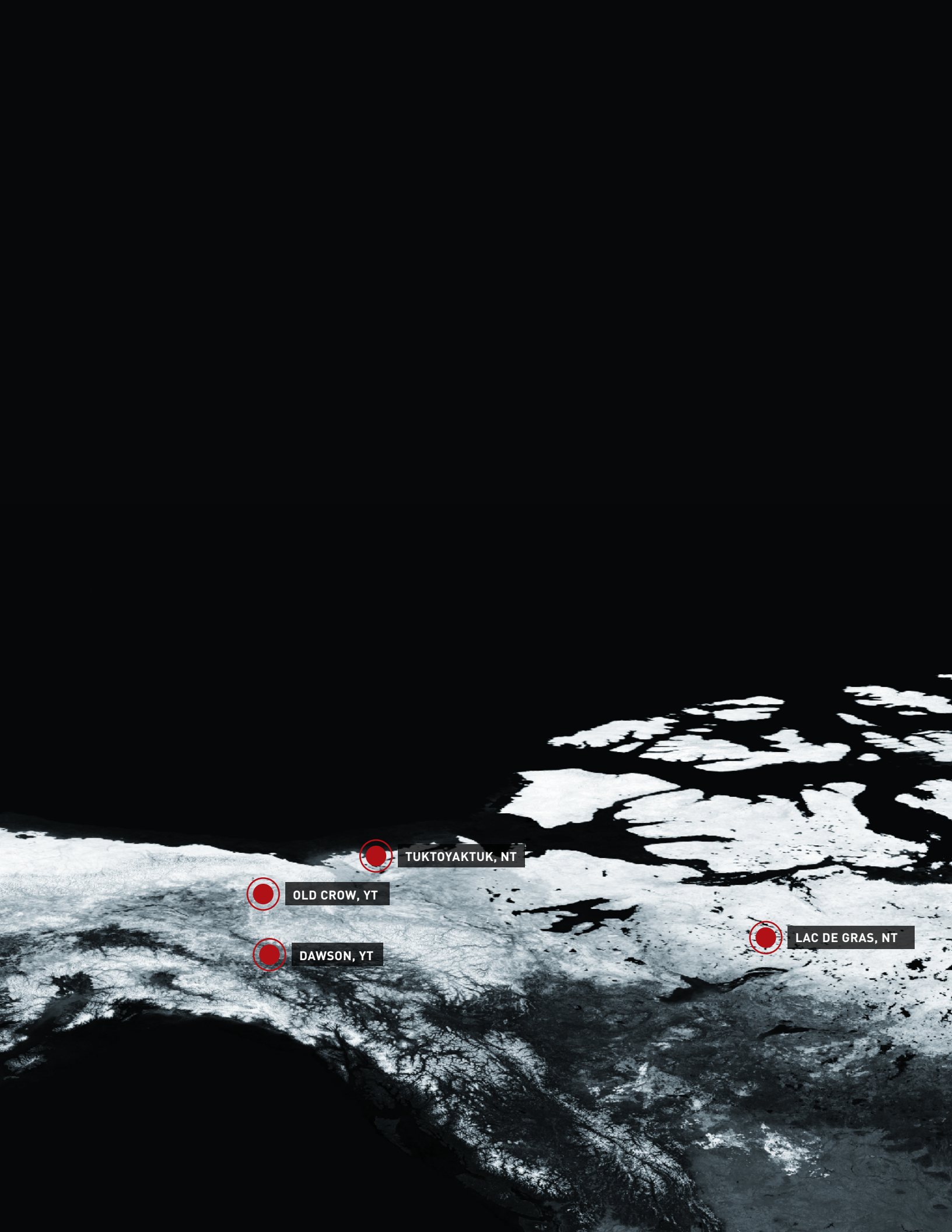
TRUE NORTH

ADAPTING INFRASTRUCTURE TO CLIMATE CHANGE IN NORTHERN CANADA

National Round Table on the Environment and the Economy | Table ronde nationale sur l'environnement et l'économie

Canada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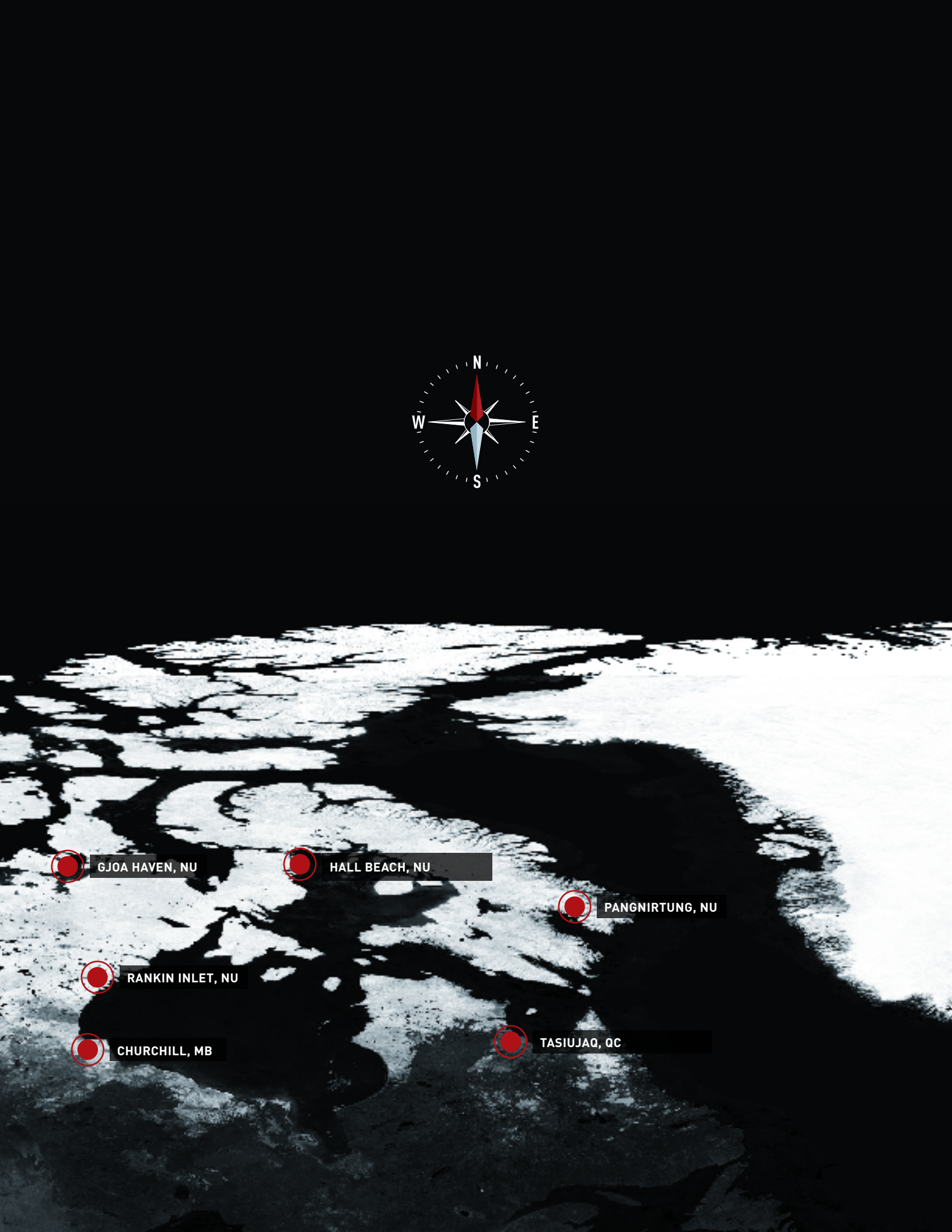
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OUR ENVIRONMENTAL COMMITMENT

