nunavut; and
5) developing a framework of recommended to Best Management Practices and associated policy action.

Resource development is an important component of economic activity in northern Canada and climate change can have a negative impact on mining activities. In Nunavut, regulators in federal government, territorial government and Aboriginal government, with some participation by non-governmental organizations (NGOs), determine the standards / conditions by which industry proceeds with resource development activities throughout the lifecycle of a mine. Potential environmental and socio-economic impacts of development activities in Nunavut (including mining) are considered in the environmental assessment (EA) process. If there is a likelihood that a project has negative impacts on the environment or the people, developers have to prepare an Environmental Impact Statement (EIS) according to guidelines established by regulators (namely the Nunavut Impact Review Board). Through the EA process, regulators have an opportunity to influence the planning and design of mines to incorporate climate change and build adaptive capacity.

Good Environmental Practices must be considered throughout resource development. The mining life cycle includes the phases of exploration and feasibility, planning and construction, operation, and closure. Current Good Environmental Practices provide recommended methods for mining project proponents to minimize the impact of those activities on the environment. However, existing guidelines and recommendations were developed for all of Canada and only few recommendations apply to Arctic permafrost conditions and don’t always consider climate change trends. The Task 1 Report identified many Adaptation Measures that are applicable to mining and large infrastructure that are not included in these Environmental Good Practices and should be considered by regulators and stakeholders in the Environmental Assessment process.

As a start to bridge this gap, this Task 2 Report identifies Best Management Practices for ports and tailings management facilities in Nunavut implementing climate change considerations. The chosen development projects are the Steensby Port (of Baffinland Iron Mine Corp.'s Mary River Project), tailings management facilities (TMFs) utilized at Agnico-Eagle Mines Ltd.'s Meadowbank gold mine.

Port developments in Nunavut are likely vulnerable to climate change which is expected to result in local sea level changes, increased storm events and waves, changes in sea ice conditions, areas of increased coastal erosion, permafrost degradation (including coastal permafrost) and shifts in currents. Adaptation measures implemented into the planning, construction and operations aspects of port developments should be incorporated to determine where and how to proceed with construction. Collecting local site-specific data and long-term monitoring is necessary to ensure that a port will be safe for workers, is able to operate throughout the lifetime of the project and does not pose risks to the environment. This will include construction of port infrastructure that can withstand and accommodate flooding and storm surges, does not get exposed to coastal erosion or permafrost thaw, and is not threatened by changes in ice cover or currents.

TMFs in Nunavut are vulnerable to a changing climate that can result in permafrost degradation, changes in frost action and ice, changes in precipitation and wind, and increased occurrences extreme weather events. The preferred approach to minimize potential impacts of climate change is to either design TMFs that depend on unfrozen ground or develop TMFs that are not sensitive to permafrost thawing. If TMFs are built on permafrost, it is recommended that they are built on bedrock or thaw-stable soils (i.e., soils that contain minimal amounts of ice). It is also recommended that soils with high amounts of ice are removed prior to construction to reduce the effect of permafrost thawing. It is recommended to build TMFs that can accommodate an increase in water capacity and / or divert water to minimize erosion. An important aspect is to control Acid Mine Drainage (AMD) also called Acid Rock Drainage (ARD) which is the outflow of acidic water from (usually abandoned) metal mines. There are a variety of proven control strategies ranging from using existing permafrost to freeze tailings and waste rock, to engineered TMF covers or disposal into water (to avoid contact between tailings and air). It is crucial to find the right strategy that will work at each specific site. Detailed site investigations and long-term monitoring are needed to determine which strategy might work.

It is suggested to assess all risks to mining infrastructure and undertake precautionary actions to reduce those risks, including the incorporation of measures to adapt infrastructure to changes in climate over time. The most efficient way to demonstrate that the appropriate Adaptation Measures and Best Practices are planned is through a climate change vulnerability risk assessment included with the Environmental Assessment for the project. A documented risk assessment framework is needed so that developers can demonstrate that they have incorporated climate variability and change into their project proposals that can be easily used by the NIRB and the commenting agencies.

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1.0 INTRODUCTION

There is widespread scientific evidence that the climate is changing and that human emissions are contributing to it (Intergovernmental Panel on Climate Change [IPCC] 2007). Worldwide, research is underway to understand climate change implications for human activities, including resource extraction and associated developments.

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program and as a start to address this gap in our knowledge, the Nunavut *Regional Adaptation Collaborative* (RAC) prepared a Report that identifies and describes the vulnerability of the Nunavut mining sector to climate change. This Report "Vulnerability Assessment of the Mining Sector to Climate Change, Task 1 Report" dated March 2012 provides a general overview of climate change and specifically:

- identifies current design considerations for infrastructure, with a focus on roads, airstrips, railways, ports and tailings management facilities as these design elements are common to most mining activities;
- describes areas of potential vulnerability and provides Adaptation Measures to build adaptive capacity for these infrastructure elements; and
- recommends areas for further assessment and research.

As part of the development of this Report a Vulnerability Assessment Workshop was held in Iqaluit and involved the participation of 16 representatives from the mining sector, territorial and federal government agencies and other involved organizations. The purpose of the workshop was to engage the stakeholders and obtain necessary feedback to identify the primary areas of concern with regards to climate change and mining infrastructure. Workshop participants assessed tailings management facilities as the most important infrastructure, followed by port infrastructure.

The mining sector is particularly vulnerable to climate change because associated development activities depend on the natural environment (Arctic North Consulting 2009). In addition, impacts of year-to-year climate variability can often be as important as the effects of longer-term climate change depending on the project component. It is acknowledged that climate variability and extremes are often the main aspect of climate that is important to consider in the development of mining projects. Similar to climate change, there can be a high degree of uncertainty in predictions of climate variability. While this Report addresses the impacts and potential adaptation measures to climate change, it is important to point out that climate variability is an equally critical consideration, in particular for more sort-term projects.

The potential vulnerability of these activities to climate change has regional significance because of their dominant economic role they play on a regional basis (*e.g.,* creation of training and employment opportunities and infrastructure development). Given this significance and the challenges that a changing climate will present for the planning, design and operation of mining infrastructure; a further mining specific assessment is required with a specific emphasis on the two priorities identified by the workshop.

Therefore, this Task 2 Report builds on the findings and recommendations of the first Report and will:

- outline the phases of the mining life cycle;
- describe Environmental Assessment process and existing policies / regulations as it pertains to the planning for mining projects in Nunavut with an emphasis on climate change;
- provide an overview of existing Best Practices as they relate to the phases of mine development in the North that could be most effected by climate change in the planning process;
- develop a case study that documents considerations for implementation by stakeholders for planning and development of ports in Nunavut;
- develop a case study that documents considerations for implementation by stakeholders for planning and development of Tailings Management Facilities in Nunavut; and
- outline a suite of Best Practices for Adaptation Measurs and associated recommended policy action to incorporate these in the Environmental Assessment process.

2.0 MINING OVERVIEW

There are a variety of closed and proposed (and one operating) precious metal, base metal and diamond mines in Nunavut. Additionally, there are uranium-related activities recorded for several areas of the territory. This section is intended to provide a brief overview of key sites of mining interest in Nunavut.

Note: A more detailed descriptions of the mining operations and associated infrastructure is provided in the Task 1 Report.

2.1 Past Mining Operations in Nunavut

The CanZinco Ltd.-owned Nanisivik zinc-lead mine, 35 km east of Arctic Bay, operated on Baffin Island from 1977 until 2002. The Nanisivik mine produced 516,544 tonnes (t) of ore, consisting of 10% zinc and 0.004% silver. Wolfden Resources purchased the mine in 2003 and agreed to reclaim the area. Reclamation was completed in 2006 (Nunavut Geoscience 2009).

North Rankin Nickel Mines Ltd. produced nickel and copper between 1957 and 1962 at the North Rankin Nickel mine. The site is located on the north-west coast of Hudson Bay. It was remediated between 1994 and 1995. The mine produced 9,690 t of nickel and 2,640 t of copper (Meldrum *et al*. 1999).

Between 1982 and 2002, the Cominco Ltd.-owned Polaris Mine on Little Cornwallis Island produced lead and zinc. The ore body was discovered in 1971 (Macey *et al*. 2007). Decommissioning and reclamation of the site began in 2002 and was completed in 2004 (Natural Resources Canada [NRCan] 2011a).

The Lupin underground gold mine in south-west Nunavut was operated by Echo Bay Mines Ltd. from 1982 until 2003. In 2003, the mine was purchased by Kinross Gold Corporation which continued production until closing the mine in 2005. The mining company Minerals and Metals Group (MMG) is the current owner of the mine, which is currently in care and maintenance status (Nuna Logistics 2010).

The Jericho diamond mine, 420 km north-east of Yellowknife, opened in 2006 and suspended production in 2008 (Canadian Broadcasting Corporation [CBC] News 2010). The Jericho mine produced over 780,000 carats of diamonds before halting operation. The mine was purchased from Tahera Diamond Corp by Shear Minerals Ltd. in 2010 (Shear Minerals 2010).

2.2 Current Exploration and Mining Proposals in Nunavut

<u>Diamonds</u>

A number of mining companies are in exploration and development stages for diamonds in Nunavut (Intierra Mapping 2010; NWT & Nunavut Chamber of Mines 2011). They include:

- Diamonds North Resources Ltd. (Diamonds North Resources 2010):
  - Amaruk project, 120 km south of Kugaaruk;
  - Sakari project, joint venture with Shear Minerals Ltd., 175 km south-west of Kugaaruk;
  - Siku project, joint venture with Arctic Star Diamond Corporation, 145 km south-west of Kugaaruk; and
  - Ualliq project, joint venture with International Samuel Corporation, 25 km west of Kugaaruk.

- Indicator Minerals Inc. (Indicator):
  - Nanuq North project, 300 km north-east of Baker Lake, partially owned by Peregrine Diamonds Ltd. and Hunter Exploration Group;
  - Grail project, 250 km north-west of Kugaaruk on the Boothia Peninsula; and
  - Borden project, 80 km south-east of Arctic Bay on the Borden Peninsula of north-west Baffin Island (Indicator 2011).
- Peregrine Diamonds Ltd. (Peregrine):
  - Chidliak project, 120 km north-east of Iqaluit, on Baffin Island;
  - Qilaq project, borders Chidliak to the north, east and south, on Baffin Island;
  - Cumberland project, 80 km east of Pangnirtung, on Baffin Island, partially owned by Indicator; and
  - Nanuq project, 300 km north north-east of Rankin Inlet, partially owned by Indicator (Peregrine 2011).
- Stornoway Diamond Corporation (Stornoway):
  - Arviat project, joint venture with Hunter Exploration Group, 120 km west of Igloolik on the Melville Peninsula;
  - Churchill project, joint venture with Shear Minerals Ltd, 40 km north of Rankin Inlet;
  - Coronation Diamond District, nine different properties approximately 50 km south south-west of Kugluktuk in western Nunavut;
  - Itza Lake project, joint venture with Bayswater Uranium Corporation, 100 km north-west of Baker Lake; and
  - Qilalugaq project, 10 km north of Repulse Bay (Stornoway 2011).

Gold

Agnico-Eagle Mines Ltd.'s Meadowbank Mine is the only mine that is currently operating in Nunavut (Nunavut Geoscience 2011; NWT & Nunavut Chamber of Mines 2011). Located 75 kilometres (km) north of Baker Lake, construction of the gold mine began in 2008 and operations commenced in early 2010. Extraction will take place in three open pits, beginning with current extraction operations in the Portage pit, to be followed by the Goose Island pit and Vault pit, with operations expected to continue until 2019 (Nunavut Geoscience 2011; Agnico-Eagle Mines Ltd. 2010). Gold mining projects currently in the exploration and development stages include (Intierra Mapping 2010):

- the Newmont Mining Corporation-owned Hope Bay area, 130 km south of Cambridge Bay (recently halted as described in Task 1 Report; CBC News 2012);
- the Committee Bay Resources Gold Corporation-owned Committee Bay area, 300 km north-west of Baker Lake; and

- the Sabina Gold and Silver Corporation-owned Hackett and Back rivers areas, 104 km south south-west of Bathurst Inlet and 372 km south-east of Cambridge Bay.

Uranium

Although there are currently no uranium mines in Nunavut, as of 2009 there were 45 uranium exploration ventures in Nunavut (Nunavut Geoscience 2010). Of the 45 projects, four are in the Qikiqtaaluk region, 30 in the Kivalliq region, and 11 in the Kitikmeot region of Nunavut.

AREVA Resources Canada Inc. (AREVA) has submitted a project proposal and a draft Environmental Impact Statement (EIS) for milling and mining operations on its two properties, Kiggavik and Sissons (collectively called the Kiggavik Project) approximately 80 km west of Baker Lake; it is the first uranium mine to start the environmental assessment process in Nunavut (AREVA 2011; AREVA 2008).

Note – Discussion of the Kiggavik Project in this Report and the Task 1 Report is mainly based upon the Project Proposal. The draft EIS was submitted in December 2011, after the submission of the Task 1 and Task 2 Draft Reports. Throughout this Report, references are made to the Project Proposal (AREVA 2008) and only if development plans have changed, the changes are described and the Draft EIS (AREVA 2011) is cited.

Other Minerals

The Hackett and Back rivers locations also hold silver, lead, copper and zinc deposits. MMG Resources is continuing exploration at the High Lake and Izok Lake areas, 245 km south-east of Kugluktuk, for silver, lead, copper and zinc (Quenneville 2010).

The Baffinland Iron Mines Corp. (Baffinland)-owned Mary River iron ore project 160 km south of Pond Inlet on Baffin Island is currently under development review by the NIRB (NIRB 2008a).

Note – The Draft EIS for the Mary River project was submitted in December 2010 (Knight Piesold Consulting Ltd. [Knight Piesold] 2010), and the final EIS (Baffinland 2012) for the project was submitted in February 2012, after the submission of the Task 1 and Task 2 Draft Reports. Throughout this Report, references are made to the Draft EIS and only if development plans have changed, the changes are described and the final EIS is cited.

2.3 Mining Life Cycle

This section is providing an overview of the entire life cycle of a mine from exploration to closure and perpetual care. The life cycle of metal mines in Canada typically involves the following phases (Environment Canada [EC] 2012a):

- exploration and feasibility;
- planning and construction;
- operation; and
- closure.

2.3.1 Exploration and Feasibility

Exploration work and feasibility assessments are carried out to identify and assess mineralized areas and determine whether it is economically feasible to advance towards mine production (EC 2012a).

Initial Exploration

Initial exploration work is conducted to identify and assess mineralized areas. This indicates whether further exploration work is warranted. A variety of methods are employed to conduct initial exploration work, including the following (EC 2012a):

- geophysical surveys (e.g., magnetic, electromagnetic, electrical, radiometric, gravity techniques; can be done from air or ground) - provide data on potential targets for future ground-based exploration;
- prospecting and geological mapping (e.g., mapping / sampling identified targets, regional-scale / detailed mapping of areas of interest) – enables initial assessment of mineralization potential over large area;
- geochemical surveys (e.g., sampling rocks / soil; sending samples for chemical analysis) – analytical results compared to results of other exploration methods;
- diamond drilling - rock cores drilled to develop a three-dimensional picture of local geology; core samples may be sent for chemical analysis; and / or
- trenching (e.g., trenches dug or vegetation stripped off outcrops) – done to map near-surface geology and for bulk sampling of near-surface ore and other geological units.

These types of reconnaissance, discovery and sampling work identify the locations of mineral anomalies that may be of interest for further assessment during advanced exploration (EC 2012a).

Advanced Exploration

Advanced exploration work is carried out in areas where initial results indicated that further exploration work is warranted. It assesses the identified potential mineral reserve (EC 2012a).

Advanced exploration aims to define the quality and quantity (including geometry) of potential ore bodies. This stage of exploration work may include developing small-scale underground mines or open pit mines to collect data. It can involve the bulk sampling of larger volumes of ore to determine rock quality, mineralogy and geochemistry, and often also involves extensive diamond drilling to determine the mineral deposit's geometry, quantity and characteristics, and to delineate the potential ore body (EC 2012a).

Information collected on the quantity and quality of the potential ore determines whether work will proceed to a feasibility study. At this time, considerations are also given to appropriate mining and processing methods for the potential future mine. Preliminary plans for the mine layout and ore processing designs may be drafted, and the development and operational costs of the mine may be estimated (EC 2012a).

Feasibility Studies

The feasibility assessment of a potential mine site determines if its development is viable. Assessment studies include considerations of technical, legal and, economic feasibility (e.g., assessing the mineral reserve and investment returns). Safety, economics, practicality and environmental issues are taken into account when establishing appropriate mining methods for a site (EC 2012a).

If mineral exploration targets are proven to be economically feasible and adequate funding and necessary permits are in place, the targets proceed towards production. Final site planning and engineering studies are required to prepare for mine construction (EC 2012a).

2.3.2 Planning and Construction

Planning

The planning phase of a mine may overlap with feasibility studies. Planning addresses all aspects of a mine's development in detail. This includes scheduling project components, environmental and social planning, carrying out environmental assessments, finalizing Environmental Assessment and other permitting requirements, identifying site infrastructure requirements, determining mining and ore separation processes, and closure planning (EC 2012a).

Construction

Mine construction involves developing underground or open pit (also known as surface) mine workings to provide direct access to the ore body. Ore processing facilities, waste management areas and site infrastructure are also developed. The scope and complexity of construction varies with the type of mining project, but key activities typically involve site preparation, mine infrastructure construction, and establishing mine workings. These activities include (EC 2012a):

- site preparation – involves clearing / blasting / stripping overburden (overburden may be stockpiled for reclamation purposes) / grading the site;
- mine infrastructure construction – developing most on-site facilities and utilities such as:
  - transportation facilities (e.g., access roads, on-site roads, airstrips, rail lines, port facilities);
  - ore handling / processing facilities;
  - tailings disposal facilities;
  - water management / wastewater treatment systems;
  - power infrastructure (e.g., generation facilities, power distribution systems);
  - shops / offices / warehouses / accommodations;
  - fuel supply / storage facilities;
  - vehicle storage / maintenance facilities;
  - explosives storage facilities;
  - water supply systems (e.g., potable water treatment / distribution systems); and
  - sewage / waste disposal facilities (e.g., incinerators / landfills / land farms);
- establishing mine workings – provide direct access to the ore body through underground (for deeper or irregular shaped ore bodies) or open pit mine workings (for near-surface ore bodies); drilling and blasting result in mostly waste rock, but ore is stockpiled for later processing; and

- may include limited ore production to test ore handling and processing facilities.

2.3.3 Mine Operations

Mine operations include the time that a mine produces (i.e., extracts) and processes ore to generate a product for market. Mine operations may continue for years or even decades but can involve periods of inactivity (EC 2012a).

During mine operations, the mining process itself produces ore and waste rock. The waste rock typically goes into a waste rock pile. Waste water also results from the mining process itself and from waste rock piles. The ore that is mined is then crushed and through a grinding process involving water or reagents (depending on the process), the ore is separated from the metal product. The tailings from the ore separation process are placed in a tailings management facility, which generates recycled water (for use in the grinding and ore separation processes) and waste water. The separated ore then goes through a concentrate dewatering process (which also results in waste water) and the ore concentrate can processed further (EC 2012a).

A key activity of every operating mine is the transportation of supplies into the mine and transportation of ore or concentrate from the mine. These activities involve roads, railways and / or ports. Transportation facilities in support of mining operations can have environmental effects and they are in turn affected by climate change and weather variability.

Ore Extraction

Ore extraction can be accomplished through open pit or underground mining. The type of mine to be developed can depend on the depth of the ore deposit, the ore's grade, the geometry and other physical characteristics of the ore deposit, and site characteristics such as topography. Features of these mines include (EC 2012a):

- open pit mines – ore extracted in an open pit; preferred for near-surface ore deposits; generally more cost-effective form of mining; the stripping ratio (ratio of waste rock to ore) varies over time in a mine, depending on the ore body's geometry, ore grades, slope stability, geology, and metal price fluctuations; and
- underground mines – ore extracted through vertical shafts / ramps / horizontal drifts (passageway) / adits (mine entrance); more selective than open-pit mining; smaller ratio of waste rock to ore than open pit mining.

Ore Processing

Extracted ore typically has a small amount of valuable minerals within large volumes of waste minerals of no economic value (gangue). The valuable ore minerals must be separated from the gangue during processing (milling) operations to liberate the higher quality metal. Ore processing involves grinding and crushing, ore separation and dewatering stages. These activities include (EC 2012a):

- grinding and crushing – physically liberates valuable minerals from the gangue prior to separation; crushing is done dry (for coarse seize reduction) and grinding is done wet (for finer size reduction) and may include chemicals to prepare for ore separation;
- ore separation – through physical or chemical methods; ore separation results in an ore concentrate product; some separated ore concentrates are sent for further processing (e.g., smelting) to produce pure metals; ore separation results in tailings (water, finely-ground rock, possibly reagent residues); ore separation can be done through:

- physical separation processes utilizing differences in physical or behavioural properties of mineral particles (e.g., size, density); most of the mineral not chemically altered, though chemical reagents may be used; physical separation processes include:
  - gravity separation (based on differences in density; uses smaller amounts of process reagents);
  - magnetic separation (based on differences in magnetic susceptibility; uses smaller amounts of process reagents); and
  - flotation separation (based on separating mineral particles that favour contact with air versus contact with water in a mixture of ground ore in water [slurry]; uses larger amounts of process reagents);
- chemical separation processes utilizing the preferential leaching of minerals; processes include:
  - leaching with cyanide (a dilute solution of calcium or sodium cyanide dissolves the metal, then the metal is recovered from the solution); and
  - leaching with sulphuric acid (sulphuric acid dissolves the metal, then the metal is recovered from the solution; and

- dewatering – most physical ore separation processes result in ore concentrates that are slurries with high water content; dewatering involves thickening the slurry through gravity settling (excess water is removed), then passing the slurry through a vacuum filter (trapping the particles); dewatering is required to prepare the ore concentrates for further processing.

2.3.4 Mine Closure

When ore minerals are exhausted or mining operations are no longer economically profitable, mines are closed. They may be temporary closed or suspended ("care and maintenance" status), as during times of low commodity prices, or they may be permanently closed, as when ore reserves are depleted (EC 2012a).

Planning for mine closure should start prior to mine operations and aspects of mine closure should be implemented during operations. Affected communities should not only determine how best to translate in ground assets to above ground assets (e.g., through employment) during mine operations but also to have a plan for the post mine closure economy. This could include environmental / climate change monitoring, a potential business development opportunity for northern and Aboriginal owned enterprises or development corporations. Training for these employment opportunities is provided through Building Environmental Aboriginal Human Resources (BEAHR; ECO Canada 2011).

Figure 1 provides a brief overview of mining life cycle phases (as described above) and associated climate change considerations. The process of approving a new mining operation and the consideration of climate change are addressed in the following sections of this Report. Potential Adaptation Measures are outlined in the Task 1 Report.