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INTERNATIONAL POLAR YEAR

True North forms part of Canada's contribution to the International Polar Year. The International Polar Year (IPY) 2007 -08 is a large scientific program focused on the Arctic and the Antarctic. IPY 2007 -08, organized through the International Council for Science (ICSU) and the World Meteorological Organization (WMO), is actually the fourth polar year, following those in 1882 -83, 1932 -33, and 1957 -58. It involved over 200 projects, with thousands of scientists from more than 60 nations examining a wide range of physical, biological, and social research topics. It also provided an unprecedented opportunity to demonstrate, follow, and get involved with cutting-edge science in real time. During the course of IPY 2007-08, Canadian researchers led and participated in a large number of projects, including the 44 different projects funded through the federal program that focused on research activities related to science for climate change impacts and adaptation, and the health and well-being of northern communities. Although many research activities took place between March 2007 and March 2009, IPY-related efforts continue in the form of educating the public, disseminating research, analyzing data, sharing and integrating research results, and communicating scientific findings to policy makers. These legacy efforts are consistent with IPY's objective to encourage the application of new knowledge.

Sources: http://www.ipy.org/index.php?option=com_content&view=article&id=18&Itemid=55
http://www.ipycanada.ca/web/guest/research

LETTER OF TRANSMITTAL

BOB PAGE
NRTEE Chair

The Hon. Jim Prentice, PC, MP
Minister of the Environment

Dear Minister:

On behalf of the National Round Table on the Environment and the Economy (NRTEE), I am pleased to forward *True North: Adapting Infrastructure to Climate Change in Northern Canada*. We believe that the infrastructure upon which all northern peoples depend is facing unprecedented challenges, and there is an urgent need for pre-emptive planning and action.

We congratulate the government on the release of its *Northern Strategy*, which has come down since the completion of our work for this report. We feel our report fills an important niche for the government in implementing its policy for Northern Canada. Shifting foundations from melting permafrost create huge new design issues for architects, engineers, and planners dealing with roads, pipelines, airports, or wildlife harvesting. We will have to work together to design a new technical and social framework with northerners.

Climate change is moving fastest in Arctic areas, requiring Canada to be a world leader in adaptation practices, more than we had ever contemplated. This will involve the professional expertise of engineers and the building codes used by planners. But above all, it will involve every community adapting to the specific circumstances of its local scene. Some coastal communities are clearly at risk, given rising sea levels and increasingly frequent storm surges.

We believe that our report will strengthen the four pillars of your *Canadian Northern Strategy* — sovereignty, social and economic development, environment, and governance. Together we believe that they help to provide a road map for sustainable development in this critical period of change in northern history. We also believe it will provide a valuable opportunity for Canada to meet the needs of all our northern peoples, while at the same time showing real international leadership for the circumpolar North.

The NRTEE has benefitted from its dialogue with northern peoples in the preparation of this report and we hope it will be useful in the plans of federal, territorial, provincial, and Aboriginal governments.

Sincerely,

Bob Page
Chair, NRTEE

MESSAGE FROM THE PRESIDENT AND CEO

DAVID McLAUGHLIN

NRTEE President and CEO

Canada's North is on the frontline of climate change. Nowhere else are the effects and stakes of failing to adapt to climate change so high. An already unique and vulnerable environment faces new and different risks associated with melting sea ice, degrading permafrost, and shifting weather patterns. Securing Canada's Arctic environment in the face of looming climate change is fast becoming a national and an international priority.

Adaptation is an essential policy response to climate change. It deals with the "here and now" to reduce the effects of carbon already in the atmosphere that are projected to cause serious climate impacts in the North in the years ahead. Infrastructure must become a core focus of Canadian adaptation policy. From buildings to roads, from airports to pipelines — infrastructure is essential to modern, secure communities. It is at risk from a changing climate and needs new, forward policy responses to make it more resilient and less vulnerable.

This new study of northern infrastructure by the NRTEE offers practical solutions to do just that, as part of a focused adaptation strategy. Using risk-management tools already in place, we can make real strides to ensure northern communities and critical infrastructures are able to adjust and adapt to the stresses of climate change.

We are proud to offer *True North* as part of Canada's contribution to the International Polar Year.

MESSAGE FROM THE ROUND TABLE

Climate change is not a future, theoretical prospect. Across Canada and the world, the impacts of climate change are evident now.

Canada's North is the frontline in the global climate change challenge. Nowhere else in our country, or on our planet, are the early effects of climate change so plain. Nowhere else in Canada are communities and traditional ways of life so clearly at risk due to climate change.

Canada's security – national, economic, social, and environmental – is impacted by climate change. Rapidly melting sea ice is opening Canada's North to new challenges and opportunities. Access to rich resource lodes is becoming more inviting and feasible. Opportunities in tourism and fisheries are expanding. New shipping lanes may bring new sovereignty challenges. Fragile and unique ecosystems will face new stresses as a result.

Canada's last frontier is more than an icon or image. 'From sea to sea to sea' is more than a motto. It reminds us, as Canadians, of just how vast and daunting our land and sea remains. It stretches our imaginations and challenges our endurance. However remote to most Canadians, it is home to a special group of Canadians who need our attention and our commitment to help them combat the looming threat of climate change while taking advantage of new economic opportunities.

The one force dominating Canada's North today is accelerating change - physical, biological, cultural, economic, and political. This includes the physical reality of changing permafrost and sea ice, shifts in the distribution of animal and plant species, more frequent marine visits and the search for oil and gas.

Canada's North provides a policy context different from any other region of the country. It faces a unique gap between myth and reality; a gap between southern perceptions of the North and the reality of northern circumstances. In the south we like to talk about 'the True North Strong and Free', romantic perceptions of northern peoples, the vision of a pristine wilderness, and popular images of polar bears and caribou. But the reality is of land, sea, communities, and peoples facing both lingering and new pressures on economic growth, social conditions, and environmental integrity.

The past few years have seen fresh, positive, and timely attention paid to Canada's North. The federal government is embarking upon a comprehensive new strategy for northern Canada. But no strategy can be complete without climate change adaptation as a key plank. And no climate change adaptation plan can be complete without a core focus on infrastructure.

Infrastructure in the North connects communities and fosters security like no other place in Canada. Climate change adds a major new level of risk. Melting permafrost is undermining building foundations, and threatens roads, pipelines, and communications infrastructure. Storm surges, wildfires, floods, blizzards, and changing wind and snowstorm patterns all pose risks to remote and vulnerable communities.

Canada's North is too much an afterthought when it comes to national rules and processes influencing infrastructure decisions. Codes and standards for buildings reflect little of what it takes to design, build, and maintain infrastructure in the North, let alone a North facing climate change challenges. Insurance coverage for failures and disasters is not adequately tailored to northern risk profiles. Community planning for disaster management is uneven and lacks resources.

True North highlights the risks to northern infrastructure posed by climate change and the opportunities in adaptation. It casts a light on one of the most critical aspects of adaptation – ensuring the infrastructure is resilient over its lifespan in the face of climate change. Our report shows clearly how we can use existing risk management tools to reduce infrastructure vulnerabilities and adapt more effectively to climate change in Canada's North.