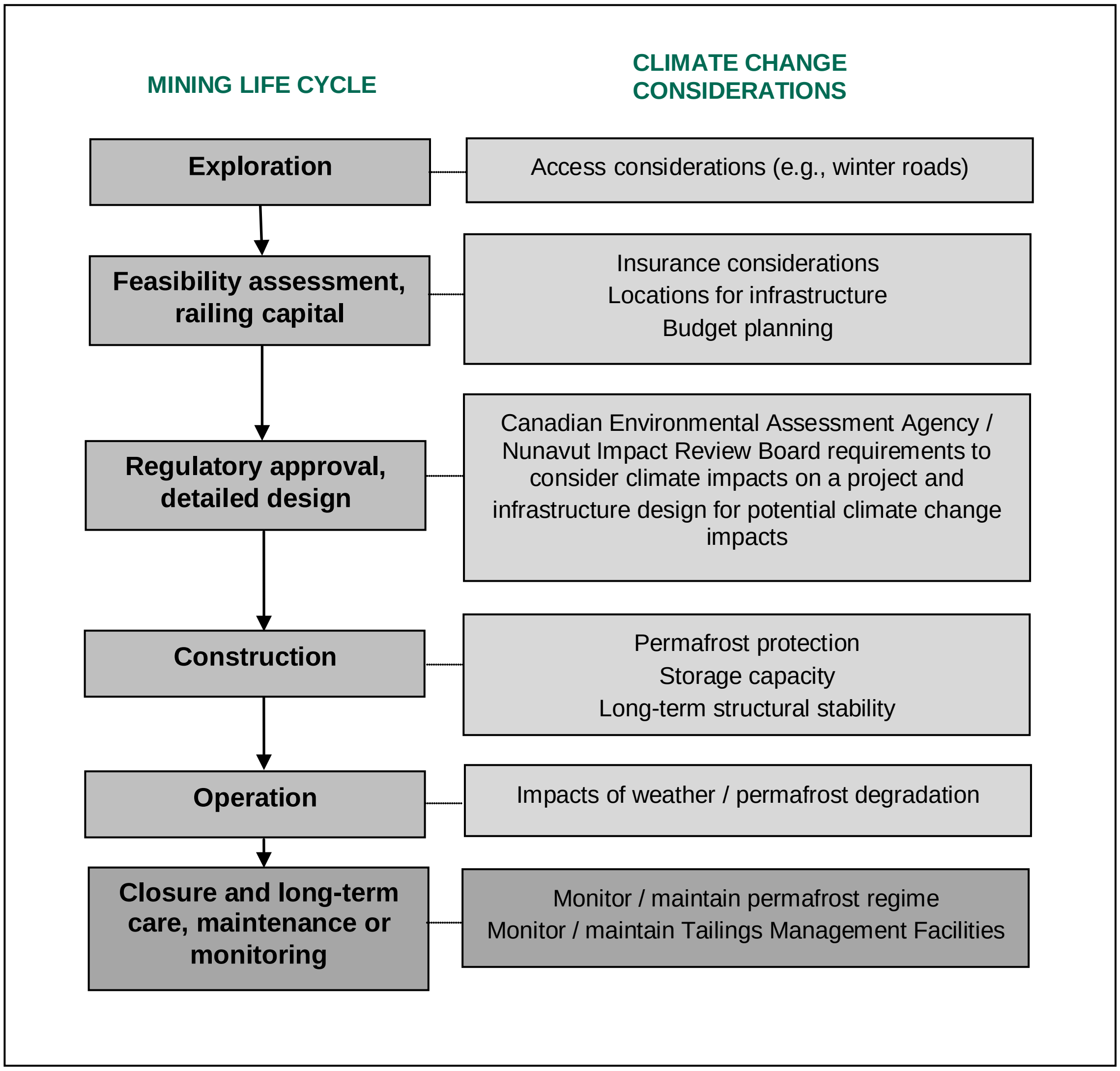

Figure 1: Climate Change Consideration during all Phases of Mining Life Cycle

3.0 ENVIRONMENTAL ASSESSMENT PROCESS

Resource development is an important economic factor in northern Canada, and over time it has contributed to the establishment of diverse infrastructure across the Arctic. As outlined in the Mining Life Cycle, between the planning and construction stages the project must receive regulatory approval, typically this is in the form of an Environmental Assessment. In general, Environmental Assessment is a process to predict the environmental effects of proposed initiatives before they are carried out. An Environmental Assessment (Canadian Environmental Assessment Agency [CEAA] 2011a):

- identifies possible environmental effects;
- proposes measures to mitigate adverse effects; and
- predicts whether there will be significant adverse environmental effects, even after the mitigation is implemented

Under the Environmental Assessment process, the impacts of climate change must be considered.

There is a diversity of organizations controlling and guiding industry in its activities, from federal agencies to local Aboriginal boards, and each plays an important role in determining how industry affects the sensitive natural environment and variable socio-economic situations in Nunavut. This Section is intended to provide an overview of aspects governing, regulating, supporting and guiding mining development and associated issues in Nunavut and what role these regulatory agencies play in assessing the impacts of climate change on proposed mining projects.

3.1 Land Ownership, Management and Land Claims

Land ownership, management and land claims are administered and regulated by a number of territorial, federal, and land claims agencies in Nunavut. This section reviews the responsibilities and policies of some key agencies governing the regulatory process of mining activity in Nunavut or contributing to the mining sector through research and development. The agencies, organizations and / or divisions considered in this section belong to the following categories:

- Government of Nunavut (GN) departments (i.e., territorial government agencies and organizations);
- federal government departments and agencies;
- land claim organizations;
- intergovernmental agencies and organizations; and
- Non-governmental Organizations (NGOs).

Note that this section does not describe agencies, organizations and / or divisions and associated legislation involved with socio-economic and cultural aspects of resource development.

Many of the described agencies and organizations do not address climate change related issues. If they do, it is emphasized in the text.

GOVERNMENT OF NUNAVUT DEPARTMENTS

3.1.1 Department of Environment

The Department of Environment (DOE) leads the GN's responsibility to ensure the protection, promotion and sustainable use of natural resources in Nunavut through supporting the management of the territory's environment, wildlife and parks. The DOE delivers a wide range of regulatory and program functions, and implements specific statutory and legal obligations of the GN, including a number of commitments under the *Nunavut Land Claims Agreement* (NLCA; GN, DOE 2011a).

The department includes four specific divisions, or program areas, through which specific roles and responsibilities are carried out.

3.1.1.1 Environmental Protection Division

The Environmental Protection Division of the DOE works to protect Nunavut's environment while developing a strong, sustainable economy for Nunavummiut by promoting and enhancing responsible resource development (GN, DOE 2010a). The Environmental Protection Division delivers a variety of regulatory and operational program functions including those mandated under the NLCA. It has a number of responsibilities which are relevant to mining activities in Nunavut.

The Environmental Protection Division enforces the *Environmental Protection Act* (EPA) and its associated regulations and guidelines. EPA compliance is promoted through the development and dissemination of environmental guidelines for use by government, industry and the public (GN, DOE 2010a). With the objective of minimizing the impacts of industrial and other activities on the environment, the DOE participates in environmental review processes and land use planning initiatives.

Climate Change

The Environmental Protection Division of the DOE is responsible for developing programs and policies that will assist Nunavut in adapting to projected changes in climate and associated events. Three areas of priority regarding climate change have been identified by the GN for Nunavut:

- advancing climate change knowledge;
- building community capacity for adaptation; and
- measurement and reduction of greenhouse gas emissions (GN, DOE 2011b).
- In 2011, the GN, DOE published *Upagiaqtavut: – Setting the course: Climate Change Impacts and Adaptation in Nunavut*, in which an approach to increasing adaptive capacity in Nunavut to climate change is presented. The report is a guiding document that is intended to give direction to present and future climate change adaptation strategies in Nunavut. Nunavut climate change adaptation strategies will be coordinated by a GN interdepartmental working group. There are four components to the approach:
  - 1. Partnership Building - Identifying and establishing partnership opportunities with government agencies, departments and organizations (at the federal, provincial and territorial level), communities, academic organizations and institutions and individuals will be integral to facilitate a coordinated approach to increasing Nunavut's adaptive capacity to climate change.

- 2. Research and Monitoring - Research and monitoring of climate change impacts in Nunavut will be strengthened through partnerships.
- 3. Education and Outreach - The development of informational materials and tools will educate and encourage climate change awareness and knowledge of climate change impacts on Nunavut and Inuit culture among Nunavummiut and will help raise global awareness.
- 4. Government Policy and Planning - Climate change must be considered at all levels of government in current and future planning to facilitate the growth of Nunavut's adaptive capacity (GN, DOE 2011c).

Relevant Legislation

Environmental Protection Act - Environmental protection is legislated under Nunavut's *Environmental Protection Act, R.S.N.W.T. (Nu.) 1988, c. E-7* (EPA) which includes descriptions of measures to be taken to protect the environment from contaminants.

The EPA provides the Chief Environmental Protection Officer with the power to order preventative measures to avoid discharges, alleviate the effects of a discharge, or stop discharges that are occurring. It allows Inspectors to enforce Clean-up Orders where a discharge has occurred, including undertaking the clean-up work if the Clean-up Order is not complied with.

When a person has been convicted of an offence under the EPA, a variety of punishments and/or terms may be imposed upon the person, including fines of up to $1 million for discharge-related offences, prison terms, payment of costs of notification of others, posting of bonds or payments to ensure compliance with an order, or pay costs associated with any research or analysis related to the offence.

In the context of mining and processing, the above roles and responsibilities of the GN may be relevant for discharges or failures to clean-up discharges associated with those activities.

Environmental Rights Act - The *Environmental Rights Act, R.S.N.W.T. (Nu.) 1988, c. 83 (Supp.),* points out the unique sense of the relationship of the people of Nunavut to the land, their values and experience. It requires that this relationship be recognized by the Legislative Assembly of the NWT / Nunavut. It describes that the people have the right to a healthy environment and a right to protect the integrity, biological diversity and productivity of the ecosystems in the NWT and Nunavut.

In the context of mining, any activities that would pose threats to the environment and the integrity, biological diversity and productivity of the ecosystems could be subject to the *Environmental Rights Act*.

Wildlife Act - The *Wildlife Act, S.Nu. 2003, c. 26* was developed to enable the comprehensive management of wildlife and wildlife habitat in the territory. It deals with the conservation, protection and recovery of wildlife Species at Risk while implementing the provisions of the NLCA with respect to wildlife, wildlife habitat, and Inuit rights related to wildlife and habitat.

The act provides details on activities that may or may not take place within critical wildlife habitats (e.g., road or structure building, exploration, prospecting or claims staking related to metals or minerals) and enables the Commissioner in Executive Council to make regulations regarding those critical habitats and other special management areas.

Under the *Wildlife Act*, Conservation Officers and Wildlife Guardians are appointed to enforce compliance with the Act. Conservation Officers enforce compliance with the *Wildlife Act*, the territorial *Parks Act* and the *Environmental Protection Act*. Wildlife Guardians may have some or all of the powers and protection afforded to a Conservation Officer.

Punishments for contraventions of the *Wildlife Act* include, for a corporation, fines of $500 to $1 million or fines up to $500,000 for an individual. For second or subsequent offences fines may be doubled, and continuing offences (i.e., committed on more than one day) are liable to separate convictions.

Conservation Officers and Wildlife Guardians may conduct inspections of industrial activities to ensure compliance with relevant legislation when persons or companies are undertaking mining-related operations in Nunavut (GN, Wildlife Management Division 2010). In addition, any activities that would pose threats to the health and safety of wildlife, wildlife habitat, or the cultural values associated with wildlife or its habitat, could be subject to the *Wildlife Act* and its regulations. For example, proposing to build a road to a mine-site through, or conduct mineral exploration in, a Critical Wildlife Area is addressed in the act.

Related Federal Legislation

Other legislation enforced by the DOE includes federal statutes such as the *Migratory Birds Convention Act, 1994, S.C. 1994, c. 22* the *Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act, S.C. 1992, c. 52* and the *Species at Risk Act, S.C. 2002, c. 29*. Relevant national and international agreements and conventions include the Convention on Biological Diversity and the International Agreement on Conservation of Polar Bears and their Habitat (GN, Wildlife Management Division 2010). These acts, agreements and conventions could be relevant when activities related to mining could pose risks to the health or safety of wildlife and/or its habitat.

3.1.2 Department of Economic Development and Transportation

GN's Department of Economic Development and Transportation (EDT) aims to support healthy communities in the territory and to build a safe and reliable infrastructure to connect its people and lands. It deals with mining in Nunavut as well as the transportation of mining-related vehicles under its three divisions: Community Economic Development, Minerals and Petroleum Resources, and Transportation (GN, EDT 2011a).

3.1.2.1 Community Economic Development Division

EDT's Community Economic Development Division is responsible for providing strategic direction towards the development of the GN's economy. Its objectives include community capacity building and promoting and funding initiatives for export development (GN, EDT 2011a).

3.1.2.2 Minerals and Petroleum Resources Division

"The Minerals and Petroleum Resources Division of the Department of Economic Development and Transportation (EDT) is committed to building a sustainable resource exploration and development sector across the territory. The division also promotes the development of an effective regulatory regime and develops programs that build capacity in communities to positively benefit from resource exploration and development."

Through EDT the GN provides core funding to the Canada-Nunavut Geoscience Office (C-NGO) and trains and funds community-based prospectors to promote investor confidence in Nunavut (GN, EDT 2011b).

EDT aims to form partnerships between Nunavummiut and industry, based on best practices and sustainable development. The department works with NTI and the federal government to make an efficient legislative, policy and regulatory environment for Nunavut (Indian and Northern Affairs Canada [INAC] *et al.* 2008).

***Nunavut Parnautit: A Foundation for the Future: Mineral Exploration and Mining Strategy* (2007)**

EDT developed *Nunavut Parnautit: The Nunavut Mineral Exploration and Mining Strategy* (GN, EDT 2007). This strategy provides a framework of policies and actions to encourage mineral discovery and development, creating the conditions for a strong and sustainable minerals industry while encouraging a high and sustainable quality of life for Nunavummiut. It addresses Nunavut's regulatory and taxation regimes, workforce, infrastructure and environmental baseline information availability (INAC *et al.* 2008). The *Nunavut Mineral Exploration and Mining Strategy* is structured according to four 'pillars':

- jurisdictional framework;
- community benefits;
- infrastructure development; and
- environmental stewardship.

Proposed Devolution Agreement

The Devolution Agreement for the territory will address transfer from the federal government to the GN the administration and control of Public Lands, rights in respect of waters, legislative powers, programs and responsibilities to manage lands and resources. The development of the agreement is underway, with a Lands and Resources Devolution Negotiation Protocol signed by Aboriginal Affairs and Northern Development Canada (AANDC; formerly known as Indian and Northern Affairs Canada [INAC]), the GN and NTI in 2008 as a step towards concluding an Agreement-in-Principle and a Devolution Final Agreement (AANDC 2011).

3.1.2.3 Transportation Division

The GN shares responsibility with Transport Canada in the administration and enforcement of the transportation of dangerous goods in Nunavut. While both the federal and territorial governments have legislation that addresses the transportation of dangerous goods (i.e., *Transportation Of Dangerous Goods Act*, 1990, R.S.N.W.T. (Nu.) 1988, c. 81 (Supp.) and *Transportation of Dangerous Goods Act*, 1992, S.C. 1992, c. 34), the two levels of government established the *Canada-Nunavut Agreement Respecting Administration of the Transportation of Dangerous Goods Act, 1992* to clarify their respective roles (Transport Canada 2009).

Relevant Legislation

Transportation of Dangerous Goods Act - Nunavut's *Transportation of Dangerous Goods Act* (1990) and its associated *Transportation of Dangerous Goods Regulations*, 1991, N.W.T. Reg. (Nu.) 095-91 address measures that must be implemented (e.g., through permitting and inspections of transported goods) to protect the environment and human health and safety.

3.1.3 Department of Community and Government Services

The Department of Community and Government Services (CGS) supports community governments build the capacities of their residents through program and funding initiatives related to core municipal operation, infrastructure development and land development (GN, CGS 2010a).

3.1.3.1 Nunavut Emergency Management Division

The Nunavut Emergency Management Division develops Nunavut's emergency response plans, coordinates the GN's emergency operations at territorial and regional levels, and supports community emergency response operations (GN, CGS 2010b).

3.1.4 Workers' Safety and Compensation Commission

Nunavut and the NWT have a combined Workers' Safety and Compensation Commission (WSCC), which administers the territorial *Workers' Compensation Act, S.Nu. 2007,c.15*, the *Safety Act, R.S.N.W.T. (Nu.) 1988, c. S-1,* the *Mine Health And Safety Act, S.N.W.T. (Nu.) 1994, c. 25,* and the *Explosives Use Act, R.S.N.W.T. (Nu.) 1988, c. E-10* to protect workers in both territories.

The WSCC was established in 1977 as a corporation under a former version of the *Workers' Compensation Act*. When Nunavut was created in 1999, Nunavut and the NWT governments agreed to a shared Workers' Compensation Board which was later transformed into the WSCC in 2008 under the new Nunavut *Worker's Compensation Act* and the NWT *Workers' Compensation Act* (WSCC 2010a). The WSCC is responsible for enforcing compliance with occupational health and safety legislation. It promotes worker and workplace safety, ensures that compensation and pensions are paid, ensures that employers meet those obligations, and works to provide benefits to injured workers while keeping assessments minimal (WSCC 2010b). It also provides training under the Work Site Hazardous Materials Information System (WHMIS) to ensure the safe storage and handling of controlled products (GN, EPS 2002).

The WSCC is governed by a Governance Council which represents labour, industry and the private sector. Its seven Directors are appointed by the NWT Minister responsible for the WSCC, two of which are recommended by the Nunavut Minister responsible for the WSCC (WSCC 2008).

The Workers' Protection Fund was established under and is maintained by the WSCC. It is a common reserve fund that employers pay assessments into and from which benefits are paid to injured workers or their dependants, including those in the mining sector (WSCC 2010b).

Relevant Legislation

The health and safety of workers and the general public is addressed under various pieces of territorial legislation which are controlled primarily through the WSCC. The following acts are administered by the WCSS.

Workers' Compensation Act - The *Workers' Compensation Act, S.Nu. 2007,c.15* and associated *Workers' Compensation General Regulation (2008)* govern mine workers in Nunavut as well as other workers who may be engaged in mining-related activities (e.g., those engaged in or engaged in training for rescue or recovery services, ambulance services or firefighting services).

Safety Act - Nunavut's *Safety Act*, *R.S.N.W.T. (Nu.) 1988, c. S-1* deals with workplace safety,including the duties of employers and suppliers as well as worker responsibilities to ensure that the health and safety of persons in workplaces are not jeopardized. Under the act, Safety Officers are appointed to enforce compliance with the act and its regulations. The act also stipulates how a Joint Work Site Health and Safety Committee may be established at a worksite to recommend improvements for the health and safety of workers.

The act outlines financial penalties associated with convictions for employers or suppliers who commit an offence under the act. Fines collected under the *Safety Act* are paid to the WSCC and form part of its Workers' Protection Fund.

Regulations which may be applicable to workers who are carrying out mining and uranium mining and processing include the *Asbestos Safety Regulations*, the *Environmental Tobacco Smoke Worksite Regulations*, the *General Safety Regulations*, the *Safety Forms Regulations*, the *Silica Sandblasting Safety Regulations,* and the *Work Site Hazardous Materials Information System Regulations.*

Mine Health and Safety Act - Nunavut's *Mine Health And Safety Act, S.N.W.T. (Nu.) 1994, c. 25* deals with workplace safety including the duties of mine owners to ensure that the health and safety of people in the workplace are not jeopardized. The act outlines how either a mine owner must submit to the WSCC and its Chief Inspector a mine design that includes the information required in the regulations, and requirements for giving notice of cessation of work at a mine site. The *Mine Health and Safety Act* also provides details on the roles and responsibilities of a mine's manager and the operations of its Health and Safety Committee if a mine has more than 15 workers. Details on mine site investigations and inspections are also provided.

Regulations which may be applicable to workers who carry out mining and processing operations include the *Environmental Tobacco Smoke Worksite Regulations, Nu. Reg. 029-2003* and the *Mine Health and Safety Regulations, N.W.T. Reg. (Nu.) 125-95*.

Explosives Use Act - Nunavut's *Explosives Use Act, R.S.N.W.T. (Nu.) 1988, c. E-10* includes provisions for the standards under which explosives may be exploded, handled and placed. Permits are required for all explosives uses. Regulations which may be applicable to workers at mines include the *Explosives Regulations*, R.R.N.W.T. (Nu.) 1990 c. E-27.

FEDERAL GOVERNMENT DEPARTMENTS AND AGENCIES

3.1.5 Environment Canada

"Environment Canada's (EC) *mandate is to preserve and enhance the quality of the natural environment; conserve Canada's renewable resources; conserve and protect Canada's water resources; forecast weather and environmental change; enforce rules relating to boundary waters; and coordinate environmental policies and programs for the federal government"* (EC 2012b).

Relevant Roles and Responsibilities

EC is a Government of Canada department that administers or helps to administer numerous acts which aim to protect the environment and support conservation, while supporting sustainable resource development activities. EC's Enforcement Branch works to deliver environmental and wildlife law enforcement under the Acts delivered by the Department. The Enforcement Branch takes action against violators of those laws (EC 2012b).

Legislation and Regulations

Canadian Environmental Protection Act (1999) - The *Canadian Environmental Protection Act* (*CEPA*) provides for pollution prevention, the protection of the environment and human health in order to contribute to sustainable development. The purpose of the Act is pollution prevention and the protection of the environment and human health in order to contribute to sustainable development. An application for an approval under this Act may trigger an Environmental Assessment under the *CEA Act* (1992). Applicable regulations include the following regulations.

- Disposal at Sea Regulations (2001) – These regulations are listed under subsection 130(4) of the Act pertains to mechanisms for screening and fee regulations; and
- Environmental Emergency Regulations (2003) - These regulations deal with the accidental release of a substance. The regulations provide a list of substances for which environmental emergency plans must be in place.

Canada Wildlife Act (1985) - The *Canada Wildlife Act* (1985) provides the authority for the acquisition of nationally significant habitats by the Minister of the Environment for the purposes of wildlife research, conservation and interpretation. The Act allows for the establishment and management of National and Marine Wildlife Areas to ensure the conservation and protection of key habitat for birds, species-at-risk and other wildlife of national importance.

Wildlife Area Regulations (2008) - provide regulations with regards to wildlife while on an area of designated public land and marine waters.

Fisheries Act (1985) - Under an agreement with Fisheries and Oceans Canada (DFO; administrator of the *Fisheries Act* 1985), EC administers the provision of the *Fisheries Act* relating to the general prohibition of the deposit of deleterious substances, and associated regulations including the Metal Mining Effluent Regulations. Further details on the *Fisheries Act* are provided in the DFO section below.

Metal Mining Effluent Regulations (2002) – These regulations prescribe the condition under which effluent form metal mines can be deposited into Canadian fisheries waters and outlines associated monitoring requirements. Under the Metal Mining Effluent Regulations the metal mining sector is required to conduct environmental studies to determine if their effluent is causing an effect on the aquatic ecosystem. EC evaluates the effects of mining effluents on the environment through the Environmental Effects Monitoring (EEM) Programs being carried out at individual mine sites. The department administers and monitors compliance with the Metal Mining Effluent Regulations for metal mines including by conducting inspections at mining sites (EC 2010).

Section 5 of the *Metal Mining Effluent Regulation (2002)* allows for the deposition of waste rock or effluent (with an approved exemption under the *Fisheries Act*) that contains any concentration of a deleterious substance of any pH into tailings impoundment areas (TIAs) as described in Schedule 2 (which was amended in February 2011 by the *Regulations Amending the Metal Mining Effluent Regulations*); this Schedule lists three water bodies in Nunavut:

- Garrow Lake located near the south end of Little Cornwallis Island;
- the dammed north-west arm of Second Portage Lake (north of Baker Lake); and

- Tail Lake, located approximately 125 km south-west of the town of Cambridge Bay.

In 2008, the *Fisheries Act* was amended pursuant to subsection 36(5) to officially include two fish bearing water bodies in Nunavut as TIAs: the northwest arm of Second Portage Lake and Tail Lake. The amendment designated these water bodies as TIAs for the Doris North gold mine project and the Meadowbank gold mine project, respectively. Designating water bodies as TIAs ensures the environmentally responsible management of mine tailings. Specifically, the respective mining companies must develop and implement Habitat Compensation Plans to offset fish habitat loss in TIAs (Canada Gazette 2009).

Migratory Birds Convention Act (1994) - The *Migratory Birds Convention Act* (1994) provides the authority to protect migratory birds in Canada through various regulations and prohibitions, including the requirement for hunting permits, the prohibition of disturbing nests or eggs of migratory birds and the prohibition of depositing a substance harmful to migratory birds in waters that are frequented by migratory birds. Under the *Sanctuary Regulations* of this *Act*, the Minister of Environment may establish management areas of major migratory bird population concentrations for the purposes of protecting the birds (including seabird breeding colonies) and their nests. Such Migratory Bird Sanctuaries on federal land / areas of federal jurisdiction also afford protection to habitat.

Migratory Birds Sanctuary Regulations (2008) – These regulations prescribe MBSs and provide for their control and management.

Migratory Birds Regulations (2008) – The Migratory Birds Regulations deals with the protection of migratory birds.

Relevant Activities

National Environmental Effects Monitoring (EEM) Program - The EEM Program was designed to ensure that the Metal Mining Effluent Regulations introduced in 2002 would achieve specific environmental objectives outlined in the *Fisheries Act* (1996) as they relate to the mining sector. EEMs aim to provide scientific evaluations to determine the effects of effluent on fish, fish habitat and fisheries (Canada Gazette 2002). EC provides national leadership for these regulated EEM programs that are required during metal mining operations. The information derived from the national science-based EEM program is used by regional EC offices to assess the adequacy of the Metal Mining Effluent Regulations in its objectives to protect the environment (EC 2011; Canada Gazette 2002).