To do so, we need to do two things: *first*, make climate change adaptation more of a 'mainstream' issue than ever before and, *second*, build northern capacity to adapt to climate change. We can help achieve this by undertaking four priorities:

1. Integrate climate risks into existing government policies, processes, and mechanisms;
2. Ensure northern interests are represented and implicated in the development of climate change adaptation solutions;
3. Strengthen the science capacity and information use in the North to support long-term adaptation efforts;
4. Build community capacity to address climate risk to northern infrastructure and take advantage of opportunities.

Climate change adaptation is at its heart, a security issue for Canadians. Making the roads we travel, the buildings we work and live in, the pipelines that carry our energy and wealth – all these and more – secure in the face of looming climate change is not just a challenge to Canada's North, but an obligation to us all.

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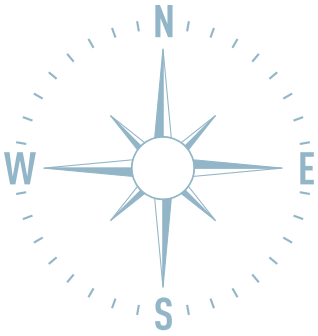
ABOUT THE PHOTOGRAPHS

The satellite images that introduce each chapter of our report pinpoint communities across the North where climate-related events have disrupted daily life, damaged infrastructure and hurt the local economy; or where climate change threatens disruptions in the future. Though not all events are definitively linked to climate change, they highlight the challenges facing Northern communities.

64° 29' 46" N
110° 16' 24" W

LOCATION: LAC DE GRAS, NORTHWEST TERRITORIES

Warmer temperatures will lead to shorter winter road seasons. Ice roads that fail to freeze thick enough to allow for resupply of equipment are of particular concern for the mining industry. For example, in 2006 the Diavik Diamond Mine resorted to using a large helicopter to airlift stranded heavy equipment to its mine 300 km northeast of Yellowknife.



EXECUTIVE SUMMARY

Why climate change adaptation of infrastructure in Canada's North?

Climate change is a reality, and the global frontline runs directly through Canada's North. Warming temperatures, changing precipitation and land ice conditions, melting glaciers and sea ice, earlier springs, increasingly volatile weather, and shifts in the distribution of animals and plants are all occurring. The impacts of climate change touch all regions of Canada, presenting environmental, social, and economic risks, and some potential opportunities. However, Canada's North is particularly affected, with warming taking place at faster rates than throughout Canada as a whole, and more quickly than projected by climate models, even under the most pessimistic scenarios.

Adapting to the impacts of climate change, not just limiting the magnitude of future change through global mitigation of greenhouse gas emissions, is essential for northern communities to be secure in the decades ahead. The impacts of climate change pose risks to a range of economic sectors and systems that northerners value. Chief among them is the region's infrastructure, including its roads, buildings, communications towers, energy systems, and waste disposal sites for communities, and large-scale facilities and waste-containment sites that support the territories' energy and mining operations. The risk to infrastructure systems will only intensify as the climate continues to warm.

For several years now, governments in Canada have been studying the issue of adaptation with the assumption that citizens will adjust as the nature of the threat becomes clear, with little or no government intervention beyond the generation and provision of information. Coordinated and strategic action in support of Canadian preparedness remains largely lacking. This is risky in the long term. Several opportunities already exist to integrate climate change adaptation alongside compatible policy goals, like *Canada's Northern Strategy.*

Recognizing the unique vulnerability of Canada's North and the potential for climate change to compromise sustainable regional development, the National Round Table on the Environment and the Economy embarked on a policy research program to consider climate change adaptation in this part of the country. This policy report includes the findings, recommendations, and conclusions of our work, and serves two purposes. First, it raises the profile of climate change adaptation in Canada's North and stresses the urgency of dealing with it. Second, it provides immediate and longer-term advice to all levels of government on adapting northern infrastructure.

Given the pace of climate change and considering the potential for economic development and accompanying infrastructure expansion in Canada's North, the time to capitalize on the adaptation opportunity is now.

Here are some of our recommendations:

- The Canadian Government should adjust funding vehicles for infrastructure development and rehabilitation so that they become incentives to integrate the risk of damage from climate change in infrastructure decisions.
- National codes and standards for engineering and construction should be reviewed and modified to accommodate risks of climate change.
- Governments and the insurance industry need to work together so that Canadians continue to have access to affordable insurance in a changing climate and so that insurance products encourage modifications to infrastructure in light of climate risks.
- Governments at all levels should collaborate with northern experts to develop the best possible design and engineering guidelines for the North.
- The Government of Canada should invest in updating and providing more comprehensive climate data, climate change projections, and information for infrastructure design.
- The Government of Canada needs to share the expertise and experience of Canada's North in addressing climate risks to infrastructure with other polar nations as part of *Canada's Northern Strategy*.

What did we examine?

Through qualitative research and extensive stakeholder consultation, including the views of over 70 northern residents and experts, we examined the risks to northern infrastructure posed by climate change and opportunities in adaptation. The NRTEE evaluated three risk-based mechanisms that together influence the degree to which the infrastructure in Canada's North can withstand the impacts of climate change, thereby ensuring continued provision of services that communities and businesses depend on: codes, standards, and related instruments; insurance; and disaster management. Although these three mechanisms do not cover the full spectrum of tools to improve the management of climate risks, they are already in place and there is an immediate opportunity to utilize them as part of a broader climate change strategy.

Codes, standards, and related instruments (CSRI) — "sets the bar" on all phases of the infrastructure life cycle, from design to construction to maintenance to decommissioning, by specifying performance or material requirements.

Insurance — a financial mechanism that allows society to pool the management of risks, as such it has the potential to foster a culture of risk reduction and provide incentives to change behaviours that increase vulnerability to climate change.

Disaster Management — includes approaches to prevent disasters, increase a community's preparedness and response capacity during a disaster, and help a community recover after a disaster.

Our research, analysis, and consultations focused on Canada's three territories — Yukon, the Northwest Territories, and Nunavut — yet, many of the NRTEE's findings, conclusions, and recommendations are likely to apply to northern reaches of several provinces.

What did we find?

Our research found that northerners are concerned that a warmer climate is already having an effect on the region's infrastructure. We heard that changing precipitation patterns, including changes in snow, rain, and freezing rain conditions; permafrost degradation; flooding and streamflow changes; sea-ice loss and coastal erosion and other climate-related changes are compromising the integrity of transportation systems, buildings, communications, energy projects, and containment structures for storing waste from mining operations.

Canada's North already faces many challenges and dealing with climate change will only add to their number. They include coping with a growing population and a diversity of socio-economic conditions as well as new opportunities for economic development and evolving northern governance structures.

We believe all sectors of society have a role to play in adapting to climate change, including the modifications needed to maintain and improve our northern infrastructure. Governments, in particular, have a range of policy instruments at their disposal — both to make direct changes and to encourage and support others to make "climate-wise" decisions across the country. In Canada's North, successfully adapting to the impacts of a changing climate will involve cooperation across all levels of government — local, Aboriginal, territorial, and federal — with the delineation of roles and responsibilities taking place as northern governance regimes evolve. The federal government, in particular, can play a critical role in shaping strategies for climate change adaptation. It has a direct role in the political and economic development of the territories, circumpolar obligations, and roles in forecasting weather and sea-ice conditions and in maintaining the knowledge base of Canada's land mass. At the same time, infrastructure development and renewal has emerged as a policy priority, presenting an incredible opportunity to phase in climate change adaptation as infrastructure planning and investments unfold.

Canada is not alone in searching for solutions to enhance the resilience of built infrastructure to a changing climate. We can be ahead of the curve by developing skills, technologies, and governance in support of climate change adaptation. Commercial opportunities exist for Canadian entrepreneurs, such as codes and standards development bodies, and public-private institutes like the Yukon Cold Climate Innovation Centre, to promote tools and technologies for adaptation in domestic and export markets.

Our evaluation of three risk-based mechanisms — codes and standards, insurance, and disaster management — as potential vehicles for adaptation of northern infrastructure led to five main findings:

1. Limited interaction among scientists and data providers, designers and builders of infrastructure, and policy-makers are barriers to problem identification and the application of solutions.

2. National institutions, such as national codes and standards, pay inadequate attention to northern interests and conditions.

3. Significant gaps exist in the availability and accessibility of data and information that form the basis for infrastructure risk management and loss prevention. These include information on current and projected impacts of climate change, and data on the stock of, and demand projections for infrastructure.

4. The capacity across and within northern jurisdictions to assess climate risks to infrastructure, and to develop, deploy, and enforce standards and risk reduction measures is uneven and lacking.

5. Important synergies exist among codes and standards, insurance, and disaster management in terms of their combined potential to drive climate change adaptation. These synergies could be better exploited.

What did we conclude?

- Strategies to address the impacts of climate change targeting Canada's North must have the flexibility to accommodate the incredible cultural, social, political, and economic diversity represented in the region. In some cases, pan-northern strategies may be less appropriate than efforts to leverage action across north-south borders.
- Conditions such as the enormous distances between settlements across the region and sometimes unreliable or limited supply of goods and services increase the vulnerability of communities to climate shocks. Enhancing community-level resilience in the face of change is key.
- Northern stakeholders face competing demands on financial and human resources, emphasizing the importance of integrating adaptation into existing or newly formed institutions, such as regulatory processes, asset management plans, resource management and community plans, to help prepare for the impacts of climate change alongside other priorities. These findings also support investments in adaptation strategies or actions that yield social, environmental, or economic benefits regardless of future climate change, including opportunities to learn from and contribute to circumpolar initiatives.
- Adapting to climate change is a shared concern across the territories, and, indeed several initiatives related to infrastructure adaptation are taking place. However, access to knowledge, technical skills, and finances to effectively plan and deliver actions to minimize climate risks to infrastructure varies within and across the territories. In light of the rapid changes in northern climates, addressing capacity constraints such as these is critical.
- Existing climate and environmental data[1] and information are insufficient and inadequate to effectively project and plan for infrastructure adaptation, particularly at the site-specific level.
- Professionals involved in northern infrastructure planning, design, and operations need better guidelines and methodologies — so-called guidance — to incorporate climate change–related information, such as trends and forward-looking projections, into their decisions.
- Finally, the absence of an overall national framework or commitment to coordinate and integrate federal, territorial, Aboriginal, and community adaptation actions, results in piecemeal responses that run the risk of being ineffective and expensive.

[1] "Data" refers to raw measurements of physical conditions. They become an input into the generation of information. For example, the values used for design of infrastructure require significant data analysis in order to become relevant information for infrastructure design, codes and standards.

What do we recommend?

Our report shows clearly how improvements in the use of existing risk-based mechanisms can reduce infrastructure vulnerabilities and address climate risks into the future.

Integrating climate risks into existing government policies, processes, and mechanisms

The NRTEE recommends that:

- The Government of Canada use its infrastructure programming and related federal-provincial-territorial frameworks to leverage the integration of climate risks in new construction and rehabilitation of infrastructure, ensuring that the systems are in place to monitor and report on infrastructure performance.
- The Government of Canada, through the Standards Council of Canada, lead efforts to ensure the effectiveness of codes and standards for infrastructure design, planning, and management to address climate risks, and that this be regularly assessed in light of new climate information.
- Governments and the insurance industry collaborate to examine the role of private insurance in managing climate risks to infrastructure, potential changes in access to coverage of insurance as new climate risk factors emerge, and the need for mandatory disclosure of financial risks that climate change poses to the industry.
- Governments at all levels undertake a collaborative review of current disaster/emergency management frameworks as mechanisms to enable adaptation to climate change on a preventative basis.

Ensuring northern interests are represented and implicated in the development of climate change adaptation solutions

The NRTEE recommends that:

- The Government of Canada promote dialogue and engagement between risk management practitioners (codes, standards, and related instruments; insurance; disaster/emergency management) operating in Canada's North and the climate change adaptation community.
- The Government of Canada consider expanding the relevant national model codes, such as the National Building Code of Canada, to provide direction to northern infrastructure practitioners on the integration of climate risks.

- Governments collaborate with northern infrastructure practitioners to develop design and engineering guidelines or peer-reviewed best practices specifically for Canada's North for each major category of infrastructure.
- Governments highlight expertise and experience in addressing climate risks to northern infrastructure at the circumpolar level, to share knowledge, learn from others, and enforce Canadian leadership as part of *Canada's Northern Strategy*.

Strengthening the science capacity and information use in the North to support long-term adaptation efforts

The NRTEE recommends that:

- The Government of Canada invest in expanding the weather and permafrost data stations in Canada's North that it uses to collect this critical information, in support of infrastructure adaptation decision-making needs.
- The Government of Canada ensure the continued investment in climate science and modelling, and in climate change impacts and adaptation research, taking advantage of partnerships with Arctic research institutes and innovative delivery mechanisms.
- The Government of Canada dedicate resources to reliably update and disseminate regionally relevant climate data and information, climate change projections, and climate design values to support infrastructure decisions.
- Governments, the private sector, and research organizations work together to make existing adaptation-relevant scientific and technical data and information more accessible and usable to northern infrastructure practitioners, owners, and operators.

Building community capacity to address climate risks to northern infrastructure and take advantage of opportunities

The NRTEE recommends that:

- Governments continue to support community-based infrastructure risk reduction through activities such as building awareness of the linkages between disaster management and climate change adaptation, critical infrastructure mapping, and developing and tracking of vulnerability indicators.
- Governments support regional innovation in Canada's North by encouraging the development of new technologies and materials adapted to cold climates and enabling their commercialization.

- Governments work together to identify gaps and support regional skills development to address infrastructure needs in a changing northern climate, including ensuring local capacity exists to conduct risk assessments, and to deploy and enforce risk reduction measures and standards locally and regionally.
- Governments, the private sector, communities, and research organizations consider how to further tap into traditional and local knowledge as a unique contributor to building community and regional capacity for adaptation.

The above recommendations address two priorities: "mainstreaming" climate change adaptation into current and future policy and decision-making processes; and building northern capacity to adapt to climate change. These priorities must be undertaken simultaneously over time if we are to organize ourselves to successfully make northern communities, businesses, and the infrastructure that sustains them, resilient and adaptive to the looming reality of climate change in Canada's North.

1.0

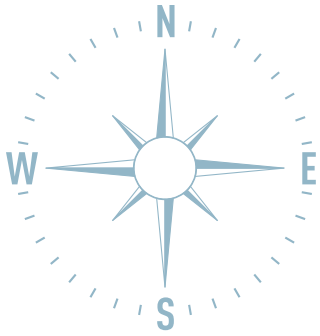
ADAPTATION AND CLIMATE CHANGE

IN THIS CHAPTER

67° 34′ 07″ N
139° 50′ 07″ W

LOCATION: OLD CROW, YUKON

In a changing climate, the potential for increased flooding, related erosion, and silt buildup is a serious concern for communities located on floodplains. These phenomena have already disrupted navigation in some areas. The Porcupine River at Old Crow (Yukon) is used to provide access to the town, but silt buildup in already low water levels is significantly restricting boat traffic.