Climate Change

EC is a national leader in the study of climate change science. EC is also responsible for managing migratory birds in Canada and manages a network of protected areas in the Arctic, and works to establish and co-manage (e.g., with local Aboriginal groups) new National Wildlife Areas (NWA; EC 2010).

EC conducts research on causes and impacts of climate change and climate variability in Canada, with the aim of understanding climate processes. EC monitors and tracks atmospheric greenhouse gas emissions (GHGs) and develops and applies climate models. The results of EC's scientific research forms a foundation upon which climate policy and development may be formed, and adaptation and mitigation actions may be implemented (EC 2012b).

3.1.5.1 Canadian Wildlife Service

Relevant Roles and Responsibilities

As subunit of EC, the Environmental Conservation Branch - Canadian Wildlife Service (CWS) focuses on ecosystem health, wildlife conservation, and biodiversity in Canada and manages Migratory Bird Sanctuaries (MBS) and National Wildlife Areas (NWA; EC 2010).

Legislation and Regulations

Migratory Birds Convention Act (1994) - The CWS administers the *Migratory Birds Convention Act* (see above) and it works to manage and conserve migratory bird populations in Canada (e.g., through establishing and administering MBS).

Canadian Wildlife Act (1985) - The CWS is also responsible for administering the *Canada Wildlife Act* (see above) which enables it to protect wildlife species in danger of extinction as well as acquire lands for wildlife research, conservation and interpretation (i.e., MWA; see below).

Species at Risk Act - The CWS is the lead federal agency in charge of applying the Species at Risk Act (SARA; 2002) which aims at protecting wildlife species at risk and their critical habitats (Latour et al. 2008).

3.1.6 Fisheries and Oceans Canada

"On behalf of the Government of Canada, the Department of Fisheries and Oceans (DFO) is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and fresh waters" (DFO 2008a).

Relevant Roles and Responsibilities

DFO is a leader in the management of Canada's oceans and freshwater resources and also deals with marine safety. It also provides coast guard and hydrographic services on behalf of the federal government and is responsible for managing fisheries, habitat and aquaculture. The DFO is one of the three RAs under the *Species at Risk Act* (SARA; 2003, together with the Department of Environment and Parks Canada [PC]) and responsible for protecting and recovering aquatic species under federal jurisdiction other than those found in NWAs (Department of Environment) and national parks (PC; DFO 2008b).

With respect to ports, DFO's priority is to sustain productive aquatic ecosystems for the present and the future, and to work with the Port Authorities to enhance the safety of Canadian waterways (DFO 2008a).

Legislation and Regulations

Fisheries Act (1996) – The *Fisheries Act* is administered by DFO and provides for the conservation and management of fisheries and fish habitats, licensing, enforcement and international fisheries agreements. The protection of fish and fish habitat is achieved through a number of general prohibitions included in the Act such as the prohibition of killing fish by means other than fishing; the prohibition of the harmful alteration, disruption, or destruction of fish habitat; the prohibition of deposits of deleterious substances; and the prohibition of fishing with explosives. Relevant regulations under the Act include:

> Metal Mining Effluent Regulations (2002) - DFO is involved with ensuring that tailings from metal mines are managed in accordance with the Fisheries Act (1996; discussed in Section 3.1).

Navigable Waters Protection Act (1985) - According to this Act, under the Approval of Works 5 (1), "No work shall be built or placed in, on, over, under, through or across any navigable water without the [DFO] Minister's prior approval of the work, its site and the plans for it".

Oceans Act (1996) - The *Oceans Act* provides for the development and implementation of a national oceans management strategy and provides for the consolidation and clarification of federal responsibilities for the management of Canada's oceans. The Act establishes Canada's sovereign rights within its exclusive economic zone, defines Canada's principles for oceans management and allows for the creation of marine protected areas. Under the Act, DFO is given the authority, in collaboration with other federal departments, provincial and territorial governments, Aboriginal organizations, coastal communities and other stakeholders, to lead the development of Canada's Ocean Strategy.

<u>Relevant Activities</u>

Project Review by DFO - Fish habitat is one of the resources of the marine environment that DFO strives to protect and maintain. DFO considers site specific sensitivity of fish habitat and also species composition. Both considerations assist in determining if a proposed work or undertaking is likely to cause harmful alteration, disruption or destruction (HADD) of fish habitat and whether the HADD should be authorized pursuant to subsection 35(2) of the Fisheries Act (DFO 2010a). In order to proceed with a work or undertaking in surrounding areas of marine environment habitat, a Project Description is required.

Fish Habitat Management Program (FHMP) – The FHMP conducts Environmental Assessments under the CEA Act (1992) before DFO makes a regulatory decision under the habitat provisions of the *Fisheries Act* (1996). This federal regulator affects most development projects occurring in or around marine and fresh fish-bearing waters. It reviews project work in or near water, monitors compliance and enforces the habitat protection provisions of the Fisheries Act (and associated regulations such as the Metal Mining Effluent Regulation; DFO 2010b).

Harbours - DFO manages its harbours through a program entitled Small Craft Harbours (SCH) that ensures the harbours sustain their proper condition by maintaining their infrastructure and environmental protection. Some of the regulations and acts pertaining to Canadian harbours (including Nunavut) are the *Fishing and Recreational Harbours Regulations*, *Small Fishing Vessel Inspection Regulations*, *Fishing and Recreational Harbours Act*, and *Federal Real Property and Federal Immovables Act* (DFO 2008c).

Operational Statements - DFO developed a series of Operational Statements (OS) to streamline the regulatory review of low risk activities. The OS are designed to identify measures and conditions for avoiding the HADD to fish habitat under the Fisheries Act (1985). Proponents are required to incorporate the measures and conditions outlined in the OS into their development plans. Proponents need to complete a Notification Form (available on DFO's website) and send it to the local DFO office prior to their planned activities (DFO 2010c).

3.1.7 Natural Resources Canada

Natural Resources Canada (NRCan) is a Government of Canada department that advances knowledge of Canada's natural resources, which include energy, forests and minerals and metals, to ensure these resources are developed and used responsibly. NRCan focuses on developing science and technology in these resource sectors, as well as in earth sciences. Additionally, NRCan provides scientific expertise that contributes to the environmental assessment process (NRCan 2011b; S. Smith, Geological Survey of Canada [GSC], pers. comm. 2011).

NRCan consists of several subunits, sectors and subsectors. Those that are relevant to this Report include:

- Earth Sciences Sector;
  - Geological Survey of Canada (GSC);
  - Climate Change Impacts and Adaptation Division (CCIAD);
- Minerals & Metals Sector;
  - CANMET (Canada Centre for Mining and Energy Technology) Materials Technology Laboratory (CANMET-MTL);
  - CANMET Mining and Mineral Sciences Laboratories (CANMET-MMSL);
  - Explosives Safety and Security Branch (ESSB);
  - Minerals, Metals and Materials Knowledge Branch (MMMKB); and
  - Minerals, Metals and Materials Policy Branch (MMMPB).
- Energy Sector;
  - Uranium and Radioactive Waste Division (URWD);
- Science and Policy Integration; and
- Major Project Management Office (MPMO).

3.1.7.1 NRCan – Earth Sciences Sector

"*The Earth Sciences Sector of Natural Resources Canada provides Canadians with the acquisition, interpretation, maintenance and distribution of maps, information, technology, standards and expertise concerning the Canadian landmass and offshore in the fields of geoscience, geodesy, mapping, surveying, and remote sensing*" (NRCan 2011c).

Relevant groups within NRCan Earth Sciences Sector that contribute to climate change research and adaptation are described below.

3.1.7.1.1 Geological Survey of Canada

"The (Geological Survey of Canada [GSC]) is Canada's premier agency for geoscientific information and research, with world-class expertise focusing on geosciences surveys, sustainable development of Canada's resources, environmental protection, and technology innovation" (NRCan 2011d).

Relevant Roles and Responsibilities

The GSC is an organization within NRCan – Earth Sciences Sector that conducts research on a variety of topics regarding the Canadian landmass that may potentially impact landscape process and the development of natural resources. This includes climate research in areas such as permafrost, geohazards (e.g., slope stability), coastal processes and hydrogeology (NRCan 2011d; Duke 2010). The responsibility of the GSC also includes providing expertise on geosciences-related topics for environmental assessments (Duke 2010).

Climate Change Geoscience Program – The objective of this program (formerly known as the Enhancing Resilience in a Changing Climate Program) is to research the effects of climate change on the landmass of Canada through geosciences and geomatics. This program is intended to produce earth science information to inform policy- and decision-makers on climate change. The Climate Change and Geoscience Program was developed to complement the Regional Adaptation Collaboratives (RACs) Program and the Tools for Adaptation Program, which are described below (NRCan 2012; NRCan 2009a).

3.1.7.1.2 Climate Change Impacts and Adaptation Division

Climate Change

"The Climate Change Impacts and Adaptation Division (CCIAD) facilitates the generation and sharing of knowledge, tools and mechanisms to integrate adaptation into policy, plans and projects" (NRCan 2009b).

Relevant Roles and Responsibilities

NRCan – CCIAD is a division within NRCan – Earth Sciences Sector and has funded over 300 climate change impacts and adaptation research projects since 1998. Two programs in which NRCan – CCIAD has supported climate change adaptation and mitigation research are: the RAC Program and the Tools for Adaptation Program (NRCan 2009b).

RAC Program – The objective of the RAC Program is to catalyze coordinated and sustained climate change adaptation planning, decision-making and action across the diverse regions of Canada. The RAC Program is scheduled to end in 2012 (S. Smith, GSC, pers. comm. 2011; NRCan 2009b).

Tools for Adaptation Program - The objective of the Tools for Adaptation Program, which ended in 2011, was to develop adaptation tools, i.e., methods to guide decision-makers in the examination of the impacts that climate change may have on their policies, plans and operations. Adaptation tools are also designed to aid in the determination of appropriate response actions (S. Smith, GSC, pers. comm. 2011; NRCan 2009b).

3.1.7.2 NRCan – Minerals and Metals Sector

"The Mineral and Metals Sector (MMS) works with other federal departments and agencies to ensure that federal policies and strategies that have an impact on the minerals and metals industry are consistent with sustainable minerals development and use in Canada and around the world" (NRCan 2011e).

Consistent with the Minerals and Metals Policy of the Government of Canada, MMS promotes the involvement of Aboriginal individuals, communities and businesses in the mining sector in Canada. MMS develops and distributes diverse information products on Aboriginal participation in exploration and mining in Canada which are available on its website (NRCan 2011f).

Relevant Roles and Responsibilities

The MMS is composed of five branches: CANMET-MTL, CANMET-MMSL, ESSB, MMMKB, and MMMPB, each with their own initiatives related to the management of minerals and metals in Canada. MMS acts as the federal government's primary source of minerals- and metals-related economic and scientific knowledge (e.g., statistics, sustainable development, commodities, technological expertise, and policy advice). Some subunits also have regulatory roles under specific acts (NRCan 2011e). The roles of the relevant branches are described below.

Relevant Activities

CANMET-MTL – The mandate of CANMET-MTL is to conduct research into the development and improvement of materials technology in the energy, transportation and metal-manufacturing sectors of Canadian industry. The objectives of CANMET-MTL's research in these areas is to improve energy production and efficiency, reduce greenhouse gas emissions, reduce environmental impacts, develop products that contribute to green economy, and enhance health, security and safety (NRCan 2011h).

CANMET-MMSL – This branch focuses on research and development in mining, processing and related environmental issues such as ground control, mine mechanization / automation, underground mine environment, metallurgical processing, mineralogy, mining effluents, tailings and waste rock, and metals in the environment. Research is primarily on mining extraction technologies, mineral processing, and developing technological solutions to reduce environmental liabilities facing the minerals industry. MMSL works with industry, provincial and territorial governments and research institutes to promote sustainable development, improve industry competiveness, and improve health and safety in the mining industry (NRCan 2011i).

ESSB – This branch is responsible for administering the *Explosives Act (1985)* and regulations and promoting explosives safety and security technology. The Explosives Regulatory Division of the ESSB provides services and support to the explosives industry. The Division administers the *Explosives Act* through a system of licences and permits which are supported by a compliance inspection program. This is applicable to mining operations that require the use of explosives. The division controls the import, manufacture, storage, sale and some aspects of transport of explosives by road, across Canada through their headquarters (Ottawa) and regional offices (NRCan 2011g).

MMMKB – This branch is responsible for collecting and disseminating knowledge and statistics on minerals, metals and materials. This includes information relating to minerals, metals and materials such as production, exploration, trade, use, prices, employment, salaries and wages, transportation and investment and finance (NRCan 2011j). .

MMMPB – The MMPB is at the centre of policy development in MMS. The responsibilities of the branch include minerals- and metals-related policy research, analysis and development over a broad scope of topics. MMS accomplishes this by engaging minerals and metals stakeholders within the federal government, territorial government, communities, Aboriginal groups and communities, industry, environmental and civil society groups, and academia (NRCan 2007).

3.1.7.3 NRCan – Energy Sector

"*The Energy Sector of [NRCan] is the lead on energy policy for the Government of Canada. Its goal is that Canadians benefit economically, environmentally and socially from the secure and sustainable production and use of Canada's energy resources*" (NRCan 2008).

Relevant Roles and Responsibilities

NRCan – Energy contributes in areas such as research and development, science and technology and regulatory processes. Energy sources and related topics in which NRCan – Energy has program initiatives include: natural gas, petroleum products and crude oil prices, petroleum products market, crude oil market, infrastructure for crude oil and petroleum products, offshore oil and gas, uranium / nuclear energy, electricity, coal, renewable energy and energy efficiency (NRCan 2009c).

Relevant Activities

URWD – The URWD of NRCan – Energy provides expert technical, economic and policy advice to the federal government on issues that concern uranium exploration, development, environmental protection, production, supply capability, foreign ownership, domestic and international markets, exports, international trade, end uses (NRCan 2009c), and uranium mill tailings management (S. Smith, GSC, pers. comm. 2011).

3.1.7.4 NRCan – Science and Policy Integration Sector

The Science and Policy Integration Sector leads NRCan's efforts at the corporate level. The sector is responsible for obtaining, analyzing and disseminating information from industry stakeholders to ensure that decision-makers are well-informed. As such, the Science and Policy Integration Sector plays an important role in coordinating environmental assessments (NRCan 2009d).

3.1.7.5 NRCan – Major Project Management Office

"*The [Major Project Management Office's] MPMO's mandate is two-fold: (1) to provide overarching project coordination, management and accountability for major resource projects within the context of the existing federal regulatory review process; and, (2) to undertake research and identify options that drive further performance improvements to the federal regulatory system for major resource projects*" (NRCan 2011k).

The key elements of MPMO's approach to follow its mandate are improved process clarity, effective project management and policy leadership (NRCan 2011k). Improving process clarity is accomplished by unifying the federal government's approach in the review of major resource projects and by contributing to the development of guidelines, procedures and service standards to facilitate regulatory review of major resource projects. MPMO ensures effective project management by coordinating inter -departmental and / or -agency Project Agreements. Additionally, the MPMO collaborates with key stakeholders and leads policy research and analysis to improve federal regulatory and legislative framework regarding major resource projects (NRCan 2011k),

3.1.8 Aboriginal Affairs and Northern Development Canada

Aboriginal Affairs and Northern Development Canada (AANDC) is involved with mining at the territorial level in northern Canada. In Nunavut, AANDC's mission is *"to work in partnership to help improve the quality of life of Nunavummiut through economic and social development, environmental stewardship and effective management of natural resources"* (AANDC 2010a).

AANDC is active in the management of resources in northern Canada. On Crown lands in Nunavut, AANDC plays an important role in the management of lands, waters and resources (INAC 2008).

Relevant Roles and Responsibilities

AANDC partners with northern governments and the private sector to support mineral development. There are a number of AANDC directorates which carry out AANDC's responsibilities in Nunavut.

Intergovernmental Affairs and Inuit Relations Directorate

The Intergovernmental Affairs and Inuit Relations Directorate represents Inuit interests with respect to their development, economic development, and the implementation of the NLCA (AANDC 2010a).

Operations Directorate

Natural resources on Crown land in Nunavut are managed through the Operations Directorate. The directorate's responsibilities include:

- coordinating regional environmental and land use planning activities to guide resource development in Nunavut;
- managing surface and subsurface rights on Crown land in Nunavut to ensure sustainable use of land resources;
- managing mineral resource development on Crown land in Nunavut;
- protecting Nunavut's water resources and increase the understanding of this resource; and
- inspecting and enforcing leases, licences, and permits issued by the department in Nunavut (AANDC 2010a).

3.1.8.1 AANDC Environment Division

The Environment Division coordinates regional environmental activities that deal with land use planning and impacts of development. It works in partnership with other organizations and agencies to effectively manage Nunavut's natural resources (AANDC 2010a). This includes:

- coordinating input into the environmental assessment of proposed projects under review by the NIRB;
- providing advice on resource development processes in the north to other government departments and Inuit organizations as required under the *CEA Act, S.C. 1992, c. 37* (CEAA; AANDC 2010a);
- working with the Nunavut Planning Commission to establish land use plans, monitor and collect data from the Nunavut General Monitoring Program;
- working with territorial and federal government departments, NTI and other organizations to establish policies and strategies with respect to northern resource management. Policy initiatives include implementing the:
  - *Species at Risk Act*;
  - Cumulative Effects Assessment Framework;
  - applicable use and collection of traditional knowledge; and
  - regional environmental assessment(s).

The Division's current priorities are new environment management legislation on cumulative effects assessment, Heritage Rivers, protected areas, caribou management, traditional knowledge, and public participation and consultation.

AANDC has numerous additional roles in the management of resources in Nunavut, including mining-related ones. In the Environmental Assessment process it provides technical advice to the NIRB and the Nunavut Water Board (NWB). It ensures compliance with the NWT and Nunavut Mining Regulations and works with licence, permit and lease holders, as well as Institutes of Public Government (IPG), to ensure that terms and conditions are met for Crown land and waters in Nunavut (INAC *et al.* 2008).

AANDC Water Resource Officers and Resource Management Officers inspect exploration camps, mines and research camps. AANDC's geologists monitor, assess and report on mineral-related activities in Nunavut. AANDC also maintains an archive of the territory's mineral exploration and mining history which is available to clients (INAC *et al.* 2008).

Permits, Authorizations and Licences

If a project (or components of the project) is on Crown land, it requires a Land Use Permit under the *Territorial Lands Act, R.S.C. 1985, c. T-7*, issued by AANDC. Under the *Northwest Territories and Nunavut Mining Regulations (2007)*, a mining company must apply for a prospecting permit and record a claim. Under these regulations, no one may prospect where it is prohibited by a Land Use Plan (AANDC 2010b).

A mining exploration project is typically referred to the Nunavut Planning Commission (NPC), NIRB and NWB through AANDC because AANDC approves the prospecting permit (Nunavummiut Makitagunarningit 2010). AANDC's Land Administration Division manages and administers surface and subsurface rights on Crown land in Nunavut, ensuring compliance with the *Territorial Lands Act* (1985) and its regulations (INAC *et al.* 2008).

Land Use Permit – Through its Lands Administration Office, AANDC issues Land Use Permits for specific activities on Crown land in the NWT and Nunavut. Relevant activities include mineral exploration, mining, and industrial activities such as constructing access roads, staging areas and fuel caches. The type of permit depends on the size of the operation. Type A Land Use Permits typically are issued for projects that may cause more significant environmental impacts than projects that require Type B Land Use Permits (for potentially less impacting projects; AANDC 2010c).

Key Policies

The Mine Reclamation Policy for Nunavut (2002) informs resource management boards and relevant regulatory authorities of AANDC Minister's expectations for their work and what is required for regulatory documents submitted for the Minister's approval. The Policy also informs industry what is expected in reclamation planning. The policy applies to new and existing mines with clearly identified owners / operators, but it does not cover orphaned or abandoned sites, which are addressed as contaminated sites. Regulatory provisions related to mine site reclamation are enforced through the *Territorial Lands Act* (1985) and associated regulations, the *Northwest Territories Waters Act*, S.C. 1992, c. 39 and the *Mackenzie Valley Resource Management Act, S.C. 1998, c. 25* as well as federal legislation such as the *Fisheries Act, R.S.C. 1985, c. F-14.*

Climate Change

AANDC has developed two programs in response to climate change: The Climate Change Adaptation Program and the ecoENERGY for Aboriginal and Northern Communities Program (AANDC 2010e).

Climate Change and Adaptation Program - AANDC has collaborated with public and private organizations and agencies to build knowledge, capacity and tools to increase the adaptive capacity of Aboriginal and northern communities to climate change. The Climate Change Adaptation Program supports projects such as climate change impact management strategy development, assessments of risk to and resilience of infrastructure, and water quality improvement and management (AANDC 2010f).

ecoENERGY for Aboriginal and Northern Communities Program - In recognition of the high use of energy derived from fossil fuel in northern locations, AANDC has also contributed to the development and implementation of energy consumption reduction projects and renewable energy projects to reduce GHG emissions. The ecoEnergy for Aboriginal and Northern Communities Program has contributed to the development of hydroelectricity, wind turbines, solar energy, biomass and geothermal technology (AANDC 2010g).

3.1.9 Canadian Coast Guard

The Canadian Coast Guard (CCG) is a federal agency that helps DFO meets its responsibilities regarding Canadian waterways, including ensuring they are safe, accessible, sustainably used, and sustainably developed. The CCG's specific mandates and services are outlined in the *Oceans Act* (1996) and *Canada Shipping Act* (1985; CCG 2010).

Roles and Responsibilities

The CCG own and manage their civilian fleet. The CCG is part of the Special Operating Agency of DFO, where a joint effort is put forward to ensure safe, accessible waterways. The CCG strives to establish continuous economic growth while maintaining and providing sustainable development and marine environment protection (CCG 2011a).

With the DFO Minister having responsibility under the *Oceans Act* (1996), the CCG works to provide navigation aids, marine communications, traffic management services, ice-breaking and ice-management services, channel maintenance, marine search and rescue, marine pollution response, and support other government departments, boards and agencies through the provision of ships, aircraft and other services (CCG 2010).

The DFO Minister has roles and responsibilities under the *Canada Shipping Act* (1985) and with the CCG works on navigation aids, search and rescue services, pollution responses, and vessel traffic services (CCG 2010).

Relevant Activities

Environmental Response Program - The CCG is responsible for the *Environmental Response Program* that manages the cleanup attempts of accident involving oil spills. It is the law and the responsibility of the polluter to compensate for the oil spill, although at times the polluter is unknown, at which point CCG is in charge of the site rehabilitation efforts (CCG 2011b). In the case of an oil spill, large areas of marine environment (and shorelines) are contaminated and an organized response is necessary. The National Response Plan framework is a responsive guideline on how to approach an oil spill cleanup while considering objectives such as minimizing environmental pollution impacts and making sure that public safety is addressed (CCG 2011b).

CCGs Icebreaking Program - The Icebreaking Program was initiated in order to navigate safely through the ice-covered waters of the Arctic. Between the months of June to November, operations take place in the Arctic where icebreakers assist with cargo delivery to isolated communities by clearing ice from ports and wharf faces (CCG 2008).

3.1.10 Canadian Environmental Assessment Agency

"[The CEAA's] role is to provide Canadians with high-quality Environmental Assessments that contribute to informed decision-making in support of sustainable development" (CEAA 2011a).

Relevant Roles and Responsibilities

The CEAA is a federal agency that is accountable to the Minister of the Environment. The CEAA conducts Environmental Assessments as required under the *CEA Act* (*CEA Act* 1992; CEAA 2011b). This Act applies to projects where the federal government has decision-making authority as a proponent, land manager, source of funding or regulator. All projects are subject to screening, but the degree of screening depends primarily on the scale and complexity of the project and its probable effects (CEAA 2011c).

The role of the Agency is to administer the *CEA Act* (1992), advance the science and practice of Environmental Assessment through research and development, provide administrative and advisory support for review panels, mediations, and comprehensive studies, and to promote the use of strategic Environmental Assessment as a key tool to support sustainable decision making. CEAA screening, which may involve public participation, documents the environmental effects of a proposed project and establishes ways to mitigate negative effects of a project through modifying project plans (CEAA 2011c).