1.0 ADAPTATION AND CLIMATE CHANGE

1.1 MAKING ADAPTATION THE ISSUE

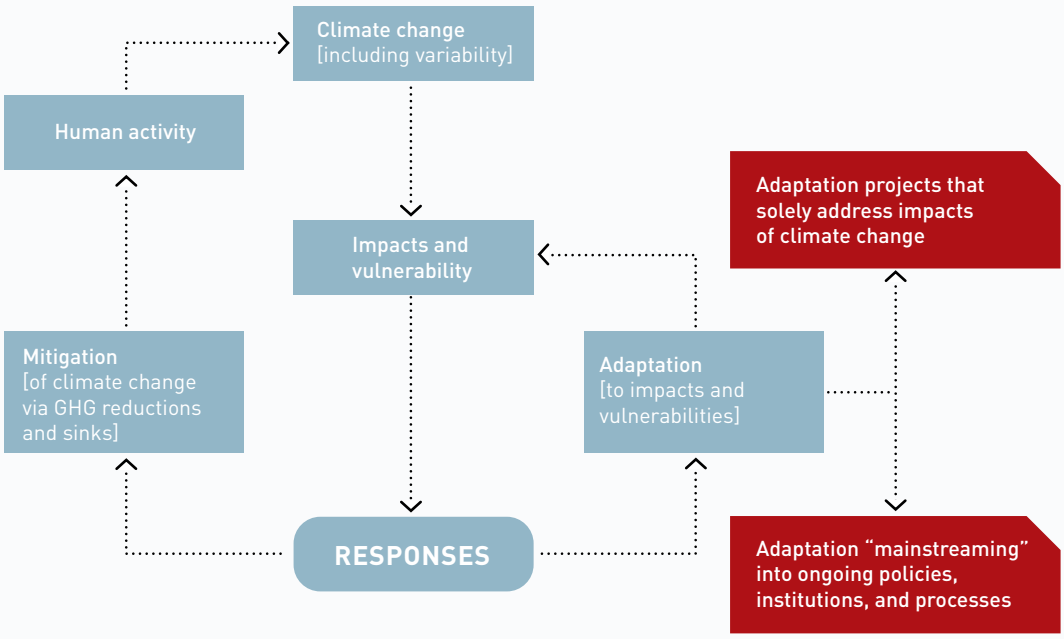
Climate change is real and upon us. Warming temperatures, changing rain, snow, and land ice conditions, melting glaciers and sea-ice, earlier springs, and shifts in the distribution of animals and plants toward higher and more northerly locations are all occurring. And Canada's North is experiencing it first and most rapidly. Action now to arrest the discharge of more greenhouse gases (GHGs) into our atmosphere cannot remove what is already there. Evidence suggests that continued trends in global GHG emissions are very likely to result in large changes in our climate. The North faces more risk, not less.

Climate change has the potential to compromise our sustainable development goals, demanding action on two important and complementary policy fronts: mitigation and adaptation (see Figure 1). We need to limit the magnitude and rate of climate change by reducing economy-wide GHG emissions from burning of fossil fuels and by altering land-use practices to enhance forest and agricultural carbon sinks. This is *mitigation*. We also need to make technical, structural, operational, and behavioural adjustments that minimize the risks from the effects of climate change we are experiencing now and expect to later, and position us to take advantage of opportunities. This response is *adaptation*.

Too little attention has been paid to the positive outcomes of reduced vulnerability we can achieve through adaptation to climate change. Yet, a little can go a long way. The reality is, we adapt every day to climate-related events such as floods, forest fires, changing snow and rain conditions, and wind-storms. Putting in place new, protective or precautionary measures such as early-warning systems, a floodway, or reinforced buildings are all part of adaptation. But to do it well, we need to understand what is at risk, what it's at risk from, and what can be done about it. Climate change is creating a more intensive, deliberate impact on our environment — built and natural — requiring equally intensive and deliberate responses by governments, communities, businesses, and individuals. Adapting to climate change, not just limiting its magnitude and speed, is essential for communities and businesses to be secure in the decades of change ahead.

Preparing now for the impacts of a changing climate is wise from a number of perspectives. Regardless of successes in global GHG mitigation, the world may well be facing decades of warming. Adaptation is the only response that addresses the effects that are now unavoidable. In contrast to mitigation, which brings long-term global benefits, adaptation is primarily a local issue with the potential to yield early benefits.

FIGURE 1: Climate change demands two types of responses: mitigation and adaptation

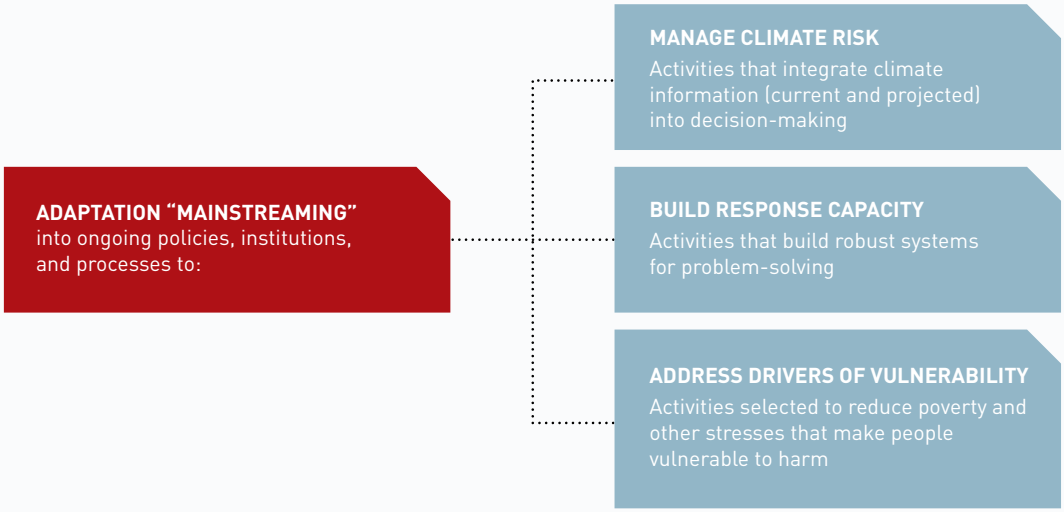


Source: Adapted from Lemmen et al. (2008).

Governments in Canada have been studying the issue of adaptation for several years now and adaptation has made its way onto the national climate agenda to an extent. But as climate change impacts intensify, particularly in northern regions, coordinated and strategic action in support of Canadian preparedness remains largely lacking. Past, ongoing, and planned adaptation initiatives in Canada generally represent fragmented responses to local trends and events. The public at large, many business and government decision-makers, and segments of the population that are not directly experiencing the impacts of a changing climate generally fail to make the connection between climate change and adaptation. And we fail to appreciate the need and scale of investment required to be ready. An implicit assumption has been that Canadians — communities, businesses, and populations at risk — will adapt as the nature of the threat becomes clear, with little or no government intervention beyond the generation and provision of climate change information.

This is risky in the long term. Just as sustainable development requires economic and environmental decisions and impacts to be considered jointly — a way of thinking and not just doing — climate change adaptation should be considered as part of existing government policies, institutions, and processes (see Figure 2). It must become part of the mainstream. Rather than simply creating new processes, institutions, and separate government programs, an effective and efficient approach to adaptation is to "mainstream" it by building on existing planning and permitting rules, for example, and by leveraging relationships and partnerships across communities of experts and with the private sector, which has an enormous stake in adaptation investment.

FIGURE 2: A range of activities fall under adaptation "mainstreaming"



Source: Adapted from McGray et al. (2007).

Yet, despite their important role in providing the conditions and signals that enable adaptation mainstreaming, governments in Canada are only starting to seriously consider how they might approach this, what the barriers might be, and with whom they might need to partner. As a wealthy country, with a skilled and talented labour force, developed markets and institutions, technological advancement, and decentralized governance, Canada's potential to successfully adapt to a changing climate is high. Governments' role in harnessing this potential is critical but remains largely unexplored. But, adaptation is more than adjustments in response to potential future climates; supporting strategies to adapt well to today's climate and its variability also requires attention. Given the many risks that a changing climate poses, to our economy and environment, there is no time to waste.

1.2 THE NRTEE'S PROGRAM ON CLIMATE CHANGE ADAPTATION POLICY

Recognizing the many economic, environmental, and social risks for Canada posed by a changing climate, the National Round Table on the Environment and the Economy (NRTEE or Round Table) embarked on a policy research program to consider climate change adaptation in the North. We focused the program on physical infrastructure in Canada's North, and the potential to adjust existing risk-based mechanisms — codes, standards, and related instruments (CSRIs), insurance, and disaster management — to reduce infrastructure vulnerability through adaptation mainstreaming. In this way, we could combine a pressing issue -climate change- in a vulnerable region -the North- and examine known risk-based mechanisms- to adapt to a changing climate.

We looked at Canada's North because of the region's unique vulnerability, with and without climate change, and the expected developmental impacts an expanding economy will have on this region's peoples and communities (see Box 1). Northern Canadians are among the first to experience how changing climate conditions can be rapid, surprising, and more significant than the projections of the climate science of the day. Systems that support adaptation, such as institutions and planning mechanisms, are less developed and robust in northern Canada than in other parts of the country. Constraints in access to financial and human resources affect northerners' ability to implement adaptive measures. Challenges faced everyday by northern Canadians from extreme cold and a unique physical reality of permafrost [2], sea ice, and community isolation, combine to make this region notable for such a study.

[2] Permafrost refers to rock, sediment, and organic material that remains frozen for at least two consecutive years.

BOX 1: NRTEE stakeholders have a range of views on climate change impacts and adaptation issues that require attention in Canada's North

During the course of the program on Climate Change Adaptation Policy, the NRTEE commissioned research on the role of government in adaptation, specifically in Canada's North. As part of this work, the research team conducted telephone interviews with northern stakeholders in April 2007. The interview format consisted of open-ended questions covering different aspects of climate change adaptation. The following presents aggregate results of answers to the question, "what are the main impacts from climate change that will require adaptation efforts?" Results are not statistically representative of northern populations. They provide an indication of Northerners' perceptions of the issue at the time of the interviews.

What are the main impacts from climate change that will require adaptation efforts?

- changes to culture
- changes to the harvesting-based way of life
- increased use of potential decline in iconic species, such as polar bear and caribou, as justification for challenging the harvesting economy
- changes to diet and food security
- threats to health, including mental health
- decreased availability of water supplies
- problems as a result of the spruce bark beetle
- melting permafrost damaging infrastructure
- damage to winter roads
- damage to municipal infrastructure
- coastal erosion and storm surges
- increase in local shipping and transit shipping in the Northwest Passage
- environment and social threats linked to increased mineral and oil and gas development
- combination of stressors is the "key" issue

The Arctic and climate change was the focus of a high-level roundtable discussion held by the NRTEE in October 2008, as part of marking its 20th anniversary (summary available at: http://www.nrtee-trnee.ca/eng/news-media/events/other/20th-anniversary/climate-forward/climate-forward-contents-eng.php). Roundtable discussions concluded the following:

- Although irreversible climate changes are already apparent in the region, we have only partial knowledge of what climate change is doing to Canada's North and what this means for policy responses to issues of melting sea ice, sovereignty, resource development, and northern peoples and communities.
- Arctic melting has clear international implications. A combination of unresolved sovereignty issues and the promise of newly accessible natural resources could lead to disputes over territory.
- Canada's Arctic peoples and communities need to be directly implicated in assessing climate risks and developing and implementing adaptation solutions.

We selected physical infrastructure because of the risks posed to it by climate change from permafrost degradation, for example; because of the costs involved in building and maintaining it; because of its crucial role in all dimensions of economic and social life for any community; and because it is typically designed and operated over lifespans of many decades. From an economic point of view alone, systematically addressing emerging climate risks to Canada's infrastructure makes sense. According to Environment Canada, *"More than 5 trillion dollars' worth of aging infrastructure could be at risk from a changing climate. Over the coming decade, billions of dollars could be invested in new infrastructure projects, and these structures will need to be designed and built to withstand changing climate conditions."*[3]

We focused on codes, standards, and related instruments (CSRIs), insurance, and disaster management as examples of existing risk-based mechanisms that governments could adjust to support adaptation to climate change. These are then strong examples of our interest in pursuing mainstreaming to facilitate climate change adaptation. All three are used to one degree or another already throughout Canada, and are familiar to governments at all levels. A brief explanation of each risk-based mechanism and their relationship to adaptation follows:

CSRIs account for a significant proportion of the rules that apply to infrastructure in Canada. Although often invisible to the public, they guide all phases of the infrastructure lifecycle from design to construction to maintenance by specifying end-product performance or material requirements. CSRIs incorporate numerous assumptions and directives in relation to the climate and weather conditions (e.g., temperature, precipitation, wind), climate-related events (flooding, freeze-thaw cycles, etc.), and environmental conditions that infrastructure must withstand. Thus, the scope for integrating climate-related risks into decision rules is significant.

Insurance is a financial mechanism that supports society's management of risk, including the risk of disruption of services caused by weather-related damage to buildings and other types of infrastructure. The availability and affordability of insurance communicates the nature, magnitude, and frequency of risk. A changing climate affects the risks to which Canadians and their physical assets and economies are exposed, and, the eventual availability, cost, and character of insurance for addressing these risks. If designed optimally, insurance fosters a culture of risk reduction.

Protecting its citizens and their property from natural and human-caused disasters has long been one of government's fundamental roles, a role that provides the rationale for services as varied as national defence, law enforcement, weather forecasting, and firefighting. Disaster management includes approaches to prevent disasters, increase a community's preparedness and response capacity during a disaster, and help a community recover after a disaster. The strong links between climate change adaptation and disaster management are becoming increasingly evident.

[3] Environment Canada, EnviroZine, Issue 87, December 8, 2008, http://www.ec.gc.ca/EnviroZine/default.asp?lang=En&n=3D5D530C-1 accessed April 13, 2009.

1.3 *TRUE NORTH* REPORT

This report serves two purposes. First, it raises the profile and hence, the urgency of dealing with climate change adaptation in Canada's North. Second, it provides immediate and longer-term advice to governments at all levels on adapting northern infrastructure — through the application of known risk-based mechanisms — to become more resilient and less vulnerable to climate change. There are lessons here for the rest of Canada.