Note: *An amendment to the Nunavut Land Claim Agreement in 2008 established that that the CEA Act (1992) no longer applies in Nunavut. In very specific circumstances a project proposal may be referred to the Federal Minister of the Environment for review. This helps avoid unnecessary duplication and acknowledges the work of the Nunavut Impact Review Board (NIRB; INAC et al. 2008).*

Legislation and Regulations

Canadian Environmental Assessment Act (*CEA Act* 1992) - The *CEA Act* (1992) forms the basis for the federal practice of EAs. Within the context of marine shipping, it addresses sectors such as oil and gas, maritime defense, tourism and recreation, marine science and technology, and marine transportation. It ensures projects are thoroughly reviewed and action is taken so they do not cause adverse environmental effects. It also promotes participation from various stakeholders including the public, provinces and territories and Aboriginal groups in the review of proposed projects. The *CEA Act* (1992) defines a project as "an undertaking in relation to a physical work (e.g., pipeline, bridge, communications antenna) or physical activities not related to a physical work that are listed in the Inclusion List Regulations (e.g., dredging for navigation, remediation of contaminated land, prospecting for minerals).

The *CEA Act* (1992) may also apply if the proposed project may cause significant adverse transboundary effects (interprovincially or internationally), cause adverse effects on federal lands, or when projects on Aboriginal lands may cause adverse effects outside those lands.

Under the *CEA Act* (1992), federal decision makers (RAs) must consider the environmental effects of proposed projects before they allow a project to proceed. A responsible authority may not do anything to permit a project to be carried out until all significant adverse environmental effects have been addressed.

Relevant Activities

According to the CEAA, Environmental Assessments are defined as current when the process is underway and the RAs have not yet determined a course of action or decision concerning the environmental effects of a project (CEAA 2011d).

The CEAA is not currently involved in any environmental assessments in Nunavut (CEAA 2009).

Although the Bathurst Inlet Port and Road Joint Venture Ltd. (Task 1 Report) was originally designated for CEAA screening, the CEAA assessment was cancelled because AANDC and DFO determined that the project did not trigger the *CEA Act* (1992; CEAA 2011d).

Climate Change

In 2003, a guideline document, entitled *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners* was produced by the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, which was lead by the CEAA, to provide guidance to environmental assessment practitioners in incorporating climate change considerations. The use of the guide is at the discretion of the jurisdiction in which an environmental assessment is performed. The document provides guidance on:

- methods to obtain and evaluate the GHG output of an environmental assessment and how climate change may impact an environmental assessment;
- key sources of information that may be helpful when incorporating climate change considerations; and
- methodology to encourage institutions of public government responsible for environmental assessment to take climate change into consideration in the environmental assessment process (The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003).

Additionally, the CEAA has been active in the research and development of methods to incorporate climate change considerations in the environmental impact assessment (EIA) process. For example, the CEAA contributed to *Evaluation of the ClimAdapt Guide to Incorporating Climate Change into the Environmental Impact Assessment Process* (Bell *et al*. 2003). The evaluation took into account six case studies of EIAs that have been completed in Canada. One of the case studies was the Beaufort Sea Gas Development, which involved the potential shipment of oil and gas through the North West Passage near the Nunavut communities of Cambridge Bay and Clyde River. An EIA for the development was submitted in 1982 but did not take climate change into consideration. The 2003 evaluation reviewed the 1983 EIA following climate change guidelines but did not draw substantially different conclusions. However, the evaluation found that taking climate change into account may help identify engineering design and operation concerns.

3.1.11 Canadian Northern Development Agency

The Canadian Northern Development Agency (CanNor) was established in 2009 by the Government of Canada as part of Canada's Economic Action Plan and Northern Strategy (CanNor 2011a; Government of Canada 2009). The agency focuses on economic development and provides business services in Nunavut, the NWT and Yukon. CanNor has assumed responsibilities formerly of AANDC, which includes programs and participation in:

- Strategic Investments in Northern Economic Development (SINED);

- Community Adjustment Fund (CAF);
- delivery of Infrastructure Canada programs including Recreational Infrastructure Canada (RInC);
- Aboriginal business and economic development programs;
- support Human Resources and Social Development Canada (HRSDC) in skills development and training programs; and
- responsibility for the Federal Councils in the North (CanNor 2011b).

CanNor works with government at the federal and regional levels and with project proponents to streamline federal government participation in regulatory processes. CanNor reports to the Minister of CanNor (CanNor 2011a).

3.1.12 Canadian Nuclear Safety Commission

"(The Canadian Nuclear and Safety Commission [CNSC]) protects the health, safety and security of Canadians as well as the environment, and respects Canada's international commitments on the... use of nuclear energy" (CNSC 2011)

Relevant Roles and Responsibilities

The CNSC is the federal body responsible for regulating nuclear facilities and nuclear-related activities under federal legislation in Canada. Established in 2000 under the *Nuclear Safety and Control Act* (1997) CNSC regulates the nuclear sector, including the mining of uranium in northern Canada. The CNSC reviews applications for licences according to regulatory requirements, determines whether Environmental Assessments are required (e.g., through the CEAA), holds public hearings about licensing decisions, issues licences for aspects of nuclear energy and materials, and enforces compliance with the Act, its regulations, and licence conditions. A licence must be obtained from the CNSC prior to preparing a site, constructing, operating, decommissioning or abandoning a nuclear facility, or possessing, using, transporting or storing nuclear substances. The CNSC does not regulate uranium exploration activities, but does regulate mining, milling, refining, waste sites and nuclear reactors; it becomes involved once there is a mine proposal that requires a licence (CNSC 2011).

3.1.13 Canadian Transportation Agency

"*The [Canadian Transportation Agency (CTA)] is an independent, quasi-judicial tribunal that makes decisions on a wide range of economic matters involving federally-regulated modes of transportation (air, rail and marine)*" (CTA 2008a).

The CTA (formerly the National Transportation Agency) was established under the *Canada Transportation Act* (1996), which replaced the *National Transportation Act* (1987) and the *Railway Act*. Reporting to the Minister of Transport, the CTA is responsible for implementing the Government of Canada's transportation policy in the federally-regulated transportation system (*i.e.*, air, rail and marine). This involves dispute resolution between users, shippers and carriers of transportation services that may occur over matters such as rates, fees and charges, and accessibility (CTA 2008a). The CTA also licenses air and rail carriers, authorizes foreign vessels to operate in Canadian waters, determines railway costs, determines the Net Salvage Value of rail lines, participates in the negotiation and implementation of international air agreements, administers air tariffs, administers the terms and conditions of international air transportation as it applies to Canada, and participates in environmental assessments (CTA 2008a; CTA 2008b). The CTA also has shared responsibilities, with respect to economic-related concerns, under the *Canada Marine Act* (1998), the *Pilotage Act* (1985), the *Coasting Trade Act* (1992), and the *Railway Safety Act* (1985; CTA 2008a).

3.1.14 Parks Canada

Parks Canada (PC) manages protected areas in Canada such as National Parks, National Historic Sites and National Marine Conservation Areas pursuant to the *Canada National Parks Act* (2000). Under the act and regulations, mining, oil and gas activities are not allowed in National Parks. However, the act makes provisions for certain conditions where park lands may be used for mining access roads, railway right-of-ways and pipelines. Pursuant to the *Canada National Parks Act* (2000), the minister responsible for PC designates park wardens and enforcement officers who operate within the National Parks to ensure the preservation and maintenance of the public peace in parks.

3.1.15 Transport Canada

Transport Canada is a federal agency that is involved with conducting Environmental Assessments for proposed projects in accordance with the *CEA Act* (1992) across Canada, along with other relevant federal Environmental Assessment process in Canada's three territories. It works with the CEAA and others to ensure that the *CEA Act* and northern Environmental Assessment processes are appropriately applied. Transport Canada completes Environmental Assessments for projects relating to a physical work or physical activity, including proposed oil and gas projects (Transport Canada 2010a).

With respect to Canadian mining related ports, Transport Canada is responsible for serving the operations of marine cargo vessels. Transport Canada has authority over the Canadian Port Authorities (CPAs) and owns and manages several ports. They provide and monitor the service standards for the marine and port facilities, emplace and collect public port fees, organize notices and consolations to the port communities and, as part of the Port Divestiture Program, they categorize regional, local, and remote ports (2010b).

Transport Canada follows the policies, regulations, and programs of the federal government concerning environmentally friendly means of transportation. Transport Canada seeks to set examples to its own employees and to convey the message to other federal departments on how to reduce air pollution caused by vehicle transportation (Transport Canada 2010c).

Legislation and Regulations

Navigable Waters Protection Act (1985) – The purpose of the *Navigable Waters Protection Act* (1985) is to ensure unimpeded navigation along navigable waters in Canada. The act protects the public constitutional right to navigation by requiring approvals for bridges, dams, booms, causeways or any other structures that substantially interfere with navigation. The administrative definition of navigable waters is any body of water which is capable, in its natural state, of being navigated by floating vessels of any description for the purpose of transportation, recreation or commerce, and includes a canal or any other body of water created or altered for public use as a result of the construction of any work.

The authority to determine the navigability of a waterway is the sole responsibility of the Minister of Transport Canada or a designated representative. An approval issued under the *Navigable Waters Protection Act* (1985) authorizes site specific works and the associated plans and their effect on navigation. Applicable regulations under the act include:

- the *Navigable Waters Bridges Regulations*; and
- the *Navigable Waters Works Regulations*.

Canada Shipping Act (2001) - The *Canada Shipping Act* concerns marine navigation, marine search and rescue, pleasure craft safety, marine ship-source pollution prevention and response, lighthouses, receiver of wrecks, and support to other federal departments and agencies. The Minister of Transport has authority under the act, along with limited responsibility by the Minister of DFO. Relevant regulations under the act include those described below.

Permits, Authorizations & Licences

Navigable Waters Protection Act (1985) Approval - Any works in, on, over, under, through or across navigable waters that would substantially interfere with navigation cannot proceed without a *Navigable Waters Protection Act* Approval given by Transport Canada. In some situations, an application for a *Navigable Waters Protection Act* Approval may trigger an EA by CEAA.

LAND CLAIM ORGANIZATIONS

Within Nunavut, jurisdiction over resource development (e.g., mining and the oil and gas sectors) varies with the type of land holder for the area.

Under the NLCA, 944 parcels (16% of Nunavut, 350,000 square kilometres [km^2]) of Inuit Owned Land (IOL) were established where Inuit hold surface title only (surface IOL). The Crown retains mineral rights to these lands. The remaining 150 parcels (2% of Nunavut, 38,000 km^2) of IOL were established where Inuit hold both surface and subsurface title (including mineral rights). Access to surface and subsurface IOL must be obtained from the appropriate Regional Inuit Association (RIA) in the form of a land use licence or commercial lease (INAC *et al.* 2008). The Crown owns the mineral rights to the remaining 98% of Nunavut. Access to surface and subsurface Crown land is granted through AANDC's land use permits.

Screening agencies are typically the first to consider resource development proposals. If they consider the proposed activities to be acceptable (e.g., environmentally, socio-economically), then applications are forwarded to the relevant land and water board for consideration for permit and licence approvals.

Land and water boards review proposed development projects and issue Land Use Permits and Water Licences when the proposed activities are considered acceptable and approved. There are typically two types of these permits and Water Licences (similar to those issued by AANDC):

- Type A Land Use Permits are for larger development projects with more significant environmental impacts;
- Type B Land Use Permits are for smaller development projects with less significant environmental impacts;
- Type A Water Licences are for larger development projects with more significant environmental impacts; and
- Type B Water Licences are for smaller development projects with less significant environmental impacts.

Land and water boards may also provide comments on applications that are being considered on Crown Land within the land claim areas or designated settlement regions INAC *et al.* 2008).

3.1.16 Nunavut Tunngavik Incorporated (NTI) - Department of Lands and Resources

"The Department of Lands and Resources promotes and protects Inuit interests in the lands and resources of Nunavut. The Department manages IOL on behalf and for the benefit of all Inuit, so as to promote economic self-sufficiency in accordance with Inuit social and cultural needs and aspirations" (Nunavut Tunngavik Incorporated [NTI] 2008a).

Relevant Roles and Responsibilities

NTI is an Inuit-owned corporation which oversees the implementation of the NLCA. The Department of Lands and Resources is responsible for implementing Inuit responsibilities related to the management of IOL, the environment, minerals, oil and gas, and marine areas (INAC *et al.* 2008).

The Department of Lands and Resources provides support and advice on matters related to land administration, land use planning and land management, environmental protection, water and marine management, and minerals to the RIA, other Designated Inuit Organizations and other NTI departments and executive members. It directly administers and manages subsurface IOL on behalf of Inuit (NTI 2008a). There are two types of mineral tenure that grant exclusive rights on subsurface IOL, administered by NTI:

- the *Inuit Owned Lands Mineral Exploration Agreement* provides exclusive rights to explore / prospect for minerals excluding oil and gas and specific substances within an exploration area on a portion of subsurface IOL; and
- the *Inuit Owned Lands Mineral Production Lease* grants the holder of an exploration agreement the right to produce minerals from a portion of the exploration area referred to as the Production Lease Area (INAC *et al.* 2008).

The department works with government institutions, Designated Inuit Organizations (DIOs) and others to develop and amend acts, legislation, regulations, guidelines, plans, policies and procedures relating to lands and resources in Nunavut. It works with RIAs to develop policies and procedures for managing and administrating all IOL. The department also participates in the NIRB screening process, reviewing project proposals in Nunavut and the Nunavut Water Board licensing processes. It monitors Inuit royalties, works with GN regarding natural resource development on Crown land, implements NLCA responsibilities retained by NTI directly related to lands and resources (including for the mineral sector), and coordinates the efforts of the department's Lands Policy Advisory Committee (LPAC; NTI 2008a).

Permits, Authorizations and Licences

NTI manages mineral exploration and development on subsurface IOL and is responsible for issuing exploration licences, concession agreements and leases on subsurface IOL (NTI 2008a).

Relevant Activities

NTI holds mineral titles (including oil and gas rights) to thousands of square kilometers of IOL in Nunavut on behalf of the area's Inuit, enabling NTI to participate in the minerals industry. The Minerals Division of NTI works to promote these mineral rights and enters into exploration agreements with various exploration and mining companies, and then collects fees and rents from those agreements (NTI 2008b).

Relevant Policies

***NTI Policy Concerning Uranium Mining in Nunavut* (2007)**

Prior to 2007, the Keewatin (Kivalliq) Regional Land Use Plan (through the Nunavut Planning Commission [NPC]) had prohibited uranium mining in Nunavut until Nunavut's environmental management boards had reviewed all of the issues relevant to uranium exploration and mining, and stated that any future proposed mining of uranium had to be approved by the people of the region (NPC 2000a).

In 2006, the Lands Policy Advisory Committee (LPAC), comprised of NTI and vice presidents of the RIAs, created a comprehensive *Draft Policy Concerning Uranium Mining in Nunavut* (NTI 2006). A draft uranium policy was developed by LPAC and circulated for review and comment to community organizations, the NIRB, NWB, the NPC, the NWMB, the GN, AANDC, Inuit Tapiriit Kanatami (ITK), Inuit Circumpolar Conference (ICC), CNSC, and several exploration and mining companies.

In 2007, NTI adopted the draft uranium policy as the *Policy Concerning Uranium Mining in Nunavut.* The policy supports uranium mining, and uranium-related exploration, providing those activities are carried out with the objectives and policy statements set out in the policy, NTI's other policies, and all regulatory requirements (NTI 2007).

The purpose of this policy is:

- to state NTI's position on matters related to uranium exploration and mining;
- to guide NTI and the RIAs in exercising their responsibilities on Inuit Owned Land (IOL) by setting out specific measures to allow for appropriate uranium exploration and mining on these lands;
- to guide NTI's role as a participant or intervener in regulatory processes related to uranium mining and exploration;
- to provide clarity for users of IOL; and
- to guide specific initiatives to support implementation of the policy.

NTI's Mining Policy's objectives are to minimize the negative impacts of exploration and mining, maximize benefits of the mining industry for Inuit, promote and attract mining investment in the territory, resolve land use conflicts, and improve communications, consultation and coordination amongst stakeholders (NTI 2007).

3.1.17 Regional Inuit Associations (RIAs)

There are three RIAs in Nunavut, with the following mandates:

- **Kitikmeot Inuit Association** – *"The objectives of the Kitikmeot Inuit Association, under the Nunavut NLCA [are] to defend, preserve and promote social, cultural and economic benefits to Inuit of the Kitikmeot Region"* (Kitikmeot Inuit Association 2010).
- **Kivalliq Inuit Association** – *"The [Kivalliq Inuit Association] mission is to represent, in a fair and democratic manner, Inuit of the Kivalliq Region in the development, protection, administration and advancement of their rights and benefits as an aboriginal people; as well as to promote their economic, social, political and cultural well being through succeeding generations"* (Kivalliq Inuit Association 2010).

- **Qikiqtani Inuit Association** – *"The Qikiqtani Inuit Association (QIA) is aimed at representing the interests of the Inuit of the Baffin Region, High Arctic and Belcher Islands in a fair and democratic way"* (QIA 2007).

Relevant Roles and Responsibilities

Surface title to all IOL is held in each region by the respective RIAs on behalf of Inuit. Access to surface IOL must be obtained from the appropriate RIA in the form of a land use licence or commercial lease (INAC et al 2008).

The three RIAS, which along with other organizations are also referred to as Designated Inuit Organizations (DIO), are affiliated with the NTI; the NTI Board of Directors is drawn from the RIAs. Each RIA acts to represent the interests of all Inuit living in their respective regions. They have ownership and responsibility for administering surface lands in their regions as well as implementing regional responsibilities under the NLCA. Each RIA is comprised of several departments which are responsible for variable issues such as economic development (including mineral development activities), business development, and administering access to IOL (Kitikmeot Inuit Association 2010; Kivalliq Inuit Association 2010; INAC et al. 2008; QIA 2007).

3.1.18 Institutions of Public Government under the Nunavut Land Claims Agreement

The Nunavut Planning Commission (NPC), the Nunavut Impact Review Board (NIRB), the Nunavut Water Board (NWB), the Nunavut Wildlife Management Board (NWMB) and the Inuit Surface Rights Tribunal are Institutions of Public Government (IPG) under the NLCA. They cooperate and coordinate their reviews, screening and application processing efforts of development projects in Nunavut.

3.1.18.1 Nunavut Planning Commission (NPC)

The NPC is an IPG established under the NLCA to develop land use plans for Nunavut (NPC 2011a). The NPC is a co-management organization with authority and decision-making responsibilities protected under the NLCA. It consults with government, Inuit organizations and other organizations and decides on how land use plans will be developed to manage the land in Nunavut. The federal government, NTI and the three RIAs are included in the approval process (NPC 2011a).

Relevant Roles and Responsibilities

The NPC identifies community, regional and Nunavut-wide goals, incorporates existing information, updates existing plans, and provides general guidance on land use across Nunavut. The Nunavut Land Use Plan is an important tool for issues related to Nunavut land and waters use and management (NPC 2011a).

The NPC reviews all applications for project proposals (e.g., mining) to determine whether the project conforms to the relevant land use plan. If it does not conform, an application to the AANDC Minister may be made for an exemption and then it must undergo NIRB screening; and the reasons for the exemption must made public (NPC 2011a).

Relevant Activities

Nunavut Land Use Plan - The NPC is in the process of developing the Nunavut Land Use Plan (NPC 2011b). It will address regional and community land use planning issues. It will include updated information from the three regional land use plans (below) and be designed to manage land, resources, wildlife and marine areas within the Nunavut Settlement Area outside of municipal and park areas. Work still to be completed includes incorporation of feedback on Priority Areas Map, community workshops, finalization of the plan, a public hearing, and then the submission of the final draft Nunavut Land Use Plan for approval (NPC 2011b).

The NPC has also completed two regional land use plans in Nunavut:

Keewatin Regional Land Use Plan (2000) - The Keewatin Regional Land Use Plan (NPC 2000a) addresses mining issues, and distinguishes between issues regarding general minerals mining versus uranium mining specifically. Terms for the mining industry are described which address the conditional ban on uranium development. It specifies that proposals for mining developments must include adequate plans for mine closure and site restoration and describes many other procedures for the mining sector in the region (NPC 2000b). Other mineral, oil and gas development and exploration issues, marine and terrestrial transportation and infrastructure issues, and clean-up and waste management issues are also addressed in the plan (NPC 2000a).

North Baffin Regional Land Use Plan (2000) - The North Baffin Regional Land Use Plan (NPC 2000c) also deals with resource development issues as described for the Keewatin Regional Land Use Plan (above).

Mapping - The NPC maintains an interactive mapping program on its website. One search option shows mapped details of Nunavut's mineral exploration activities and locations (NPC 2011c).

3.1.18.2 Nunavut Impact Review Board (NIRB)

The NIRB was created with the signing of the NLCA as an IPG. The NIRB was assembled to ensure that the potential impacts on the biophysical and socio-economic environments of proposed developments in the Nunavut Settlement Area are thoroughly assessed (NIRB 2010a).

Relevant Roles and Responsibilities

Using both traditional knowledge and recognized scientific methods, the NIRB assesses the biophysical and socio-economic impact of proposed projects and makes recommendations and decisions about which projects may proceed. The NIRB may also monitor the impacts of projects that have been reviewed and approved to proceed (NIRB 2010a). Section 3.2 provides complete description of the role of NIRB in the environmental assessment process.

The NIRB screens resource development project proposals to determine whether they are likely to have significant environmental or socio-economic effects or public concern. In the opinion of the NIRB, if effects are determined to be adverse, the project must be reviewed under Part 5 or 6 of the NLCA. The NIRB makes recommendations regarding the issuance of licences in the Nunavut Settlement Area. These recommendations are made to the responsible federal or territorial Minister (e.g., the AANDC Minister; NIRB 2010b). If development projects have the potential to result in negative environmental and / or socio-economic impacts, the NIRB will develop the project-specific guidelines for an Environmental Impact Assessment to be completed by the proponent for review by the NIRB.

Permits, Authorizations and Licences

The NIRB issues certificates of authorization that allow projects to proceed, and stipulates terms and conditions under which those projects may proceed (NIRB 2010b).

Relevant Activities

Project Monitoring - The NIRB has the authority to establish project-specific monitoring programs for projects. These programs may be in the form of effects monitoring (i.e., measuring and interpreting changes to environmental and socio-economic parameters to determine relevant project effects) or compliance monitoring (i.e., determining how the relevant resource use is carried out in accordance with regulatory requirements, including the terms and conditions contained in the NIRB project certificates and / or screening decisions; NIRB 2008a).

Guides - The NIRB has a series of guides that are available to provide information about the NIRB and its processes. They include guides on “Filing Project Proposals and the Screening Process”, “Projects Exempt from Screening”, and the “Preparation of Environmental Impact Statements” (NIRB 2010b).

3.1.18.3 Nunavut Water Board (NWB)

“The NWB is an IPG that was created under the NLCA in 1996. It has responsibilities and powers over the use, management and regulation of inland water in Nunavut and its objectives are to provide for the conservation and use of waters in Nunavut – except in national parks – in a manner that will provide the optimum benefits for the residents of Nunavut in particular and Canadians in general” (NWB 2010a).

Relevant Roles and Responsibilities

The NWB is part of a larger management regime comprised of other IPGs (e.g., the Nunavut Surface Rights Tribunal, the NIRB, and the NPC) and other land and resource management bodies. It manages and regulates the use of inland fresh water to ensure that the conservation of water and the optimum use of water are achieved (NWB 2010a). It does not have regulatory jurisdiction over marine areas but it does have an advisory function over marine areas in Nunavut on its own as well as through the Nunavut Marine Council (NWB 2010a).

Under the *Nunavut Waters and Nunavut Surface Rights Tribunal Act, S.C. 2002, c. 10,* the NWB can issue, renew, amend and cancel water licences. The NWB regulates mining exploration (including for uranium) through water licences. The NWB must approve all water uses, including the deposit of waste into water, except domestic and emergency uses of water. The NWB may hold public hearings before it issues a licence but typically does not do so for uranium exploration permits (Nunavummiut Makitagunarningit 2010). The NWB does not have enforcement powers; its jurisdiction is limited to the issuance of Water Licences. AANDC is responsible for the compliance and enforcement of water licences and provisions of the *NWT Waters Act* (NWTWA; 1992; NWB 2010a).

The *NWT Waters Act* (1992) regulations will continue to apply in Nunavut until the new Nunavut Water Regulations established under the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (2002) are finalized (NWB 2010b).

3.1.18.4 Nunavut Wildlife Management Board (NWMB)

The mandate of the NWMB is to ensure the protection and wise use of wildlife and wildlife habitat for the long-term benefit of Inuit, as well as other residents of Nunavut and Canada (NWMB 2011).