Structure of the Report

The rest of the report follows this structure:

Chapter 2 introduces trends and conditions that influence decisions about climate change adaptation in Canada's North. It describes a diverse and vast region that is undergoing unprecedented changes in its climate, governance, economy, and society.

Chapter 3 provides information on the challenges of managing infrastructure in Canada's North and discusses the vulnerability of northern infrastructure to current and expected impacts of climate change. The chapter underscores the importance of addressing this challenge in the context of economic and social changes to ensure a reliable flow of services to northerners and those visiting Canada's North.

Chapter 4 explores the dual roles of governments as *facilitators* of climate change adaptation in Canada and as *adaptors* themselves, and discusses implications of these roles for Canada's North. This chapter also introduces a range of instruments and mechanisms that governments can use to support and leverage implementation of adaptation.

Chapter 5 assesses the potential of three existing risk-based mechanisms — CSRIs, insurance, and disaster management — as vehicles for improving the management of climate risks in relation to northern infrastructure.

Chapter 6 presents the conclusions of the NRTEE program, including lessons for other parts of Canada and recommendations for governments for enhancing the resilience of northern infrastructure in a changing climate.

Research Process

The following research and stakeholder engagement processes informed the analysis, findings, and recommendations in this report.

Research on Three Risk-based Mechanisms: The NRTEE commissioned three study teams to explore the relationship between CSRIs, insurance, and disaster management and northern infrastructure adaptation, respectively. Based on literature reviews (published scientific literature and grey literature), expert knowledge, and consultative processes, they examined current practices and institutional frameworks and analyzed gaps and policy options to address them through case studies on a variety of infrastructure types.

Integrated Research: To complement the work of the three study teams, the NRTEE commissioned additional studies of broad program relevance. This research included exploration of climate change adaptation and the role of governments and an analysis of the potential for legal liability as it relates to adaptation decisions of infrastructure professionals.

Stakeholder Consultation: An Expert Advisory Committee met several times during the course of the program to provide guidance to the three study teams, review emerging program findings, and identify and discuss common themes. Representation on the committee included the federal and territorial governments, Aboriginal organizations, research organizations, risk management practitioners, and industry. The committee provided valuable guidance to the study teams on key issues and policy options, and helped the NRTEE program integrate the work of the three studies by identifying and exploring important crosscutting themes.

Consultation with northern stakeholders was integral to the research of the three study teams. Stakeholder consultations were of several formats, including focus groups, unstructured interviews, and workshops. These processes allowed study teams to fill information gaps, validate research assumptions, and test ongoing findings. NRTEE study teams held consultation sessions between October 2007 and January 2008, most of which took place in northern communities. Aside from sessions in Toronto (Ontario) and Edmonton (Alberta), study teams visited Yellowknife (Northwest Territories), Gjoa Haven (Nunavut), Inuvik (Northwest Territories), and Whitehorse (Yukon). This research includes contributions from over 70 northern stakeholders, including the views of stakeholders from all orders of government, infrastructure practitioners, businesses, and research organizations. See Appendix 7.5 for a complete list of stakeholder sessions and participants.

2.0

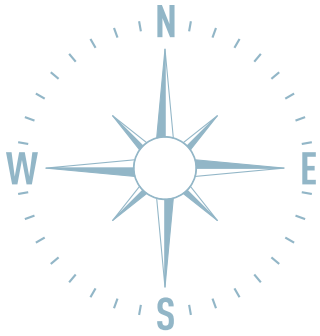
CANADA'S NORTH AND CLIMATE CHANGE

IN THIS CHAPTER

69° 26’ 34” N
133° 1’ 52” W

LOCATION: TUKTOYAKTUK, NORTHWEST TERRITORIES

Loss of sea ice and greater wave action have resulted in the erosion of some coastlines. Tuktoyaktuk (Northwest Territories), a community of under 1,000 people located at the edge of the Arctic Ocean, has experienced some of the fastest rates of coastal erosion and permafrost melt in Canada, estimated at more than six feet a year.



2.0 CANADA'S NORTH AND CLIMATE CHANGE

This chapter describes the implications of a changing climate for northern Canada, and the unique environmental, social, and economic characteristics and key drivers that shape how it affects communities and people living there. Over the past fifty years, the region has been undergoing a rapid social, economic, political, and cultural evolution that a changing climate had historically little to do with, but is now accentuating. The region's population also presents unique attributes in terms of demographics, culture, settlement patterns, skills base, and health outcomes. This context is important, as it guides the selection of strategies to adapt to the impacts of climate change. Among other publicly available information, the chapter draws from the section by Furgal and Prowse (2008) on northern Canada in *From Impacts to Adaptation: Canada in a Changing Climate*.

2.1 A CHANGING CLIMATE

Our climate is changing. Scientific evidence increasingly points to human activity as a main cause of change. Together with natural drivers of climate variability, we are contributing to warmer average air, ground, and ocean temperatures, extensive melting of sea ice, sea-level rise, more frequent and intense extreme events, and changing snow, rain, and land ice conditions. According to the 2007 scientific

assessment of the Intergovernmental Panel on Climate Change, global average temperatures have risen by 0.8ºC since pre-industrial times, and a further 0.6 ºC is likely unavoidable due to momentum in the climate system.[4]

Climate change is occurring gradually, but continued trends in global GHG emissions could lead to sudden and large changes in major components of the climate system, resulting in rapid and widespread effects that exceed the capacity of humans and ecosystems to adapt. Massive diebacks of major forests such as the boreal, rapid melting of Arctic sea ice, and large-scale melting of permafrost, are examples of such catastrophic events causing feedbacks that further exacerbate climate change. Widespread melting of permafrost in certain types of terrain would release large amounts of GHGs into the atmosphere. Massive melting of ice and snow reduces the earth's ability to reflect the sun's radiation back to the atmosphere, thus an ice-free Arctic traps more heat and amplifies warming.

In Canada, the impacts of a changing climate are already apparent, and especially acute in Canada's North. Canadian climate change impacts and adaptation assessments provide a picture of specific vulnerabilities on a regional and sectoral basis.[5] The impacts of climate change touch all regions of Canada, presenting environmental, social, and economic risks, and some potential opportunities. However, the North has been and will continue to be particularly affected, with warming taking place at a greater rate than throughout Canada as a whole. This trend hides important local differences as rates of warming in some areas, like the Mackenzie Valley, have been greater than in others.

Changes in the Arctic are happening much more rapidly than what was anticipated under even the most pessimistic scientific projections. The accelerated melting of Arctic sea ice is the most obvious example of how scientific projections have underestimated the rate and magnitude of changes taking place in the region. The *2004 Arctic Climate Impact Assessment* estimated open Arctic summer waters by 2050. Recent findings suggest that this might take place within a decade.[6] And, it is worth noting that the Northwest Passage has been navigable in each of the past four summers. Other important changes in the earth's ice and snow systems that are happening at faster rates than models projected are the significant retreat and thinning of glaciers of the Greenland ice sheet, along with rates of permafrost melting. Evidence from communities in Canada's North indicates that rapid changes in climate conditions have resulted in permafrost melting at unprecedented rates, affecting nearly every type of built structure in the region. The variance between observed and expected changes suggests that either global climate models inadequately capture ice and snow processes or global changes are happening more rapidly than projected and this is most evident in the Arctic.[7]

[4] IPCC (2007); Hansen et al. (2004).