Relevant Roles and Responsibilities

The NWMB is a decision-making body on terrestrial and marine wildlife-related issues with advisory authority in the waters adjacent to Nunavut. Even though the ultimate responsibility for wildlife management in the territory is under the jurisdiction of territorial and federal governments, those governments' decisions are based on the NWMB's guidance on Nunavut's wildlife. The NWMB is funded by AANDC and is accountable to AANDC and the general public, but takes direction from the NLCA, not government (NWMB 2011).

Relevant Activities

The NWMB participates in research and other activities related to Nunavut's wildlife. It makes recommendations to the NPC on planning matters in wildlife management zones and areas of high biological productivity. It establishes wildlife harvest quotas, approves management and protection plans for wildlife and their habitats, and sets trophy fees. It advises governments, the NIRB and others on compensation that should come from developers (e.g., mines) that damage wildlife habitat. The NWMB also provides advice and recommendations to the government on Marine Zones I and II which are adjacent to Nunavut, including on development activities in those zones (NWMB 2011).

3.1.18.5 Surface Rights Tribunal

"The Nunavut Surface Rights Tribunal is responsible for regulating entry and access to lands, for determining rights of, and compensation payable to, the titleholder and for determining the amount for wildlife compensation claims in the Nunavut Settlement Area" (INAC *et al.* 2008).

Relevant Roles and Responsibilities

The Surface Rights Tribunal was established under the NLCA to resolve conflicts regarding land claims in the territory. These occur where Inuit have the right to occupy or use the land but where a third party holds subsurface rights (such as where Inuit are granted hunting rights but the Crown may grant subsurface rights to a mining company). When land uses conflict (e.g., hunting and mining on the same land) the Surface Rights Tribunal would be called upon to resolve the land use conflict (Sosa and Keenan 2001).

INTERGOVERNMENTAL AGENCIES AND ORGANIZATIONS

3.1.19 Canada-Nunavut Geoscience Office (C-NGO)

The Canada-Nunavut Geoscience Office (C-NGO) provides accessible geoscience information and expertise in Nunavut in support of responsible exploration and development of mineral and energy resources, geoscience education, training, and capacity building (C-NGO 2011).

The C-NGO is a partnership between the Geological Survey of Canada, AANDC, and the GN (Department of Economic Development and Transportation; C-NGO 2011). The C-NGO undertakes regional-scale geosciences mapping and research projects, targeted geosciences projects, manages and disseminates publically-accessible geosciences databases and reports, and provides scientific expertise to support resource development in Nunavut (C-NGO 2011).

3.1.20 Mine Environment Neutral Drainage

The Mine Environment Neutral Drainage (MEND) program was initiated to develop and apply technologies to prevent and control acidic drainage at mines. Priorities of the program include verification of full-scale mitigation technologies, closure management, early prediction, neutral and alkaline pH drainage, sludge management, passive treatment and cold temperature effects. Additionally, MEND contributes to the production of case studies, guidance documents and technology transfer activities related to acid drainage at mine sites. NRCan and the Mining Association of Canada (MAC) jointly fund the program (NRCan 2011l; MEND Date Unknown).

NON-GOVERNMENTAL ORGANIZATIONS

3.1.21 Canadian Aboriginal Minerals Association

The Canadian Aboriginal Minerals Association (CAMA) is a non-profit organization that was formed to address the need expressed by Aboriginal communities for equitable Aboriginal involvement in the development of land and resources. CAMA supports Aboriginal communities by: increasing involved parties' understanding of the mining industry, Aboriginal mining, and the interests of Aboriginal communities in lands and resources; promoting economic development, environmental management and environmental protection in Aboriginal communities; and promoting cooperation between mining companies and Aboriginal communities to help advance economic self-sufficiency in Aboriginal communities. In addition, CAMA holds an annual conference on the resource industry and Aboriginal community development and presents a variety of workshops (CAMA 2011).

3.1.22 The Mining Association of Canada (MAC)

MAC is a national organization of the Canadian mining industry made up of companies engaged in mineral exploration, mining, smelting, refining and semi-fabrication. Its key role is to present industry information and views to the federal government. MAC provides information on the mining industry to the media and public institutions such as schools and libraries. It has an extensive publications program (MAC 2011).

MAC's stewardship initiative, *Towards Sustainable Mining,* launched in 2004, aims to sustain the mining industry's role as an important economic player by increasing public trust in its ability to responsibly manage environmental and social issues. The initiative is focussed on improving the mining industry's reputation by increasing its performance and aligning its actions with the priorities and values of affected communities (MAC 2011). MAC also produced a variety of guidelines and manuals with respect to tailings facilities (Task 1 Report)

3.1.23 NWT and Nunavut Chamber of Mines

"*The NWT and Nunavut Chamber of Mines has the responsibility and mandate to represent the interests and concerns of the mining industry in the Northwest Territories and Nunavut*" (NWT and Nunavut Chamber of Mines 2010).

Relevant Roles and Responsibilities

The Chamber addresses the major issues facing the mining industry, including: land alienation and single-use land withdrawals, increasing public awareness of mining's substantial economic and social roles in northern development, mineral policy and legislation and environmental regulation, taxation issues, the long-standing need for a broader base of infrastructure support, and devolution of responsibility for mineral resources from the Federal to territorial government (NWT and Nunavut Chamber of Mines 2010).

Relevant Activities

In addition to the above listed activities, the Chamber organizes an annual northern Geoscience Forum, an annual Mining Week, and develops publications and resources on mining and exploration activities (NWT and Nunavut Chamber of Mines 2010).

3.1.24 The Prospectors and Developers Association of Canada

"*The Prospectors and Developers Association of Canada (PDAC) exists to protect and promote the interests of the Canadian mineral exploration sector and to ensure a robust mining industry in Canada. The PDAC will encourage the highest standards of technical, environmental, safety and social practices in Canada and internationally*" (PDAC 2012a).

PDAC represents the interests of the Canadian mineral exploration and development industry by participating in activities and providing services related to advocacy, information and networking. This includes organizing conventions, trade shows and investors exchanges. PDAC also has a number of programs, such as the "e3 Plus Program". The e3 Plus Program provides a framework for responsible mining exploration regarding environmental stewardship, health and safety and social responsibility. Among the goals of the programs is to produce good practice guidelines in this respect (PDAC 2012a; PDAC 2012b).

PDAC membership includes individuals (*e.g*., prospectors, developers, geoscientists, consultants, mining executives, students, and people involved in the drilling, financial, investment and legal fields) and corporations (*e.g*., mining companies and mining-related service providers; PDAC 2012a).

3.1.25 MiningWatch Canada

MiningWatch Canada is a NGO active across Canada that is supported by environmental, social justice, Aboriginal and labour organizations. Its objectives concern mineral development and include ensuring that practices are consistent with goals of sustainable communities and ecological health, strengthening technical and strategic skills within affected parties, supporting appropriate terms and conditions on mining that prevent negative impacts, and advocating policies to improve efficiency and reduce risks associated with mineral development activities (MiningWatch Canada 2010).

MiningWatch Canada maintains a newsarticles database where it writes, co-writes and provides detailed mining-related news articles for public review on its website (http://www.miningwatch.ca/). MiningWatch Canada also distributes a quarterly newsletter to interested recipients. These newsletters are also available on the MiningWatch website (MiningWatch Canada 2010).

3.2 Specific Requirements for Permits and Licences for Mine Construction and Operation in Nunavut

When applying for development of a mine and associated infrastructure (e.g., roads, staging areas, camp sites) in Nunavut, the developer has to submit a variety of permit and licence applications and present their project description for review.

As described earlier, the *NLCA* established five IPG in Nunavut (INAC *et al.* 2008), all involved in the approval process of development activities in Nunavut. The following provides a brief summary of the process:

- The **Nunavut Impact Review Board** (NIRB) reviews all Environmental Assessments (EAs) for proposed projects for development activities, including mining related projects. If required (i.e., negative environmental and/or socio-economic impacts are likely) an EIS are prepared by project proponents according the guidelines issued by the NIRB. The NIRB's role is to issue guidelines for EIS on a project-specific basis, and to assess potential environmental and socio-economic impacts of proposed development in Nunavut prior to approval from the required agencies. Using both Traditional Knowledge and scientific methods, the NIRB recommends which projects can go ahead and under what conditions.

The EA process is the best opportunity to influence the planning and design of mines to incorporate climate change and build adaptive capacity.

- The **Nunavut Planning Commission** (NPC) ensures that projects conform to approved Land Use Plans.
- The **Nunavut Water Board** (NWB) is in charge of regulating and managing inland water use and disposal through issuing water licenses.
- The **Nunavut Wildlife Management Board** (NWMB) protects and conserves wildlife using traditional Inuit and scientific knowledge.
- The **Surface Rights Tribunal** resolves any upcoming disputes between government, Inuit organization and industry.

There are three Regional Inuit Associations (RIAs) — the ***Kivalliq Inuit Association***, the **Kitikmeot Inuit Association** and the **Qikiqtani Inuit Association** (NTI 2008b). The RIAs are administering Inuit Owned Lands (IOLs) in their respective regions through the issuing of land use licences to companies that plan development projects that are located (partially or completely) on IOLs of the respective region. Proponents of large development projects that could provide a benefit for Inuit also need to negotiate an Inuit Impact Benefit Agreement (IIBA) with the RIAs as stipulated in the *NLCA*. IIBAs are compensation agreements that are required between a company proposing a “major development project” (defined in the *NLCA*; typically projects that may have substantial effects on Inuit) and the involved Designated Inuit Organization (DIO; such as the RIA of the affected region). The AANDC Minister has some authorities with respect to the approval of an IIBA (Sosa and Keenan 2001). IIBAs are likely to be required for any proposed mining activities for Nunavut. RIAs are supported by NTI and Surface Rights Tribunal in the case that resolution is needed (NTI 2008b).

Crown land in Nunavut is administered through **Aboriginal Affairs and Northern Development Canada** (AANDC). AANDC will issue land use permits if any project components fall within Crown land. Commissioners land (around highways and communities) is managed and administered by the GN.

The **Nunavut Research Institute** (NRI) is the territorial licensing agency that issues scientific research licences under the *Nunavut Scientist Act*. Most types of environmental sampling and health and social research studies in Nunavut require a scientific licence from the Institute (Inuit Tuttarvingat 2011).

If the development has the potential to impact fish-bearing water bodies, a Section 35 *Fisheries Act* Authorization needs to be obtained from **Fisheries and Oceans Canada** (DFO). This authorization regulates projects in or around water where fish habitat may be negatively affected and will consider HADD of fish habitat to request appropriate compensation (DFO 2010d). There are also a number of DFO Operational Statements (OS) for Nunavut that may also apply to the development of associated infrastructure that need to be adhered to at all times (e.g., Mineral Exploration Activities OS, Bridge Maintenance OS, Clear Span Bridge OS, Culvert Maintenance OS; Ice Bridge OS; DFO 2011a)

If parts of the proposed development interfere with public navigation, e.g., the installation of bridges or culverts, the developer needs to obtain a Navigable Water Permit from **Transport Canada** (Transport Canada 2010a).

Depending on the location of their development activities, companies may need additional licences or permits from other Canadian agencies. For example, companies may require permission from **Environment Canada** to access migratory bird sanctuaries and wildlife conservation areas. Or they may require a review by Joint Parks

Management Committees according to **Parks Canada** protocol if any portions of the project fall within national parks land (Inuit Tuttarvingat 2011).

In summary, there are very few agencies involved with the regulatory process of (or otherwise related to) the mine development process in Nunavut that consider climate change impacts on mining infrastructure. The NIRB requires that all Valued Ecosystem Components (VECs; e.g., climate, and by extension climate variability and climate change) are taken into consideration. However, there is no policy or regulation that explicitly addresses mine-related and large infrastructure vulnerability to climate change and potential Adaptation Measures. The NIRB develops Draft EIS guidelines on a project-specific basis and provides significant influence on the planning and design process of mines. Developers must incorporate climate variability and change into their project proposals through the development of potential climate change scenarios and adaptive design of mining infrastructure components.

Figures 2 and 3 provide an overview of key element discussed throughout Section 2. Figure 2 describes the regulatory process for a mine site in Nunavut, from the prospecting stage to abandonment. Figure 3 describes the environmental assessment process in Nunavut for proposed mining projects.

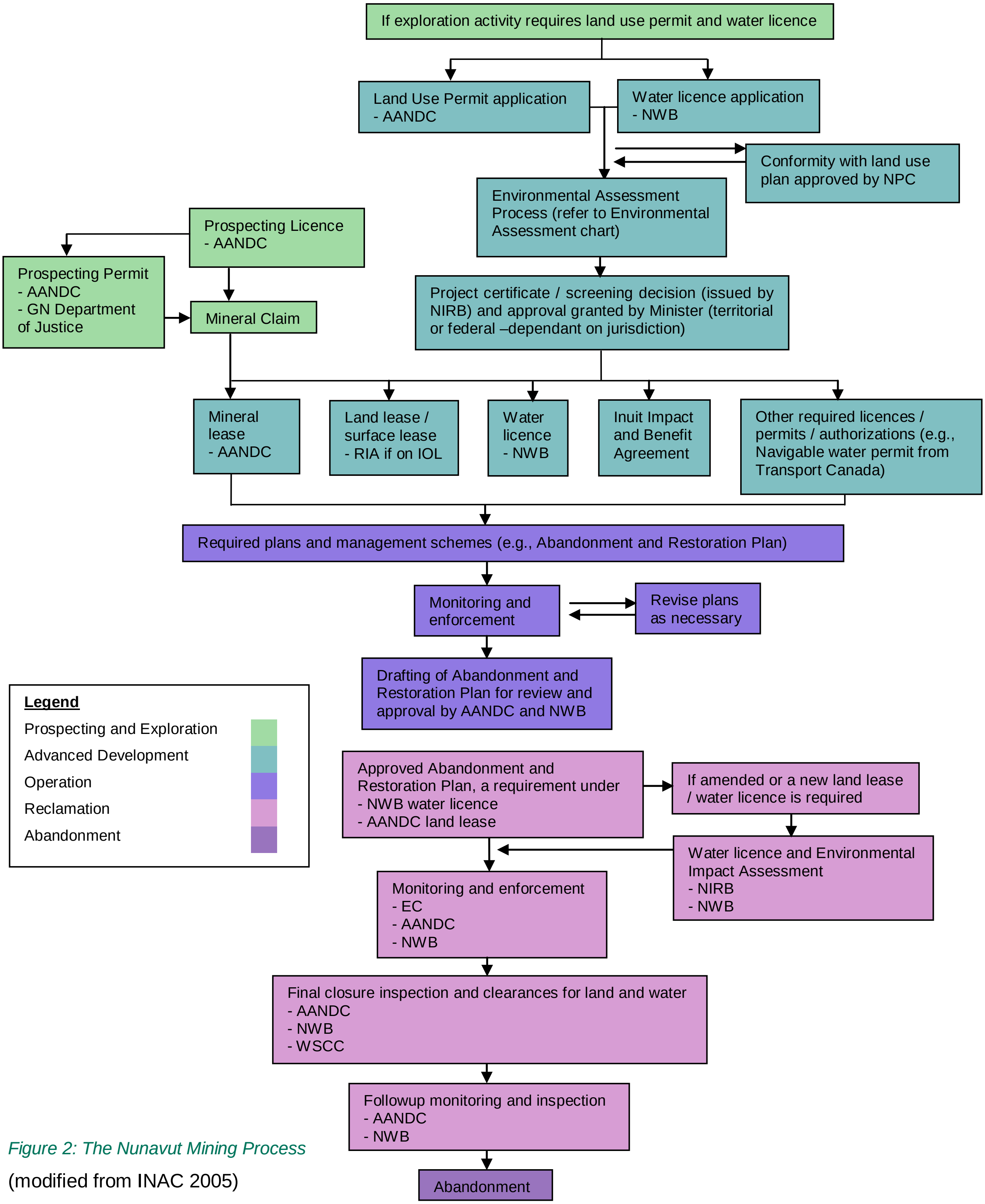

Figure 2: The Nunavut Mining Process

(modified from INAC 2005)

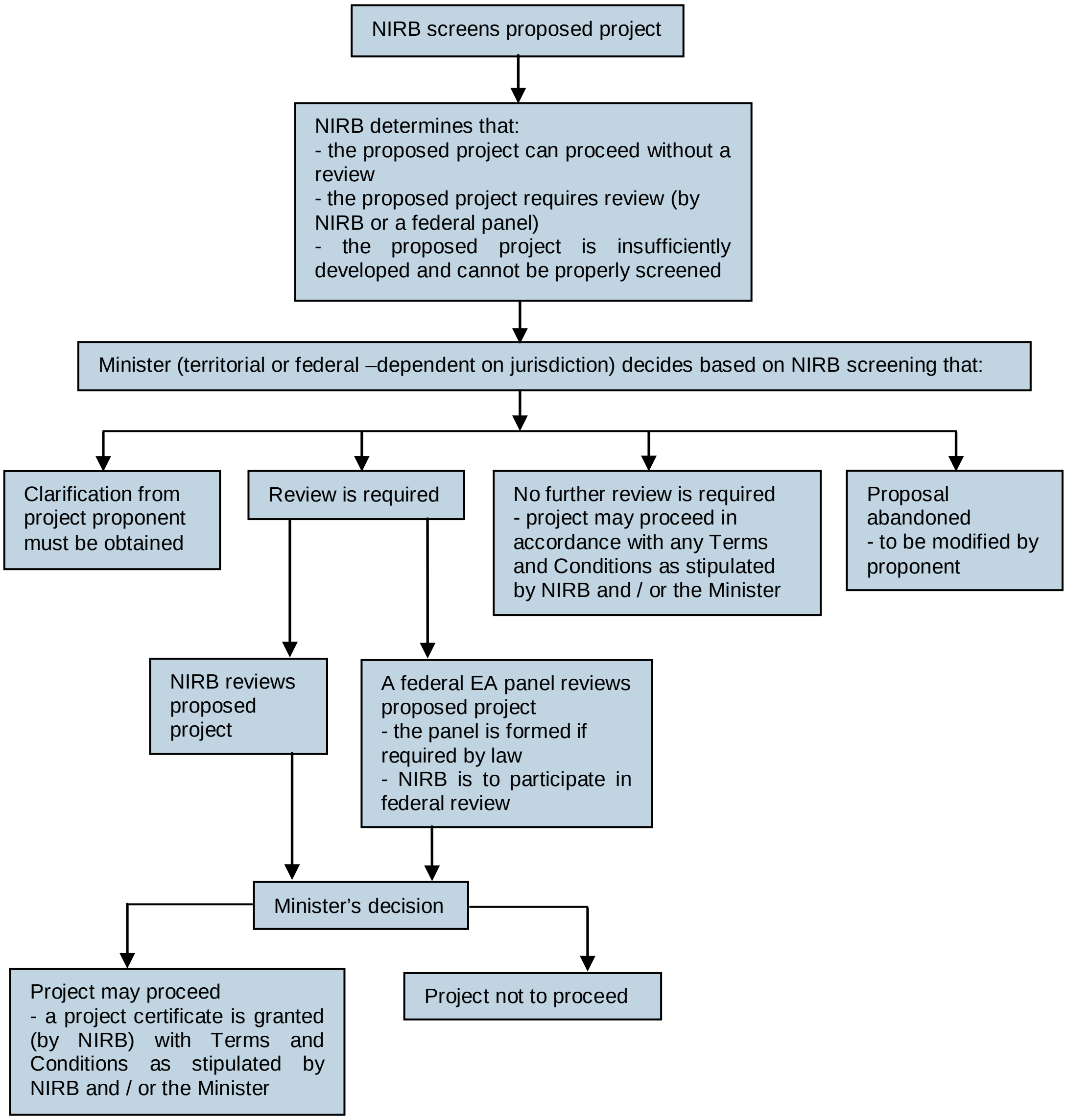

Figure 3: Nunavut Environmental Assessment Process for Mine Development (modified from INAC 2005)

4.0 EXISTING GUIDELINES FOR GOOD ENVIRONMENTAL PRACTICES IN PERMAFROST REGIONS

This section provides an overview of good environmental practices developed for mining related infrastructure by EC (2012a) with a focus on tailings management facilities. Note that these practices were developed for all of Canada and with no specific focus on climate change. They are described briefly in this section to provide an overview of existing Environmental Good Practices. CEAA has also published guideline documents for incorporation of climate change (referred to in Section 3) and NRCan's MEND program (Section 3) provides relevant input to best practices.

Please note that other Adaptation Measures utilized in mine development, engineering design and assessment of environmental effects are summarized in the Task 1 Report (Canadian Standards Association [CSA; 2010] and Transportation Association of Canada [TAC; 2010]). A risked-based screening tool, developed by EC in 2008 is frequently utilized by engineers to determine the level of analysis required with respect to climate change. This screening tool has been used for design of dams for Ekati and components of other northern mines. However, there is no formal guidance linking these Adaptation Measures into the Environmental Assessment process.

4.1 The Environmental Code of Practice for Metal Mines

A multi-stakeholder review of the aquatic effects of the mining sector and its regulations was initiated, and resulted in the development of the *"Assessment of the Aquatic Effects of Mining in Canada"* (AQUAMIN) which recommended updates to the original Environmental Code of Practice for Metal Mines.

The Environmental Code of Practice for Metal Mines (the Code) supports the *2002 Metal Mining Effluent Regulations (MMER)* under the *Fisheries Act* (1985). Although the MMER deal with many of the environmental impacts of mining operations, the Code addresses additional issues of concern (EC 2012a).

The MMER apply to all metal mines (except placer mines) in Nunavut and Canada that:

- exceed an effluent flow rate of 50 cubic meters (m^3) per day; and
- deposit effluent info fisheries waters (after the 2002 MMER regulations were put in place).

Mines operating under the MMER must conduct Environmental Effects Monitoring (EEM) programs to assess the impacts of mining effluent on the receiving aquatic environment, particularly as they relate to fish, fish habitat, and the utilization of fisheries resources (EC 2012a).

Recommendations provided in the Code do not carry regulatory status. The Code is a guidance document that recommends environmental protection practices for metal mines, described in this Report as best practices (limited to those for mines in permafrost areas).

The Code addresses all phases of the mining life cycle (Section 2) and aims to identify and promote recommended best practices to improve the environmental performances of mining facilities in Canada. It deals with environmental issues including air, water, waste management and biodiversity (EC 2012a).

4.2 Exploration and Feasibility

4.2.1 Environmental Concerns

While the environmental practices in EC's document were developed for all of Canada, only those best practices have particular relevance to the mining sector in northern environments are described in the below section.

The environmental concerns of initial exploration and feasibility activities may be considered relatively small, and are primarily concerned with non-intrusive practices that have limited, short-term environmental impacts. Work is typically conducted over short periods of time, and based out of temporary work camps with few people (EC 2012a).

In general, exploration activities which cause potential environmental impacts can include the following (EC 2012a):

- access / line cutting – terrestrial / wildlife habitat; stream crossings;
- geophysical surveys – noise impacts on wildlife from aircraft;
- field camps – sewage / garbage disposal, water supplies, fuel storage; impacts on terrestrial / wildlife habitat;
- trenching / pitting – physical scarring / land disturbances; acid generation (from exposed sulphide minerals); metal leaching; sediment erosion; blasting impacts on wildlife;
- drilling – water supply; drilling fluid disposal; fuel storage / spills; groundwater contamination; physical scarring / land disturbances; acid generation; released metal-bearing groundwater; diamond drilling;
- bulk sampling – above issues with potentially larger impacts; reclamation considerations; dewatering impacts on receiving water (historic mine workings); and
- exploratory mining – smaller-scale versions of the potential impacts of full-scale mining operations.

4.2.2 Best Practices in Permafrost Conditions

The use of off-road vehicles in northern areas should be limited to low-ground pressure equipment to minimize potential impacts on permafrost. Access to mining sites in permafrost areas should occur by aircraft whenever possible.

When exploration activities have identified that a site is not targeted for further development, reclamation and closure planning for the exploration area should include the removal of all machinery, equipment and structures (e.g., water intakes, culverts, docks and buildings), ensuring that waste dumps, sumps and drill holes are properly capped, and ensuring that disturbed areas are revegetated or rehabilitated to assist reinstating permafrost conditions (EC 2012a).

4.3 Planning and Construction

4.3.1 Environmental Concerns

Site preparation and the construction of associated infrastructure are phases of a mine's life cycle that can cause a variety of environmental impacts. Concerns include impacts to air, water and soil quality, impacts to aquatic and terrestrial ecosystems, and impacts from anthropogenic noises.

The following list provides some specific examples of environmental concerns identified in the Code. These and other concerns relating to the planning and construction phases of mines (EC 2012a):

- slope failures on waste rock piles can impact aquatic / terrestrial habitat and compromise measures to prevent / control acidic drainage;
- failures of tailings management facilities can cause severe impacts on aquatic / terrestrial ecosystems and pose significant risks to human health and safety;
- pipeline failure can have significant impacts on aquatic and terrestrial ecosystems;
- using conveyor systems increases risks of airborne particulate matter; and
- eroded sediment that is mobilized into the environment can enter waterbodies and impact fish and fish habitat.

4.3.2 Best Practices in Permafrost Conditions

Best practices applicable for planning and construction activities particularly relevant in the North are (EC 2012a):

Designing for Extreme Weather Events – Water management planning for a mine site should consider extreme weather events, and be designed to handle the peak conditions of 100 year flood events. However, as increases in extreme weather events may be expected to be increasing as a result of global climate change, the conventional planning for 100 year flood events may not be considered adequate. Water management infrastructure must be able to handle high precipitation events so the infrastructure is not overwhelmed, risking the release of untreated effluent (EC 2012a).

Acidic Drainage in the North – In northern environments, freezing waste rock or tailings in permafrost may be used to prevent or control acidic drainage (Task 1 Report). This may eliminate the potential of acidic drainage if designed properly with sufficiently thick cover to permanently encapsulate acid generating waste in permafrost. Planning for the use of permafrost as a method to prevent or control acidic drainage should include considerations such as (EC 2012a):

- potential construction material thaw in a future warmer climate; and
- alternative methods to prevent / control acidic drainage that do not depend on frozen materials.

Oxidation of sulphides in waste rock and tailings has potential environmental impacts, though oxidation is generally slower in cold, northern climates. Acidic drainage in colder regions can be slower because (EC 2012a):

- snow / ice cover can reduce rates of oxygen diffusion into waste material / rate of oxidation;
- materials encapsulated in permafrost have reduced oxidation rates; and
- low temperatures in the active layer (during summer) reduce oxidation reactions that do occur.

Threats that can increase acidic drainage in northern environments can include (EC 2012a):

- precipitation / seasonal snow melts can flush accumulated acid into the environment;

- oxygen is more soluble in cold water;
- sulphide mineral oxidation is an exothermic reaction (releasing heat energy) which can prevent / slow penetration of permafrost into waste materials; and
- climate change can result in future permafrost thawing (Task 1 Report), contributing to increased acid generation.

The six main Acid Mine Drainage (AMD) or Acid Rock Drainage (ARD) control strategies for permafrost regions are summarized in Table 1 (MEND 1996):

Table 1: Strategies to Control Acid Mine Drainage in Permafrost Regions*

Strategy	Tailings	Waste Rock
Freeze Controlled	-total or perimeter freezing options can be considered; -can freeze up to greater than 15m annually if freezing in thin layers; and -process chemicals could cause high unfrozen water contents.	-requires large volumes of non-acid waste rock for insulation protection; and -need better understanding of air and water transport through waste rock required for reliable design.
Climate Controlled	-may not be a reliable strategy for saturated tailings.	-requires control of convective air flow through waste rock, infiltration control with modest measures and temperature control; and -need better understanding of waste rock air, water, and heat transport for reliable design.
Engineered Cover	-special consideration for freeze-thaw effects; and -availability and cost of cover materials are major impediments to this option.	-same as for tailings; and -consider strategies offered by climate control.
Subaqueous Disposal	-special considerations for winter ice conditions and pipeline freeze-up.	-very difficult to dispose of waste rock beneath winter ice.
Collection and Treatment	-costly to maintain at remote locations; and -long term maintenance cost.	-costly to maintain at remote locations; and -long term maintenance cost.
Segregation and Blending	-tailings are normally geochemically homogeneous.	-may be very effective; -research and development currently ongoing.

*Source: MEND 1996.

Designing Containment Structures for Tailings Management Facilities – Strict engineering standards should be incorporated into the design and construction of containment structures for tailings management facilities. The facilities require long-term monitoring and inspection, with appropriate monitoring instruments installed during construction to enable monitoring throughout the mine operation and closure phases. When designing tailings management facilities, site-specific conditions such as permafrost, slopes, seismic activity and site drainage requirements should be considered (EC 2012a).

In northern environments, tailings dams need to use materials and construction methods that allow for potential permafrost thaw that would contribute to soil instability and settling. Such settling can cause differential movement and cracking of dam structures, internal erosion, and subsequent dam breaching. Dams can also be compromised when freshly deposited tailings melt permafrost and when the concentration of process liquids lowers the freezing point of soil water that is exposed to tailings (EC 2012a).

Northern Conditions and Permafrost Issues – The planning and construction of mines in the North need to take the uniqueness and sensitivities of the environment into consideration. Mines should be designed to minimize impacts to the environment (e.g., permafrost). Best practices for planning mine activities in permafrost regions should consider (EC 2012a):

- potential environmental impacts from airstrips, campsites / accommodation facilities, fuel / supply storage areas, survey lines, excavations, waste disposal sites, other infrastructure; mine component locations;
- the area's geography / vegetation / natural features (e.g., eskers, rivers streams, lakes, ponds, pingos); and
- on-going monitoring of permafrost conditions; and
- other conditions specific to the North such as:
  - extreme weather (long cold winters / short summers);
  - thin / sensitive vegetation cover;
  - low precipitation / arid conditions;
  - unstable bedrock conditions with thin / absent soil cover; and
  - wildlife vulnerabilities (particularly impact-prone species such as caribou / muskox / polar bear / migratory birds).

4.3.3 Climate Change and Adaptation

Managing Mine Sites in the Planning and Construction Phase – The potential impacts of climate change need to be considered throughout all aspects of mine planning and operations, particularly for water management and mine waste management and disposal. Regional long-term predictions of climate change (e.g., for temperature, precipitation and extreme weather events) should be considered (EC 2012a).

In permafrost areas, the potential impacts of climate change and deteriorating permafrost conditions should be considered for site infrastructure such as roads, pipelines and on-site buildings. Infrastructure that could be vulnerable to permafrost degradation should be planned, constructed and operated in a manner that reduces or eliminates those potential impacts (EC 2012a).

Best practices planning should incorporate strategies to reduce carbon releases into the atmosphere in all phases of a mine's life cycle (e.g., through using fuel efficient and/or alternative fuels in heavy equipment and vehicles; EC 2012a).

Managing Mine Sites in the Operations and Closure Phases – Regional long-term predictions of climate change should be consulted during mine operations and closure phases, and risk assessments conducted to determine if site infrastructure could be impacted by climate change. Adaptive measure can then be planned and implemented to reduce or prevent those potential impacts (EC 2012a).

Best practices planning should account for changing climatic parameters. For example, water management infrastructure that has been traditionally designed to withstand 1 in 100 year flood events may not be adequate if extreme precipitation events become more common and more extreme, or tailings management strategies that rely on water to cover the tailings may become vulnerable in extreme drought events, leading to metal leaching or acidic drainage of the tailings (EC 2012a).

In the North, climate and climate change impacts can be of particular concern. The following management strategies must be given careful consideration to determine their vulnerabilities to climate impacts (EC 2012a):

- permafrost encapsulation to prevent metal leaching / acidic drainage of waste materials (permafrost can thaw);
- frozen core dams / other containment structures designed to remain frozen to be structurally sound (can thaw and fail); and
- roads / airstrips / building foundations (at risk if permafrost deteriorates).

4.4 Mine Operations

4.4.1 Environmental Concerns

Environmental concerns associated with ore extraction activities primarily include the disposal of rock and release of mine water. Such activities can cause environmental impacts through the release of dust and generation of noise and vibration (e.g., from drilling, blasting and transportation activities; EC 2012a).

Environmental management strategies for mines differ for underground versus open pit mines. For example, open pit mines disturb a larger surface area and usually produce larger volumes of waste rock.

Ore Processing -Ore processing results in environmental concerns related to the disposal of tailings and management of wastewater. Ore processing can result in spills and accidents which can release contaminants such as chemical reagents into the environment (EC 2012a).

There are various potential sources and environmental impacts of wastewater contamination. These include (EC 2012a):

- **acidic drainage** – sulphide minerals are ore minerals for many base metals and are present in ore deposits; sulphides oxidize in the presence of water and oxygen to produce sulphuric acid (known as acidic drainage, acid mine drainage or acid rock drainage); resulting effluents are metal-laden and have a low pH and can significantly impact aquatic ecosystems;
- **alkaline effluents** – ore separation process (particularly separation) use chemical additives to achieve an alkaline pH; effluents from ore processing facilities are often alkaline, and may require lowering prior to discharge;
- **metal leaching** – mining and ore processing facilities create wastewater that contains metals naturally-occurring in the rock; metals are typically soluble at low pH, so metals concentrations can be elevated in acidic drainage (but also occurs in areas without acidic leaching);
- **cyanide** – cyanide is often used to process gold ore; it can be reused in processing but is also discarded in tailings so wastewater may contain cyanide and cyanide compounds; it is also used during separation flotation and can occur in tailings wastewater from base metal flotation processing facilities;

- **ammonia** – ammonia can be found in wastewater if ammonium nitrate and fuel oil (ANFO) is used as a blasting agent; ammonium nitrate spills or leftover residues can increase ammonia concentrations in wastewater; it is also a decomposition product of cyanide wastes;
- **suspended solids** – suspended solids in wastewater can be colloidal (non-settleable) to settleable materials; discharged effluents with high levels of suspended solids can impact aquatic environments by impeding fish oxygen intake and reducing light availability for aquatic plants; settling of suspended solids can result on sediment contamination (e.g., with metals); and
- **thiosalts** – thiosalts are sulphur oxide compounds some sulphide ores are partially oxidized under alkaline conditions during milling / grinding / flotation separation; they can oxidize in water to form sulphuric acid, lowering pH and affecting metal mobility in water, and impacting aquatic organisms.

Waste Rock and Tailings Disposal – Waste rock and tailings are produced during mine operations, and both generate effluents. Waste rock effluent may be sent to a tailings disposal area for treatment or a separate treatment facility. Environmental concerns associated with these mine waste disposals are preventing and controlling the release of contaminants that can cause environmental impacts such as (EC 2012a):

- groundwater seepage releasing contaminants (from waste rock piles / tailings management facilities); and
- dam / containment structure failure at tailings management facilities leading to environmental / human health risks.

Treatment Sludge Disposal – The acidic drainage from mines is often treated with lime, and sludge is a by-product of that treatment. It contains a variety of metals, and is typically produced in large volumes. Sludge can be disposed of on-site or sent to smelters for recycling. Sludges may have variable long-term chemical stabilities, and can release metals to the environment (EC 2012a).

Water Management - Water and wastewater management are important environmental considerations at mine sites. Preventing water contamination and managing water in an appropriate manner are primary concerns, and operations must consider issues such as (EC 2011):

- segregating clean / contaminated water flows to reduce required effluent treatment;
- controlling / addressing seepage losses from tailings containment structures;
- reducing water usage / recycling water for further process use; and
- reducing impacts on groundwater regimes.

4.4.2 Best Practices in Permafrost Conditions

Water management at a mine site should follow site-specific programs that were designed to monitor the quality of collected mine water and the seepage from waste rock piles and tailings management facilities. A variety of best practices are addressed in EC's document. When the disposal of waste rock and tailings poses a risk of acidic drainage, procedures can be implemented to prevent or control the drainage (as outlined in Table 1). Subaqueous disposal is an effective disposal method because the submerged materials have reduced exposure to oxygen and subsequent oxidation reactions. Decreased risk of acidic drainage decreases the risks of associated metal leaching. Strategies for controlling the risk of acid drainage in permafrost areas are addressed in Table 1 (MEND 1996).

4.5 Mine Closure

4.5.1 Environmental Concerns

Concerns related to mine closure include ensuring that the following closure objectives are met (EC 2012a):

- public / wildlife safety is ensured (e.g., by capping shafts / preventing access to mines and mine infrastructure);
- providing stable, long-term storage for waste rock / tailings;
- ensuring mine site is self-sustaining and preventing / minimizing environmental impacts; and
- rehabilitating disturbed areas for specific land uses.

Environmental concerns that should be addressed during mine closure include (EC 2012a):

- **underground mines** – unauthorized access through unseal shafts / inclines and declines / ventilation raises; backfill seepage impacts; mine water drainage; unstable ice plugs;
- **open pit mines** – slope / bench stability; natural (e.g., rain) water / groundwater management; unauthorized access / security issues; wildlife entrapment; drainage impacts into and out of the pit;
- **ore processing facilities** – removal of buildings / foundations; clean-up of workshops / fuel / reagents; disposing of scraps / waste materials; grading / revegetating the site;
- **waste rock piles** – slope stability; leaching / seepage impacts on surface water / groundwater; dust releases; aesthetics; special considerations for some mines (e.g., uranium mines);
- **tailings management facilities** – dam stability; tailings geochemistry changes; tailings seepage; managing surface water / discharge; dust releases; access / security; wildlife entrapment; special considerations for some mines (e.g., uranium mines);
- **water management facilities** – dam restoration or removal / reservoirs / settling ponds / culverts / pipelines / spillways; surface drainage / discharge; maintenance of water management facilities;
- **landfill / waste disposal facilities** – hazardous wastes disposal or removal; treatment sludge disposal / stability; sewage treatment plant removal; prevention of groundwater contamination; illegal dumping; access / security; and
- **infrastructure** – power / water supply removal; haul / access road removal; transportation / supply depot reuse.

4.5.2 Best Practices in Permafrost Conditions

Although many of the environmental considerations of the mine closure phase are applicable to many phases of a mine's life cycle, additional concerns may exist for particular mine sites (e.g., reclamation of uranium mine radioactive wastes). In permafrost conditions, the downstream slopes of tailings containment structures at mine sites in permafrost areas should be revegetated (e.g., through encouraging natural revegetation). Tailings management facilities should be capped and revegetated. These procedures help establish permafrost in the tailings. If capping cannot be completed, a permanent spillway may be required for a tailings impoundment with a pond to prevent dam overtopping and failure (EC 2012a).

5.0 CASE STUDY ON PORTS IN NUNAVUT

The proposed Steensby Port (described in detail in Task 1 Report) has been selected as a case study to examine the vulnerabilities of ports to climate change in the Arctic, to demonstrate how climate change can be incorporated in the design and outline recommended best management practices. Baffinland Iron Mines Corp. (Baffinland) submitted a Draft Environmental Impact Statement (EIS) to the NIRB in December 2010. This document provides details on Baffinland's proposed Mary River Project which aims to extract and ship iron ore to international markets. To facilitate this, Baffinland is intending to construct two ports of which Steensby Port is one (Knight Piesold 2010; Task 1 Report).

Steensby Port is situated on Northern Baffin Island on Steensby Inlet. Steensby Inlet is a wide bay with shallow waters (typically less than 100 m deep) and surrounding low-relief terrain. Shorelines include wide tidal flats, lagoon complexes, and mixes of bedrock and coarse sedimentary materials. Steensby Port would be located on the inlet's eastern shore, approximately 50 km into the inlet. Facilities at the port would be located in Steensby Inlet as well as on nearby Steensby Island. It is anticipated that the port and associated railway would take four years to construct, and then once the railway was operational, the port would be used for year-round shipping operations, with ore being transported from the mine site to Steensby Port on the railway. Stockpiled ore would be stored at the port prior to shipment (i.e., on Steensby Island) until loaded onto the ore carriers (Knight Piesold 2010).

Since the port is anticipated to operate year-round, the use of vessels with ice breaking capabilities is expected. A fleet of ice-breaking ore carriers will transport most of the ore from Steensby Port to market, with the additional use of supplementary ships chartered on the open market during the open water season. Resupply sealifts would likely be delivered to Steensby Port during the open water season only (e.g., mid-July through mid-October under present climatic conditions) with supplies then moved from the port to the mine site on the railway. However, various freight and oversized equipment that would not be able to move through the tunnels on the railway would be directed to Milne Port (a second port proposed for this project; Knight Piesold 2010).

The Steensby Port site is proposed to include temporary construction docks, a freight dock, ore management and port site facilities. The ore management facilities include a rotary rail car dumper, ore stockpiles, a rail-mounted stacker / reclaimer system, a secondary screening plant, and an ore loading dock. The port site facilities include a power generating station, communications system, service / administration / accommodation buildings, a maintenance shop / main office, portable water treatment system, wastewater treatment system, tank farm, incinerator, airstrip, navigational aids, site roads, railway maintenance facilities and offices, and a rail yard (Knight Piesold 2010).

Additionally, Baffinland would require a crossing to access Steensby Island. A combination bridge-causeway structure would be constructed to link infrastructure on the mainland to the island. It would allow the movement of vehicles across it, and also support conveyors that would move ore from the railway car dumper on the mainland to the ore stockpiles on the island. It would require no blasting in its construction, and would be built from both directions by placing fill (appropriately sized to withstand ice loading) during the open water season (Knight Piesold 2010).

5.1 Identified Vulnerabilities of Port Facilities to Climate Change

5.1.1 Sea Level Rise

Baffinland discussed changes in sea levels in its Draft EIS, noting that sea levels have risen approximately 120 m over the past 20,000 years and that currently sea levels are estimated to be rising at 2 mm/y (Knight Piesold 2010).

The port facilities at Steensby Inlet are situated in an area of recognized falling sea levels because isostatic rebound in the area is greater than the rate of sea level rise. Studies for that port have predicted that when considering maximum isostatic rebound and minimum sea level rise, the sea level would fall by 1.39 m by the year 2100, and when considering minimum isostatic rebound and maximum sea level rise, the sea level would rise by 0.17 m by 2100. The design of the docks at Steensby Inlet will account for these potential changes in sea levels by ensuring sufficient clearance for the shipping route and clearance at the dock (Knight Piesold 2010).

5.1.2 Sea Ice

Steensby Inlet is ice-covered for most of the year, with an approximate three-month open-water season in summer (but its port would be used year-round; Knight Piesold 2010). Proposed year-round shipping at the Steensby Port would require that vessels break the sea ice, approach the ore dock and depart from the dock independently. The ore carriers using the Steensby Inlet Port would be equipped with advanced navigational equipment appropriate for ice navigation. During the ice-free season, vessel docking would be assisted by harbour tugs and lines personnel on the docks, and any ships waiting for the port to be clear of other ships required to stage and anchor in specific offshore areas. When there was sea ice, the ice-breaking vessels would break their own paths to the dock, approaching and departing the area without the assistance of any ice-breaking harbour tugs (Knight Piesold 2010).

The ice around the dock would also be disturbed during the ships' time at the dock, potentially through the use of a bubbler system (if one were utilized to minimize ice build-up at the dock) and through ballast water discharge. Baffinland has determined that because ballast-water discharge would be collected in the North Atlantic, it would have higher density (due to temperature and salinity differences) than the Steensby Inlet water and would therefore sink upon discharge, causing little or no effect on sea ice beyond the immediate vicinity of the dock (Knight Piesold 2010).

Baffinland is proposing to use a shipping route through Hudson Strait and Foxe Basin to access the proposed port in Steensby Inlet. Concerns related to sea ice and actual shipping activities include freeze-up and thaw times, open water leads in ice, and the movement of pack ice (e.g., due to strong winds and currents in Hudson Strait; Knight Piesold 2010). Baffinland did not anticipate that changes in sea ice cover due to climate change would significantly affect its shipping operations in the Foxe Basin because the proposed shipping operations for the project were developed to account for both ice and ice-free conditions (the report does not address potential sea ice impacts on the project's proposed Northern shipping route; Knight Piesold 2010). Baffinland discussed sea ice conditions in its Draft EIS, noting that with increasing global temperatures, sea ice is expected to form later and clear earlier in the year. It is speculated that the loss of sea ice could increase atmospheric humidity, cloudiness and precipitation, and also alter marine mammal habitats (Knight Piesold 2010).

5.1.3 Permafrost Degradation

Baffinland discusses general climate change effects to permafrost in its Draft EIS, noting that climate-induced changes to average snow cover could impact permafrost by increasing soil temperature, increasing active layer depths, increasing surface runoff, changing drainage patterns as a result of subsidence and thermokarst formations, and increasing sediment loadings and mass wasting on slopes (Knight Piesold 2010) However, there was no explicit assessment of the potential effects of climate change on permafrost conditions in the Draft EIS. For the marine environment, there was limited information presented regarding sub-sea permafrost. In the coastal environment, the potential changes which were identified in the Draft EIS could contribute to shoreline erosion processes and impact port-related infrastructure. Baffinland predicts that its Mary River project will remain within the zone of continuous permafrost for the life of the project, but that the area's active layer depth will increase up to 50% and with that the permafrost thickness decreases (Knight Piesold 2010).

During the open water season vessels would be required to use ballast water exchange for ballast water management (i.e., they would discharge ballast and take on new ballast water in deep sea areas away from coastal zones), and ships arriving at Steensby Port would discharge only a partial load of ballast water at the ore dock (estimated at 70,000 cubic metres [m^3]). However, during winter the ice-breaking ore carriers must break ice all the way to the port facilities, and require the full ballast to enable this. Therefore, approximately 200,000 m^3 of ballast water would be released from these vessels at the dock during winter. The ballast water would be taken onto the vessels in the North Atlantic, and heated (e.g., 2 to 4°C) while on the vessel through heat recovery from the ship engines. Due to differences in temperature and salinity, it is predicted that the ballast water, being denser than the Steensby Inlet water, will sink once discharged. The anticipated sinking of the ballast water may limit the warmer water's exposure to the sea ice and therefore minimize expected melting but the process of ballast water release is thought to be useful for controlling the accumulation of ice around the dock (Knight Piesold 2010).

The sinking warmer water may result in a warming of the seafloor. This potential warming may impact on the stability of subsea permafrost in the port area through melting. In the event that the warmer ballast water results in melting of the subsea permafrost, it is possible that degradation of the substrate may occur. Assessments done for the port suggest that the warmer water will flow to deeper areas along the sea floor after sinking. The flow of the water would minimize the impact of the warmer water on the subsea permafrost. (Knight Piesold 2010).

5.2 Recommended Components for Best Management Practices for Ports in Nunavut

5.2.1 Sea Level Rise

Changes in sea levels and the vertical movements of land change the characteristics of entire coastlines. Prehistoric changes in sea level have had a strong influence on coastal development worldwide and caused large fluctuations in sea levels; typically over 100 m along the coasts of Canada. Many factors contributed to these fluctuations; for example, sea levels were impacted as growing ice sheets reduced the amount of water in the oceans, but also land heights were impacted as the weight of ice sheets caused the depression of the land (followed by the rebound of the land when the ice sheets retreated, i.e., isostatic rebound).

During the twentieth century, the global sea level has been estimated to raise an average of 1.7 millimetres per year (mm/yr), with rates slightly increasing since the 1960s. Climate model projections indicated that this rate could increase to 2.5 mm/yr during the twenty-first century for a rise of mean sea level of 0.2 to 0.6 m, accounting for both thermal expansion of the oceans and melting of the Antarctic and Greenland ice sheets, but estimates of a rise of up to 1 m have been proposed for some areas (PIANC 2008).

Sea level related impacts to ports could include (PIANC 2008; Task 1 Report):

- reduced top clearance between ships and overhead structures (e.g., bridges, loading facilities);
- increased elevation at which wave forces attack a structure, potentially increasing the vulnerability of the structure;
- increased exposure of dock decks;
- increased corrosion rate and the degradation over time of materials that were specifically designed for a particular range of sea level conditions;
- more wave action / sea spray on navigational installations; and
- an increase in absolute low sea levels allowing greater under-keel clearance for vessels, possibly reducing the need for dredging in low sedimentation areas.

To manage for sea level rise, a best management approach to key port design components (e.g. dock heights, berth depths, dock structural strength) is to assess both eustatic (changes in sea level due to thermal expansion, total ocean volume, and changes in upwelling and therefore independent of crustal adjustment) sea level rise and isostatic (crustal adjustments which are independent of changes in sea level) rebound of the ground and determine the highest and lowest sea level that will occur over the duration of the project design life. In the Arctic estimates of eustatic sea level rise are of the order of 80 cm to 160 cm by 2100 (Arctic Monitoring and Assessment Program [AMAP] 2011) but isostatic rebound of the earth's crust following the end of the last glaciations may result in coastal uplift of the order of 1 to 1.5 m per century or more and with that counteracting sea level rise. The overall rate of sea level rise may therefore be small or sea level may even be falling relative to the ground surface. Therefore, it is possible that in some locations, the highest sea levels may occur at the beginning of the project.

Key strategies to address sea level rise in the planning and construction of port facilities are:

- **avoid** – build outside of areas which are subject to projected sea level rise for the design life of the project;
- **accommodate** – build port facilities so that tolerance of sea level rise and potential inundation is incorporated into the design (i.e., account for the highest wave forces predicted over the life of the project in the design) ;
- **managed retreat** – plan and build so that as sea level rises the port can retreat back from the new sea level; and
- **protect** – protect critical infrastructure so that sea level rise does not affect the port.

Best management practices for port planning, construction and operation that address sea level rise may be summarized as:

- Collect water level data at the site during the planning and design of the port infrastructure and maintain a water level recording station for the life of the project.
- Adopt a design process for siting key port infrastructure that specifically adopts a strategy or a combination of strategies (e.g., avoid, accommodate, managed retreat, protect) to incorporate projected sea level rise.
- Plan and design flood elevations and erosion protection (Adaptation Measures outlined in Task 1 Report) using a quantitative risk assessment approach. Determine the highest risk sea level conditions which occur over the duration of the project design life.
- Plan and design flood elevations and erosion protection to accommodate reasonable levels of climatic variability (e.g. the 1 in 200 year water level). For water levels this would include storm surge.
- Plan and design the location of port facilities requiring adequate water depth (e.g., vessel draft) based on the lowest sea level conditions which occur over the duration of the project design life.

An analysis has been undertaken to assess both isostatic rebound and sea level changes in elevation to assess the potential impact to the Steensby Port facility. The assessment indicated that predicted sea level changes by 2100 ranged from a drop in sea level of 1.39 m to a rise in sea level of 0.17 m. The Draft EIS stated that the design of the docks would account for these potential changes but an explicit analysis of the potential effects of climate change on sea level was not included in the analysis. The short anticipated life of the project (20 to 30 years) may have been a factor in not including these details.

5.2.2 Storm Events and Waves

Climate change is projected to lead to increasing storm frequency in the Arctic (Task 1 Report). Increased storm frequency and intensity due to climate change can increase available wave energy and impact port facilities (Perrie 2007; Instanes *et al.* 2005). Wave characteristics can be impacted by a variety of climate-related parameters, including (PIANC 2008; Instanes *et al.* 2005):

- changes in temperature affecting winds, causing shifts to the seasonal distribution of wind speeds and direction which may impact the frequency, pathways and durations of storm and hurricane events;
- increases in the expanse of open water in the Arctic, and increase in the duration of the open water period, resulting in a corresponding increase in available wave energy (e.g., due to increased fetch), and consequently increased rates of wave-induced coastal erosion;
- changes in climate affecting the seasonal distribution of wave heights, periods and directions;
- changes in climate affecting the frequency and pathway of high waves events; and
- changes to the location, duration and extent of the shore ice fringe could cause changes to the wave regime experienced by the shoreline over the course of a year (e.g. more exposure to waves in the shoulder season, less robust protection in winter leading to ice push/thrust effects at the shoreline, reduced shorefast ice).

In general, changes in the characteristics of storms can result in (PIANC 2008):

- degradation of structures;
- increased wave run-up and salt spray impacting structures;
- loss of viable industrial land around ports;
- reduced regularity of port services (e.g., availability / use);
- the permanent loss of offshore and onshore sediments (e.g., sand);
- retreat of coastal landscapes (i.e., erosion);
- reduced capacity of natural systems to recover.

In the Arctic, the proportion of winds with speeds above 15 m/s is projected to increase, resulting in higher waves and affecting navigation, berthage availability and potentially shipping routes (e.g., because manoeuvring through narrow channels would be more difficult; PIANC 2008).

To manage for storm events and waves, a best management approach to key port design components (e.g. dock structural strength, erosion protection, wave protection for berthing vessels) is to assess a combined event which addresses the anticipated change in storm regime for the area of the port, the anticipated change in duration of ice-free conditions around the port and the anticipated change in sea level over the duration of the project design life. For example, if sea level is dropping relative to the land at the project site then water depths may reduce in the vicinity of the port resulting in decreased wave energies. The effect of storm events and waves must be assessed together with other climate parameters to determine the period of greatest wave exposure. In some cases this may occur at the start of the project.

Best management practices considering storm events and waves in port design and development may be summarized as:

- Collect detailed bathymetry and topography during the planning and design phases of the project and update at regular intervals over the life of the project.
- Collect wave data at the site during the planning and design phases of the project and monitor waves on a periodic basis over the life of the project.
- Plan and design wave loading using a quantitative risk assessment approach to evaluate the combined events of anticipated storm regime, ice-free condition, and sea level condition occurring over the duration of the project design life which yields the greatest risk of wave exposure for the port facilities.
- Plan and design flood elevations and erosion protection to accommodate reasonable levels of climatic variability in keeping with suitable design guidelines (e.g. the 1 in 200 year storm event or the highest total water level from waves and water levels with a combined probability equivalent to a 200 year return period). For waves and storm events this would include wind speed and direction leading to appropriate wave heights and periods, wave setup and wind setup.
- Plan and design the port operations to accommodate both the anticipated storm regime and waves which could occur over the design life of the project.

5.2.3 Sea Ice

Sea ice has the potential to impact shipping by making access difficult for non ice-breaking rated ships and also the potential to decrease the exposure of a port site to erosion by reducing wave exposure outside of the open-water season. Changes in sea ice cover and duration will affect port infrastructure and shipping activities.

Considerations for developing, constructing and maintaining port infrastructure and associated dock facilities to withstand sea ice stresses could include (Knight Piesold 2010):

- completing bathymetric work during the planning phase to determine safe and sensible transportation routes when considering ice conditions;
- completing ice studies and other marine assessments to determine the most appropriate dock locations considering expected ice conditions, define shipping lanes, and determine what ice class of vessel would be appropriate for use in the area (as required);
- designing docks using caissons instead of solid structures to allow ice to accumulate between the caissons and help ice move past dock structures;
- using ice-reinforced vessels such as tug-boats to break up ice around docks for subsequent removal;
- using bubbler systems around docks to minimize the development of sea ice in the area; and
- using warmed ballast water discharge from vessels to minimize the development of sea ice or help reduce the thickness of already developed sea ice around docks.

To manage for sea ice, a best management approach to key port design components (e.g., dock structural strength, erosion protection) needs to consider both sea ice loading and also the persistence of sea ice. It is anticipated that large parts of the Arctic Ocean will no longer have permanent ice cover by 2100 (PIANC 2008). As climate change is expected to result in the reduction of ice-cover thickness, it can be assumed that the resulting ice loading on support structures in the water (e.g., bridge piers, dock pilings) would be diminished (Instanes *et al.* 2005). As mentioned above in the section on storm events and waves, a decrease in sea ice may lead to an increased exposure to waves and result in increased wave loading on those same support structures in the water. The change from ice loading to wave loading may shift the design emphasis between loading types: however, until correlations are made which demonstrate adequately the reduction in ice loading due to climate-related thinning of Arctic ice designers will need to adopt the most conservative approach.

Additionally, a best management approach to key port operations (e.g., vessel type, approach routes and docking) needs to consider the anticipated change in duration of ice-free conditions around the port over the duration of the project design life. With anticipated navigation in the North opening up, ports and other coastal infrastructure would likely be required to supply increased services such as ice-breaking assistance and improved emergency response capabilities (e.g., for oil cleanup; Instanes *et al.* 2005), increasing the use of and stresses upon port infrastructure.

Best management practices addressing sea ice impacts on port infrastructure may be summarized as:

- Collect ice thickness and duration data during the planning and design phases of the project. Monitor ice thickness and duration over the life of the project.
- Plan and design the port facilities to accommodate the ice loading anticipated on the basis of historical data, unless design information is available which supports correlation of reduced ice loading over the design life of the project.
- Plan and design the port operations to accommodate both the shortest anticipated open water season and longest anticipated open water season which occurs over the design life of the project.

In the case of Steensby Port, the Draft EIS indicated that changes in sea ice cover would not significantly affect the proposed shipping operations. The rise in global temperatures is expected to result in later formation and earlier breakup of sea ice. The Draft EIS also stated that both a bubbler system and warmed ballast water discharge would be used to manage ice around the docks during the winter season.

5.2.4 Coastal Erosion

Climate change is projected to lead to increasing storm frequency and intensity in the Arctic which may result in increased erosion along the Arctic's shorelines (Perrie 2007; Instanes *et al.* 2005). Coastal erosion rates vary across the Arctic and are influenced by numerous processes including climatic parameters, environmental forcing, sedimentology, geocryology characteristics (i.e., frozen rocks, soil and ground), geochemistry, and also anthropogenic disturbances along coastlines. Anthropogenic influences can either increase erosion rates (through disturbances) or slow erosion rates (through using shoreline protection strategies; Instanes *et al.* 2005).

The actual impact that climate change has on coastal morphology can be difficult to assess because, as an example, although climate change can affect waves and currents (which modify coastlines), localized bathymetry then causes variations to those waves and currents, making impacts to coastal morphology a site-specific phenomenon (PIANC 2008). A variety of other climatic parameters can directly and indirectly cause changes to the stability of coastal and subsea permafrost, and influence coastal erosion types and rates, including air temperature, sea-level increases, longer open-water seasons, and freshwater discharge into the marine environment (Task 1 Report).

Uncertainties in the future impacts of sea-level rise and storm activities make it difficult to predict coastal bluff erosion. In general, coastal erosion rates in the Arctic are not readily quantifiable, but have increased over the past 30 years; satellite imagery may be used to assess these rates in the future and increase the understanding of coastal dynamics and appropriate adaptive measures required to protect port infrastructure (Instanes *et al.* 2005).

Changes in near-shore sediment deposition patterns can alter dredging requirements at ports (PIANC 2008; Walsh *et al.* 2005). The sediment regime at the start of a project may be significantly different by 2100 if sediment sources within the littoral cell containing the port are activated by erosion, sea level rise or thawing permafrost.

The inland movement of eroding shorelines can cause the disturbance and potentially the required removal, reinforcement, reconstruction or moving of onshore port structures (PIANC 2008; Deduce 2007). While less of a potential impact on bedrock shorelines, ports located on erodible soils or soils subject to thaw could be impacted by the shoreline changing shape or location to accommodate the new climate and oceanic regime.

The foundations and superstructure of port infrastructure along coastlines may be subject to erosion and deterioration, considering environmental parameters such as coastal permafrost stability and thaw subsidence, and the vulnerabilities of structural components to warming and/or thawing permafrost (PIANC 2008; Walsh *et al.* 2005).

Adaptation measures to adress coastal erosion may include:

- rubble mounds – graded layers of natural (*e.g.,* quarried) rock;
- gabions – gabions are rock-filled wire baskets and mattresses; they tend to corrode, have a very short life in seawater and are generally avoided; and
- engineered mounds – constructed of pre-cast structures (e.g. dolostones) and built similarly to rubble mounds (Nysigh 2001; Task 1 Report).

Ports themselves cause disturbances to the natural flow of sediments in coastal areas. Port structures can generate new erosion and accretion processes where breakwaters act as a barrier to sediment transport and then force the flow of sediments further offshore. Planning for port locations should take into account their influences on sediment dynamics, and ensure the incorporation of preventative measures and mitigative solutions. Collecting information on historic and ongoing shoreline changes can help predict future changes and enable the preparation and development of adaptation measures that would help address climate change impacts (Deduce 2007).

To manage for coastal erosion impacts, a best management approach to key port design components (e.g. erosion protection, siting of breakwaters, jetties and seawalls) needs to consider both historic and anticipated future rates of erosion. As described above, many factors contribute to coastal erosion and it is important to integrate analysis of anticipated sea level, storm, wave, sea ice, current and permafrost responses to evaluate projected coastal erosion. Additionally the surficial and bedrock geology of the proposed site, as well as topography, should be assessed to evaluate the locations ability to resist erosive forces.

Best management practices to address coastal erosion in port infrastructure planning and development may be summarized as:

- Collect shore profile and sediment size data during the planning and design phases of the project. Monitor shore profiles and sediment sizes over the life of the project.
- Review historical imagery (satellite and air photo) of the proposed site to document observable shoreline changes. Update surveys and imagery on a regular basis, approximately every 5 years, over the life of the project, to evaluate changes to the shoreline.
- Identify and map the surficial and bedrock geology and collect detailed topography during the planning and design phases of the project.
- Evaluate the sea level, storm and wave regime, ice regime, and permafrost regime for the site.
- Plan and design the port facilities to accommodate the extent of coastal erosion anticipated on the basis of historical data unless design information is available which supports correlation of increased coastal erosion over the design life of the project.

5.2.5 Permafrost Degradation

All of Nunavut's coastline areas are within the zone of continuous permafrost (Transportation Association of Canada [TAC] 2010). Coastal permafrost refers to geologic materials that have remained below 0°C for two years or longer and are found at or below sea level. They include onshore and offshore areas of permafrost that are impacted (directly or indirectly) by marine processes (Walsh *et al.* 2005).

Subsea permafrost is formed because of a negative mean annual sea-bottom temperature or through the inundation of terrestrial permafrost. The thermal regime of subsea permafrost is controlled by seawater temperature. The distribution of subsea permafrost in the Arctic Ocean is not well known and it is likely that there are several areas of Nunavut's seabed that are underlain by permafrost (U.S. Arctic Research Commission 2003). There was limited discussion of sub-sea permafrost conditions in the port section of the Draft EIS. It is understood that frozen conditions are relevant to the foundation design of the wharves and jetties.

The freezing point of sediments can be depressed below 0°C (e.g., by the presence of salt or by capillary effects in fine-grained materials), so coastal and subsea permafrost is not necessarily in a solid state (Walsh *et al.* 2005). In marine environments, the definition of frozen permafrost includes either ice-bonded (mechanically cemented by ice), ice-bearing (permafrost or seasonally frozen sediments containing some ice), or a mixture both. The ice content of permafrost can consist of pore or interstitial ice in soil pore spaces, or it can consist of larger forms referred to as massive ice. Unfrozen fluids can be present in soil pore spaces in both ice-bonded and ice-bearing materials (Walsh *et al.* 2005).

In general, coastal permafrost conditions are impacted directly by oceanographic (e.g., sea-ice thickness) and meteorological (e.g., storm-surge frequency) processes (Walsh *et al.* 2005).

Direct influences on coastal permafrost include (Walsh *et al.* 2005):

- seawater temperature;
- sea-ice action;
- storm surges;
- wave action; and
- tides.

Indirect influences on coastal permafrost include (Walsh *et al.* 2005):

- erosion (e.g., of cliffs and bluffs)
- sea level rise.

Coastal infrastructure can be impacted by decreases in coastal and subsea permafrost stability. Near-shore thaw subsidence can contribute to increased erosion rates and ground level subsidence, impacting infrastructure that is located close to the coast. Therefore docks can be vulnerable to warming and/or thawing permafrost due to the reduced foundation strength of the docks and associated pilings (Walsh *et al.* 2005). Additionally, the rebuilding or incorporation of new design elements for land-based port infrastructure in the Arctic may be required because of melting permafrost conditions (The World Association for Waterborne Transport Infrastructure [PIANC] 2008).

To manage for impacts of permafrost degradation on port infrastructure, a best management approach to key port design components (e.g. bearing capacity, structural elevations) needs to consider the potential changes in temperature at the surface and at depth.

Erosion protection measures implemented elsewhere include (Wolfe *et al.* 1998):

- the use of sandbags (or geotextile tubes) placed on the beach;
- the use of fill at a coastline to rebuild, maintain and regrade coastal bluffs and shorelines; and
- the deposition of rocks and gravel on the beach to dissipate wave energy.

Best management practices for permafrost considerations in the construction of port facilities may be summarized as:

- Collect subsurface profiles of temperature and ice content data during the planning and design phases of the project. Monitor these temperature profiles and ice content of the soils over the life of the project. These samples should be collected both on land and below the sea where feasible.
- Plan and design the port facilities to accommodate the potential changes to permafrost anticipated on the basis of historical data unless design information is available which supports predictions of permafrost degradation over the design life of the project.

The Draft EIS assumed that Steensby Port would remain within the zone of continuous permafrost for the life of the project but that the active layer depth would potentially increase by up to 50%. The use of warmed ballast water and potential impacts on subsea permafrost was also addressed and was expected to be minimal.

5.2.6 Currents

Large areas of the Arctic Ocean are ice-covered year-round, with seasonally open waters in the remaining areas. This ocean is relatively isolated from the rest of the world's oceans (Woods Hole Oceanic Institute 2006). The Arctic's deeper waters are saline and dense, and are more resistant to flow (viscous) when compared with oceanic waters further south. The presence of submarine ridges also minimizes movement of deeper water, with very cold water (approximately -1°C) remaining relatively stagnant at the bottom of the Arctic Ocean. However, the surface water (i.e., water to a depth of approximately 46 m) are less saline and in the Arctic Ocean circulate in a large rotational pattern (i.e., a gyre) from east to west around the polar ice cap (Heberts 2010).

As an adaptation measure to address the impacts of currents, breakwaters and jetties can function to minimize littoral drift in the near-shore zone caused by currents or waves (Nysigh 2001). However, these must be carefully planned and should not result in adverse effects upcoast or downcoast within the littoral zone.

To manage for potential impacts of currents on port infrastructure, a best management approach to key port design components (e.g. docks, jetties, breakwaters) needs to consider the siting and potential impact of these components on currents around the port. These currents may change over the design life of the project with changing sea level, ice cover and frequency of storms (e.g. wave-driven currents). The impact of changes to currents may not be noticed for several years once the port is built as the impacts may occur slowly as the seabed and littoral zone responds to the altered current regime.

Best management practices to consider currents in the planning and design of port components may be summarized as:

- Collect current data during the planning and design phases of the project. Monitor currents over the life of the project.
- Plan and design the port facilities to minimize impacts to currents within the littoral zone over the design life of the project.
- Plan and design the port operations to accommodate potential changes to currents over the design life of the project.

6.0 CASE STUDY ON TAILINGS MANAGEMENT FACILITIES IN NUNAVUT

Agnico-Eagle Mines Ltd.'s Meadowbank Mine, located 75 km north of Baker Lake, is currently the only operational mine in Nunavut. Construction of the Meadowbank Mine began in 2008 and operations commenced in early 2010. Extraction will take place in three open pits with operations expected to continue until 2019. The Meadowbank Mine (described in detail in Task 1 Report) was selected as a case study to demonstrate potential vulnerabilities of a Tailings Management Facility (TMF) in Nunavut to climate change, to demonstrate how climate change can be incorporated in the design and outline recommended best management practices.

Dry stacking of filter cake tailings and surface disposal of high density thickened tailings were considered as potential tailings management strategies for the Meadowbank Project. However, surface disposal of tailings at a solids content of 45% to 55% (by weight) in a natural impoundment (i.e., a portion of the north-west arm of Second Portage Lake) was selected. A dike will separate the north-west arm of Second Portage Lake and create the tailings impoundment. Initially, the tailings will be deposited subaqueously (i.e., below water) with the majority of tailings being deposited subaerially (i.e., above water). A reclaim pond will be operated within the tailings impoundment and water will be reclaimed to the mineral processing plant for reuse (Cumberland 2004).

Tailings generated at the site will be stored in the basin formed by dewatering the northwest arm of Second Portage Lake. The Tailings Management Facility (TMF) is bounded by a series of perimeter containment dikes. The dikes include the Central Dike, Stormwater Dike, and Saddle Dams. The Central Dike and Saddle Dams are permanent structures. The Stormwater Dike divides the TMF north to south for a four year time period. The dikes were constructed primarily from materials generated during mining including rockfill, a filter zone, and an upstream impermeable element (Golder Associates Ltd. [Golder] 2007).

Monitoring of the ground temperature and pore water pressure will be carried out during construction and operations to confirm that dike performance is consistent with the predictions made during the design studies with respect to stability, deformation, seepage and thermal analyses; and to provide early warning of the development of potentially adverse trends such as excessive pore water pressure, seepage and/or deformation. An automatic field data acquisition system will allow for regular collection of measurements from the piezometers and thermistors during operation (Golder 2007).

The current tailings deposition plan involves placing tailings in the north basin, or North cell, during Years 1 to 3 followed by deposition in the main basin, or South cell, during the remaining years of mine life (Agnico-Eagle Mines Ltd. 2009). The updated tailings deposition approach removes the requirement to fully dewater the northwest arm of Second Portage Lake and construct the Central Dike prior to mill start up, and provides greater operational flexibility and less risk associated with dewatering and dike construction schedules (Agnico-Eagle Mines Ltd. 2009). Ice is expected to become entrapped in the deposited tailings during placement and subsequent freeze-back with up to 30% of the tailings storage volume potentially being consumed by entrapped ice. The amount of entrapped ice can be minimized by effective tailings beach management and the implementation of appropriate operational strategies. A minimum 2 m thick cover of non potentially acid generating rockfill will be placed over the tailings to physically isolate the tailings and confine the active thaw layer within the inert rockfill cover layer. Cover trials will be completed during operations to confirm the required thickness to confine the active layer within the rockfill cover, minimize water infiltration into the tailings and encapsulate the tailings in permafrost (Agnico-Eagle Mines Ltd. 2009). Thermal modelling of the Meadowbank tailings and dike were carried out for various scenarios during operations and post-closure (Junqueira *et al.* 2007). Maximum average air temperature in the Arctic is predicted to potentially increase by 6.4°C by the year 2100 (IPCC 2007). This increase in air temperature was applied uniformly over a 100 year period in the thermal model to simulate potential global warming at the Meadowbank Project (Junqueira *et al*. 2007). For all scenarios, the tailings were assumed to be deposited at a temperature of 10 °C. Depending on the time tailings are exposed to freezing winter temperatures during deposition and the air temperature during deposition, thermal modelling indicated that some of the tailings in the impoundment may still be unfrozen at the end of mine operations. However, at closure the dike rockfill and downstream foundation are expected to be frozen for all model scenarios. After closure, the presence of a lake on the downstream side of the dike is expected to progressively thaw the downstream portion of the dike. However, long-term thermal modelling indicates that freezing conditions will prevail in the upstream tailings and the dike foundation will remain frozen to a depth of about 30 m below tailings 100 years post-closure (Junqueira *et al*. 2007).

6.1 Identified Vulnerabilities of Tailings Management Facilities to Climate Change

6.1.1 Permafrost Degradation

Potential consequences of permafrost warming include (Esch and Osterkamp 1990):

- increase in annual thaw or active layer depth;
- warming of permafrost at depth; and
- development of new or larger thaw zones (taliks).

Permafrost thaw can cause the settlement of structures (EBA Engineering Consultants Ltd. [EBA] 2004), and permafrost degradation beneath a dam in permafrost zones can result in both settlement and foundation instability (MAC 1998). Thawing and potential creep or slumping of dam abutments (i.e., slopes adjacent to dams) can also have a negative impact dam stability and impoundment performance (e.g., seepage).

The Central Dike is constructed of thaw-stable rockfill on a foundation that was previously thawed (i.e., not frozen permafrost) because the dike is located within a lake. Therefore permafrost degradation is not expected to cause settlement or foundation instability of the Central Dike. The Saddle Dams are also constructed of rockfill with an impermeable element to retain tailings and limit seepage from the tailings impoundment. However, ice rich soils were removed from beneath the Saddle Dam foundations prior to construction to mitigate stability concerns by thawing of ice rich foundation soils (Golder 2007). The downstream slope of the Saddle Dams will not be flooded and the upstream tailings are expected to freeze during operations and post-closure.

However, till placed over the rockfill as an impermeable element for the Saddle Dams will be subject to freeze-thaw effects until covered with tailings. Thermal analyses indicate that depth of the active layer in the till will be approximately 1.9 m so an upper till layer of 4 m was recommended (Golder 2007).

The Meadowbank tailings impoundment design assumes that an existing talik beneath the lake will begin to freeze during mine operations (i.e., tailings deposition) and remain frozen after closure preventing discharge of seepage from the tailings facility into the adjacent lake. Development of new or larger talik (thaw) zones is not expected to be a concern at the Meadowbank Project.

Pore Water Pressure and Seepage

The thawing of permafrost can increase pore water pressure in dams and increase seepage from a tailings impoundment (EBA 2004).

The Meadowbank dike designs provide impermeable elements to prevent discharge of seepage to the adjacent lake during operations. During initial tailing deposition operations, the tailings basin will be lower than the water elevation in Second Portage Lake and therefore groundwater flow will initially be into the tailings impoundment. However, as the adjacent Portage Pit mine is excavated, it will become lower than the tailings impoundment and seepage will drain into the open pit where it will be captured and directed back to the tailings area (Agnico-Eagle Mines Ltd. 2009).

The Central Dike is designed to remain stable with a thawed downstream slope (i.e., adjacent lake). Should the tailings and dike foundation thaw more than predicted by the thermal modelling there is potential for discharge of seepage from the tailings into the adjacent lake. Thermistors and piezometers will be used to monitor ground temperature and pore water pressure in the dike and foundation during operations and post-closure to confirm freezeback of the tailings that will limit seepage from the tailings impoundment. Thermal modelling predicted the range of time required to freeze the tailings and underlying talik by simulating ground temperatures during operations and after closure (Agnico-Eagle Mines Ltd. 2009). Climate change was also incorporated into the modeling exercise using a climate warming trend of 6.4^{o}C over 100 years (Agnico-Eagle Mines Ltd. 2009).

Piping and Internal Erosion

Thawing of frozen core dams or a dam foundation can increase seepage through a dam and increase the potential for piping (Bjelkevik 2005; EBA 2004). Piping is a form of internal erosion that, in tailings dams, involves the transport of particles within the pores of the dam construction materials.

The Central Dike is designed to remain stable (see above). Should the Central Dike foundation thaw more than predicted by the thermal modelling there is potential for discharge of seepage from the tailings into the adjacent lake. Moreover, should the Saddle Dam foundations thaw more than predicted by the thermal modelling there is potential for increased seepage from the tailings. However, increased seepage is not expected to result in piping or internal erosion of dike materials. Modelling was carried out to determine maximum (i.e., worst case) expected rates of seepage and hydraulic gradients to design internal erosion control measures or filter zones (Golder 2007).

Landslides

Landslides can occur as a result of permafrost thaw on slopes around a tailings pond. A large landslide into a tailings impoundment with ponded water adjacent to a dam could cause waves to overtop the dam. A landslide in a tailings impoundment could block a spillway and combined with a precipitation event could also lead to dam overtopping (MAC 1998).

The Meadowbank tailings area was previously a natural lake with a thawed perimeter shoreline indicating that the slopes are stable in a thawed condition therefore future thawing of the impoundment perimeter slopes is not expected to result in landslides. Furthermore, the tailings impoundment will not have a water cover at closure so there is no risk of a landslide causing waves in the tailings impoundment.

At closure there will be a flooded pit lake on the other side of a dike immediately adjacent to the tailings impoundment. The potential of landslides into the flooded lake is not known. Landslides into the flooded pit lake could potentially result in waves that could contact the downstream slope of the Central Dike separating the pit lake from the tailings impoundment. However, a landslide induced wave in the pit lake causing overtopping of the Central Dike is considered unlikely given the flooded water elevation of the Portage Pit lake at closure is almost 20 m lower than the Central Dike crest elevation (Agnico-Eagle Mines Ltd. 2009).

6.1.2 Frost Action and Ice

Frost Action

Impacts of frost action include:

- repetitive freeze-thaw action can split soil particles, change the soil structure, increase hydraulic conductivity of dam materials and impact performance (e.g., increased seepage) or lead to dam failure;
- repetitive freeze-thaw of foundation and dam fill materials can result in cracks in dams and impact performance (e.g., increased seepage) or lead to dam failure; and
- repetitive freeze-thaw and ice lens development can result in consolidation of tailings and may decrease hydraulic conductivity of the tailings.

Till placed over rockfill, if used as an impermeable element for the Saddle Dams, will be subject to freeze-thaw effects until covered with tailings. Thermal analyses indicate that depth of the active layer in the till will be approximately 1.9 m so an upper till layer of 4 m was recommended (Golder 2007).

Ice Accumulation

Tailings impoundments in a cold climate may not be able to reclaim water if it becomes frozen and permanently entrapped as ice. Tailings impoundment design in a cold climate should allow for ice to consume some of the available storage volume. At the Meadowbank Mine, it is estimated that the volume of ice trapped in the tailings impoundment could be up to 30% of the total storage volume and increase the height of the facility by approximately 3 m relative to the height expected if there was no ice entrapped (Cumberland 2004). Future thawing of entrapped ice in a tailings impoundment has the potential to increase available storage but an increased volume of water will have to be managed and/or treated prior to discharge.

The Meadowbank tailings impoundment and dike design has considered and allowed for ice accumulation risks. The tailings impoundment design conservatively allows for 30% of the storage volume to be entrapped ice.

6.1.3 Precipitation and Water

Impoundment Water Levels

Precipitation events increase water flow into a tailings impoundment area, potentially exceeding their design storage capacity and causing overtopping of dams (MAC 1998).

Water Covers

Water covered tailings impoundments must have spillways or discharge facilities that can handle design storm events (Bjelkevik 2005).

Erosion

Storm events can result in increased water flow into an impoundment and erosion at spillway outlets. Precipitation can cause erosion of exposed tailings surfaces or dam slopes with insufficient erosion protection.

As described above, the Meadowbank tailing impoundment does not rely on a water cover at closure. Therefore, water levels, erosion and spillway outlet design are not considered a risk to the Meadowbank tailings management facility.

6.1.4 Wind

Wind erosion at Tailings Management Facilities can lead to dusting and migration of tailings particles from the impoundment. Dusting and migration of tailings during operations is a potential risk if tailings are allowed to dry prior to discharge of a subsequent layer of tailings. The Meadowbank tailings will be covered with rockfill at closure so dusting is not expected to be a concern.

Wave action from wind can cause erosion of upstream dam slopes with inadequate erosion protection and even overtopping of the dams (MAC 1998; Bjelkevik 2005). The downstream slope of the Central Dike at Meadowbank will be exposed to waves from the adjacent pit lake, however the fetch length will be short and design of the dike considered potential wave action on the downstream slope post-closure (Golder 2007). Erosion protection must be designed for expected wind and wave action including potential higher wind speeds due to climate change.

Wave action can cause turbulence in a tailings water cover, increasing the oxygen concentration, re-suspending tailings particles, and allowing oxidation of sulphide tailings. The Meadowbank tailing impoundment does not rely on a water cover at closure therefore this risk is not a concern.

6.1.5 Extreme Weather Events

It is anticipated that the frequency of extreme weather events (e.g., floods, droughts, high winds) will increase over the long-term (Bjelkevik 2005). Extreme storm events (e.g., flooding) can exceed the discharge capacity of an impoundment spillway and result in dam overtopping and possibly dam failure.

Extreme weather events may present increased risk to the tailings impoundment at the Meadowbank Project. Extreme precipitation events, including flooding, could cause increased erosion in drainage ditches and/or increased water levels in the flooded Portage Pit Lake adjacent to the tailings impoundment. The Meadowbank tailings facility does not have a water cover and the tailings will be covered with rockfill at closure therefore tailings erosion due to an extreme weather event is unlikely. Furthermore, as discussed above, the flooded water elevation of Portage Pit Lake at closure is almost 20 m lower than the Central Dike crest elevation and the downstream slope of the Central Dike has been designed for post-closure wave action (Golder 2007).

6.2 Recommended Components for Best Management Practices for Tailings Management Facilities in Nunavut

6.2.1 Permafrost Degradation

The following are suggested best management practices to address the impacts of permafrost degradation on Tailings Management Facilities in Nunavut:

- Consider potential climate warming in thermal analyses for all components of tailings management facilities. Predict future climate change by assessing long-term historical records from meteorological stations in the area. The best and most recent available predications of future climate conditions should always be used for design.
- The preferred approach to minimize potential impacts of climate warming is to either design tailings facilities with unfrozen embankments or design embankments that are thaw-stable.
- Dams on permafrost should be constructed on bedrock or thaw-stable (with minimal ice content) foundations and incorporate traditional seepage control measures such as geomembrane liner or bedrock foundation grouting, so that dam performance is not impacted by future permafrost degradation (INAC 2003). Removal of ice rich foundation soils is also recommended to reduce the potential for thaw-related settlement.
- The use of frozen core dams is not recommended at sites with discontinuous permafrost or where climate change may result in the disappearance of permafrost (INAC 2003). Furthermore, reliance on frozen conditions is not recommended in areas with warm permafrost conditions (i.e., ground temperatures above -5^{o}C) or where ground temperatures are expected to increase near or above 0^{o}C due to climate warming.
- Consider increased thaw depth (e.g., active layer thickness) due to climate warming in tailings cover and dam design over the long-term (i.e., post-closure). Both the potential for changes in hydraulic conductivity (e.g., increased seepage) and changes in soil strength properties (e.g., slope instability) should be considered.
- Thermistors (i.e., ground temperature sensors) should be used to monitor temperature changes in permafrost, frozen core dams, and/or dam foundations.
- Piezometers can be used to monitor pore water pressure and provide advance warning of related slope instability and/or increased seepage beneath and dam.
- Survey monuments should be established on dam structures and monitored to identify thaw settlement and/or slope creep. Regular surveys should be conducted.

6.2.2 Frost Action and Ice

The following are suggested best management practices to address the impacts of frost action and ice on Tailings Management facilities in Nunavut:

- Climatic (e.g., temperature) and geotechnical (e.g., soil material properties) parameters that affect frost action should be considered when planning tailings management facility structures (such as dams) in order to minimize damage due to frost heave, thaw creep, thaw settlement and other ice-related processes.
- Installation of thermosyphons, air ducts or convention cooling systems can be considered to maintain freezing ground temperatures to mitigate frost heave and thaw settlement (Instanes *et al.* 2005; U.S. Arctic Research Commission Permafrost Task Force 2003).
- Provide increased thickness of exposed low-permeability soil elements and/or frost protection to maintain design function with increased active layer thaw and related freeze-thaw effects (e.g., increased till thickness at Meadowbank Saddle Dams to ensure the active layer remains above the impounded water level; Golder 2007).
- The entrapment of ice into tailings can be minimized by dewatering tailings prior to deposition, effective beach management and employing appropriate operational strategies to reduce ice entrapment (e.g., developing a detailed deposition plan; Cumberland 2004).

6.2.3 Precipitation and Water

The following are suggested best management practices to address the impacts of precipitation and water on Tailings Management Facilities in Nunavut:

- Design water retaining dams with conservative assumptions regarding maximum water levels and extreme storm events resulting in increased dam crest elevations (INAC 2003).
- Consider the use of clean water diversion channels to reduce storm inflows to a tailings impoundment and prevent the overtopping of dams and erosion during heavy rainfall events (Witt *et al.* 2004).
- Spillways and outflow channels should be adequately sized to pass storm flows and, if possible, excavated into bedrock so they are not suspectible to erosion (Bjelkevik 2005).

6.2.4 Wind

The following are suggested best management practices to address the impacts of wind on Tailings Management Facilities in Nunavut:

- Planning and design of Tailings Management Facilities should account for potential wind impacts (e.g., dusting, erosion and wave action) and include adaptive strategies to deal with increased wind speeds.
- Provide tailings cover to prevent tailings erosion due to wind (e.g., rockfill cover over Meadowbank tailings; Agnico-Eagle Mines Ltd. 2009).
- On-site wind monitoring equipment can aid in establishing trends and observing changes in wind pattern.

6.2.5 Extreme Weather Events

The following are suggested best management practices to address the impacts of extreme weather events on Tailings Management Facilities in Nunavut:

- Tailings management facilities should be designed to withstand more frequent and intense storm events.
- Design adaptations may include a larger spillway capable of passing larger storm flows and higher dam crests so that tailings impoundments can store increased precipitation volumes from more intense storm events.

6.2.6 Risk Assessment

Additionally to the above recommended practices it is suggested to assess project and site-specific risks and undertake precautionary actions to reduce identified risks, including the incorporation of measures to adapt to changes in climate over time (Brennan *et al.*, 2001).

7.0 RECOMMENDATIONS FOR GUIDANCE AND STANDARDS RELATED TO ENGINEERING AND MINE OPERATIONS IN NUNAVUT

The NIRB reviews all Environmental Assessments for proposed mining related projects in Nunavut and works with the other regulatory agencies identified in this Report. The NIRB requires that all VECs including weather and climate, are taken into consideration. Currently, the Environmental Assessment process is the best opportunity to influence the planning and design of mines to incorporate climate change, build adaptive capacity by implementing Adaptation Measures.

It is clear that the published guidance materials including the current Good Environmental Practices documented by Environment Canada (2012a) do not identify all of the Adaption Measures that are outlined in the Task 1 Report. These practices were developed for all of Canada and with no specific focus on climate change or the Arctic environment. Some of the agencies have stated climate change goals and the effects of climate change may impact their respective regulatory mandates. However, there is no single process that identifies all potential climate change risks and hence no clear guidance for developers and regulators on how to plan for climate change.

Despite the lack of formal guidance, the case studies examined in this Report are good examples of how climate change and Best Practices can be incorporated and documented on a project-specific basis. Based on these case studies and the Adaption Measures documented in the Task 1 Report, the following Best Management Practices should be incorporated into the review of ports and TFMs.

Ports – Climate Impacts	Recommended Best Management Practices
Sea Level Rise	
■ Reduced top clearance between ships and overhead structures (e.g., bridges, loading facilities). ■ Increased elevation at which wave forces attack a structure, potentially increasing the vulnerability of the structure. ■ Increased exposure of dock decks. ■ Increased corrosion rate and the degradation over time of materials that were specifically designed for a particular range of sea level conditions. ■ More wave action / sea spray on navigational installations. ■ An increase in absolute low sea levels allowing greater under-keel	■ Collect water level data at the site during the planning and design of the port infrastructure and maintain a water level recording station for the life of the project. ■ Adopt a design process for siting key port infrastructure that specifically adopts a strategy or a combination of strategies (e.g., avoid, accommodate, managed retreat, protect) to incorporate projected sea level rise. ■ Plan and design flood elevations and erosion protection using a quantitative risk assessment approach. Determine the highest risk sea level conditions which occur over the duration of the project design life. ■ Plan and design flood elevations and erosion protection to accommodate reasonable levels of climatic variability (e.g. the 1 in 200 year water level). For water levels this would include storm surge. ■ Plan and design the location of port facilities requiring adequate water depth (e.g., vessel draft) based on the lowest sea level conditions which occur over the duration of the project design life.

Ports – Climate Impacts	Recommended Best Management Practices
clearance for vessels, possibly reducing the need for dredging in low sedimentation areas.	
Storm Events and Waves	
■ Degradation of structures. ■ Increased wave run-up and salt spray impacting structures. ■ Loss of viable industrial land around ports. ■ Reduced regularity of port services (e.g., availability / use). ■ Permanent loss of offshore and onshore sediments (e.g., sand). ■ Retreat of coastal landscapes (i.e., erosion). ■ Reduced capacity of natural systems to recover.	■ Collect detailed bathymetry and topography during the planning and design phases of the project and update at regular intervals over the life of the project. ■ Collect wave data at the site during the planning and design phases of the project and monitor waves on a periodic basis over the life of the project. ■ Plan and design wave loading using a quantitative risk assessment approach to evaluate the combined events of anticipated storm regime, ice-free condition, and sea level condition occurring over the duration of the project design life which yields the greatest risk of wave exposure for the port facilities. ■ Plan and design flood elevations and erosion protection to accommodate reasonable levels of climatic variability in keeping with suitable design guidelines (e.g., the 1 in 200 year storm event or the highest total water level from waves and water levels with a combined probability equivalent to a 200 year return period). For waves and storm events this would include wind speed and direction leading to appropriate wave heights and periods, wave setup and wind setup. ■ Plan and design the port operations to accommodate both the anticipated storm regime and waves which could occur over the design life of the project.
Sea Ice	
■ Reduced ice loading on support structures in the water (e.g., bridge piers, dock pilings). ■ Decrease the exposure of a port site to erosion by reducing wave exposure outside of the open-water season.	■ Collect ice thickness and duration data during the planning and design phases of the project. Monitor ice thickness and duration over the life of the project. ■ Plan and design the port facilities to accommodate the ice loading anticipated on the basis of historical data, unless design information is available which supports correlation of reduced ice loading over the design life of the project. ■ Plan and design the port operations to accommodate both the shortest anticipated open water season and longest anticipated open water season which occurs over the design life of the project.

Ports – Climate Impacts	Recommended Best Management Practices
Coastal Erosion	
■ Uncertainties in the future impacts of sea-level rise and storm activities make it difficult to predict coastal bluff erosion. ■ Ports located on erodible soils or soils subject to thaw. ■ Coastal permafrost stability and thaw subsidence can be impacted and result in coastal erosion.	■ Collect shore profile and sediment size data during the planning and design phases of the project. Monitor shore profiles and sediment sizes over the life of the project. ■ Review historical imagery (satellite and air photo) of the proposed site to document observable shoreline changes. Update surveys and imagery on a regular basis, approximately every 5 years, over the life of the project, to evaluate changes to the shoreline. ■ Identify and map the surficial and bedrock geology and collect detailed topography during the planning and design phases of the project. ■ Evaluate the sea level, storm and wave regime, ice regime, and permafrost regime for the site. ■ Plan and design the port facilities to accommodate the extent of coastal erosion anticipated on the basis of historical data unless design information is available which supports correlation of increased coastal erosion over the design life of the project.
Permafrost Degradation	
■ Near-shore thaw subsidence can contribute to increased erosion rates and ground level subsidence, which results in a decrease in coastal permafrost stability. ■ Docks can be vulnerable to warming and/or thawing coastal permafrost due to the reduced foundation strength of the docks and associated pilings.	■ Collect subsurface profiles of temperature and ice content data during the planning and design phases of the project. Monitor these temperature profiles and ice content of the soils over the life of the project. These samples should be collected both on land and below the sea where feasible. ■ Plan and design the port facilities to accommodate the potential changes to permafrost anticipated on the basis of historical data unless design information is available which supports predictions of permafrost degradation over the design life of the project.
Currents	
■ Littoral drift in the near-shore zone can be caused by currents or waves.	■ Collect current data during the planning and design phases of the project. Monitor currents over the life of the project. ■ Plan and design the port facilities to minimize impacts to currents within the littoral zone over the design life of the project. ■ Plan and design the port operations to accommodate potential changes to currents over the design life of the project.

TMFs – Climate Impacts	Recommended Best Management Practices
Permafrost Degradation	
■ Permafrost thaw can cause the settlement of structures. ■ Permafrost degradation beneath a dam in permafrost zones can result in both settlement and foundation instability. ■ Thawing and creep or slumping of slopes adjacent to dams can impact dam stability and impoundment performance. ■ Thawing of permafrost can increase pore water pressure in dams and increase seepage from a tailings impoundment. ■ Thawing of frozen core dams or a dam foundation can increase seepage through a dam and increase the potential for piping. ■ Landslides can occur as a result of permafrost thaw on slopes around a tailings pond.	■ Consider potential climate warming in thermal analyses for all components of TMFs. ■ The preferred approach to minimize potential impacts of climate change is to either design TMFs with unfrozen embankments or design embankments that are thaw-stable. ■ Dams on permafrost should be constructed on bedrock or thaw-stable (with minimal ice content) foundations and incorporate traditional seepage control measures such as geomembrane liner or bedrock foundation grouting, so that dam performance is not impacted by future permafrost degradation. Removal of ice rich foundation soils is also recommended to reduce the potential for thaw-related settlement. ■ The use of frozen core dams is not recommended at sites with discontinuous permafrost or where climate change may result in the disappearance of permafrost. Furthermore, reliance on frozen conditions is not recommended in areas with warm permafrost conditions (i.e., ground temperatures above -5°C) or where ground temperatures are expected to increase to near or above 0°C due to climate change. ■ Consider increased thaw depth (e.g., active layer thickness) due to climate change in tailings cover and dam design over the long-term (i.e., post-closure). Both the potential for changes in hydraulic conductivity (e.g., increased seepage) and changes in soil strength properties (e.g., slope instability) should be considered. ■ Thermistors (i.e., ground temperature sensors) should be used to monitor temperature changes in permafrost, frozen core dams, and/or dam foundations. ■ Piezometers can be used to monitor pore water pressure and provide advance warning of related slope instability and/or increased seepage beneath and dam. ■ Survey monuments should be established on dam structures and monitored to identify thaw settlement and/or slope creep. Regular surveys should be conducted.

TMFs – Climate Impacts	Recommended Best Management Practices
Frost Action and Ice	
■ Repetitive freeze-thaw action can split soil particles, change the soil structure, increase hydraulic conductivity of dam materials and impact performance or lead to dam failure. ■ Repetitive freeze-thaw of foundation and dam fill materials can result in cracks in dams and impact performance or lead to dam failure. ■ Repetitive freeze-thaw and ice lens development can result in consolidation of tailings and may decrease hydraulic conductivity of tailings. ■ Tailings impoundments may not be able to reclaim water if it becomes frozen and permanently entrapped as ice.	■ Climatic (e.g., temperature) and geotechnical (e.g., soil material properties) parameters that affect frost action should be considered when planning TMF structures (such as dams) in order to minimize damage due to frost heave, thaw creep, thaw settlement and other ice-related processes. ■ Installation of thermosyphons, air ducts or convention cooling systems can be considered to maintain freezing ground temperatures to mitigate frost heave and thaw settlement. ■ Provide increased thickness of exposed low-permeability soil elements and/or frost protection to maintain design function with increased active layer thaw and related freeze-thaw effects (e.g., increase till thickness so that the active layer remains above the impounded water level). ■ The entrapment of ice into tailings can be minimized by dewatering tailings prior to deposition, effective beach management and employing appropriate operational strategies to reduce ice entrapment (e.g., developing a detailed deposition plan).
Precipitation and Water	
■ Precipitation events increase water flow into a tailings impoundment area, potentially causing overtopping of dams and / or water covered tailings impoundments. ■ Storm events can result in increased water flow into an impoundment and erosion at spillway outlets. ■ Precipitation can cause erosion of exposed tailings surfaces or dam slopes with insufficient erosion protection.	■ Design water retaining dams with conservative assumptions regarding maximum water levels and extreme storm events resulting in increased dam crest elevations. ■ Consider the use of clean water diversion channels to reduce storm inflows to a tailings impoundment and prevent the overtopping of dams and erosion during heavy rainfall events. ■ Spillways and outflow channels should be adequately sized to pass storm flows and, if possible, excavated into bedrock so they are not suspectible to erosion.

TMFs – Climate Impacts	Recommended Best Management Practices
Wind	
■ Wind erosion at TMFs can lead to dusting and migration of tailings particles from the impoundment. ■ Dusting and migration of tailings during operations is a potential risk if tailings are allowed to dry prior to discharge of a subsequent layer of tailings. ■ Wave action from wind can cause erosion of upstream dam slopes with inadequate erosion protection and even overtopping of the dams. ■ Wave action can cause turbulence in a tailings water cover, which increases the oxygen concentration, re-suspends tailings particles, and allows oxidation of sulphide tailings.	■ Planning and design of TMFs should account for potential wind impacts (e.g., dusting, erosion and wave action) and include Adaption Measures to deal with increased wind speeds. ■ Provide tailings cover to prevent tailings erosion due to wind (e.g., rockfill cover). ■ On-site wind monitoring equipment can aid in establishing trends and observing changes in wind pattern.
Extreme Weather Events	
■ Extreme storm events (e.g., flooding) can exceed the discharge capacity of an impoundment spillway and result in dam overtopping and possibly dam failure. ■ Extreme precipitation events, including flooding, could cause increased erosion in drainage ditches and / or increased water levels in tailings impoundments	■ TMFs should be designed to withstand more frequent and intense storm events. ■ Design adaptations may include a larger spillway capable of passing larger storm flows and higher dam crests so that tailings impoundments can store increased precipitation volumes from more intense storm events.

These **Best Management Practices** along with the identified **Adaption Measures** identified in the Task 1 Report should be formalized in guidance documents produced by NIRB and made available for development proponents and regulators in Nunavut.

Monitoring programs should be designed and implemented to ensure that mine closure activities and any potential environmental impacts are mitigated and ensure that mine closure objectives are met (described in Rask 1 Report). It is crucial that information from mining projects is made publicly available to assist in the Environmental Assessment process and the establishment of specific Best Practices.

Additionally, as part of the Environmental Assessment a **risk assessment** should be conducted to document that the climate change vulnerabilities have been identified and the appropriate Adaption Measures or monitoring programs are planned. This risk assessment can be build into the specific regulatory process and appropriate guidance should be provided to developers.

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

IMG-Golder Corporation
Suite 206, 125 Mackenzie Road, Box 2340
Inuvik, Northwest Territories, X0E OTo
Canada
T: +1 (867) 777 5997

IMG-Golder Corporation
Environmental Consulting Inuvik, NT