[5] These studies include the *Canada Country Study* (Mayor and Avis 1998), the report *Climate Change Impacts and Adaptation: A Canadian Perspective* (Lemmen and Warren 2004), *From Impacts to Adaptation: Canada in a Changing Climate 2007* (Lemmen et al. 2008), and *Human Health in a Changing Climate* (Séguin 2008).

[6] Arctic Council (2009).

[7] D.S. Lemmen, personal communication, May 19, 2009.

In light of emerging scientific findings, the projections in Table 1 and Table 2 of changes in two climate indicators for Canada's North are very likely to be conservative. We can still draw out a few observations. Average conditions in Canada's North are likely to be significantly warmer and wetter by the end of the century. Changes in temperature in winter and fall months are likely to be greater than in other seasons. Among other consequences, significantly less cold winters could be beneficial in terms of reduced space-heating costs, but could also facilitate the spread of forest pests. Relative changes in precipitation are moderate and comparable among seasons, with expected variations in ratios of rain to snow. Warming, longer ice-free seasons, and changes in wind patterns are likely to affect evaporation rates, with implications for lake levels and soil moisture.

TABLE 1: Projections of temperature and precipitation changes for Canada's North

	Mean annual temperature change (º Celsius)			Mean annual precipitation change (%)		
	2020	2050	2080	2020	2050	2080
West	1 to 3	2 to 9	3 to 12	-5 to 8	0 to 20	0 to 40
East	1 to 3	2 to 6	4 to 12	-5 to 7	0 to 15	5 to 20

Source: Furgal and Prowse (2008). Ranges are based on scatter plots from projections of seven global climate models and a combination of emission scenarios. Projections are relative to a 1961-1990 baseline. The division between "west" and "east" is along longitude 102º. See reference for details.

TABLE 2: Projections of seasonal temperature and precipitation changes for Canada's North

	Winter temperature change **2050** (ºCelsius)	Winter precipitation change **2050** (%)	Spring temperature change **2050** (ºCelsius)	Spring precipitation change **2050** (%)	Summer temperature change **2050** (ºCelsius)	Summer precipitation change **2050** (%)	Fall temperature change **2050** (ºCelsius)	Fall precipitation change **2050** (%)
West	3 to 11	-7 to 35	2 to 6	0 to 30	1 to 3	5 to 15	3 to 10	5 to 25
East	4 to 9	-7 to 40	2 to 5	0 to 25	1 to 3	5 to 20	3 to 9	3 to 30

Source: Furgal and Prowse (2008). Ranges are based on scatter plots from projections of seven global climate models and a combination of emission scenarios. Projections are relative to a 1961-1990 baseline. The division between "west" and "east" is along longitude 102º. See reference for details.

In addition to changes in averages, extreme weather events are likely to become more frequent and severe. Evidence so far suggests more intense precipitation events, and fewer moderate and low-intensity events. There may also be an increase in peak wind speeds during intense storms; lightening strikes may also become more frequent.[8] Scientific evidence also points to an accelerating trend in Arctic storm activity.[9]

With the rapid warming of the northern Canadian climate comes a wide range of changes in physical conditions. Table 3 below summarizes some of these, as documented in scientific literature. Chapter 3 explains the implications of these changes on northern infrastructure and the people and industries reliant on these systems.

TABLE 3: Physical effects of climate change in Canada's North

Effects on water systems, ice, and snow	Effects on ecosystems
A. Warming (air, ground and oceans), sea-level rise, and decreased sea-ice extent, contribute to accelerated coastal erosion.	**H.** Increased productivity, range, and abundance of certain plant species (grasses, sedges, flowering species). Likely narrowing of ecological niches for high-latitude or uniquely northern species. Shifts in species composition and ecosystem structure (e.g., displacement of Arctic tundra by boreal forest at southern fringes; changing patterns of natural disturbances, such as forest pests and fires).
B. Reduced sea-ice extent and thickness. Among other factors, this could mean a seasonally ice-free Arctic within this century, possibly as soon as the end of the next decade. Rapid sea-ice loss in summer months could also lead to pronounced overland warming and trigger rapid permafrost degradation.	**I.** Increased vulnerability of freshwater and marine species adapted to narrow range of Arctic climate conditions. Increased threat from habitat losses and competition from northward advance of southerly species.
C. Melting of glaciers and ice sheets, contributing to global sea-level rise. Melting of mountain glaciers likely to affect regional hydrology.	
D. Warming and thawing of permafrost (area and depth), with implications for groundwater as a contributing source to streamflow. Discontinuous permafrost at southern margins could disappear. Large-scale melting of permafrost has global implications, as the process would release GHGs (methane) into the atmosphere further contributing to warming of the atmosphere.	
E. Earlier break-up of river and lake ice, thinner ice cover.	
F. Changing snow season length and characteristics, regionally variable snow cover, more frequent "rain-on-snow" events.	
G. Changes in streamflow, with direction of trend varying regionally.	

Sources: Anisimov et al. (2007), Furgal and Prowse (2008), Lawrence et al. (2008), WMO (2009), Richardson et al. (2009).

[8] McBean et al. (2005), IPCC (2007).

[9] Cassano et al. (2006); Hakkinen et al. (2008).

2.2 OVERVIEW OF CANADA'S NORTH

Defining the North

Canada's North is both a geographic label and a political term. Yukon, the Northwest Territories, and Nunavut constitute Canada's territorial North, each being distinct from the other. Environmental and cultural aspects of northern latitudes of many provinces — British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Newfoundland and Labrador — drift "north of 60" into the political boundaries of the territories. Two observations occur: first, while our focus is principally on the three territories known collectively as the North, many of the NRTEE's conclusions and recommendations can be considered and applied by these provinces; second, while our report targets "Canada's North" in the context of the three territories, it is worth remembering that this region is diverse, requiring further consideration of how our conclusions and recommendations can be applied within each territory.

The Physical Environment

Canada's North is vast. Covering more than 3.5 million km^2, Canada's three northern territories make up over 40 per cent of our country's landmass (Figure 3).[10] Nunavut alone is comparable in size to Western Europe.

A number of physical features shape the region's characteristic harsh, fragile environment and abundance of natural resources:

Climate: Northern climates consist of long, cold winters and short summers, with substantial variation among places, seasons, and decades. Average yearly temperatures range from -1 to -5ºC in the southern reaches of the region, whereas islands in Canada's High Arctic experience average annual temperatures approaching -18 ºC.[11] South of Canada's High Arctic, summers can be quite warm, with average temperatures ranging from 7 to 14 ºC.[12] Daily maximum temperatures in Whitehorse and Yellowknife in July and August reach the low 20s.[13] On average, the region is relatively dry, with greater precipitation falling in southern Northwest Territories, Yukon, and eastern Nunavut.

Landforms: Canada's diverse landscapes fall into eight distinct regions called *physiographic regions*. Each region is associated with different natural resources, such as minerals, oil and gas, and forests. Canada's North includes six physiographic regions, three of which extend southward to the border with the United States. For example, the Cordilleran Region, with its steep mountains and narrow valleys, includes most of Yukon and British Columbia, extending into western Northwest Territories. The Interior Plains, comprising low-lying plateaus and extensive wetlands, includes a portion of Yukon, much of the Northwest Territories, Alberta, and southern parts of Saskatchewan and Manitoba. With its characteristic exposed bedrock, lakes and swamps, the Canadian Shield includes eastern parts of the Northwest Territories, southern parts of Nunavut, and much of Ontario, Quebec, and Newfoundland and Labrador.

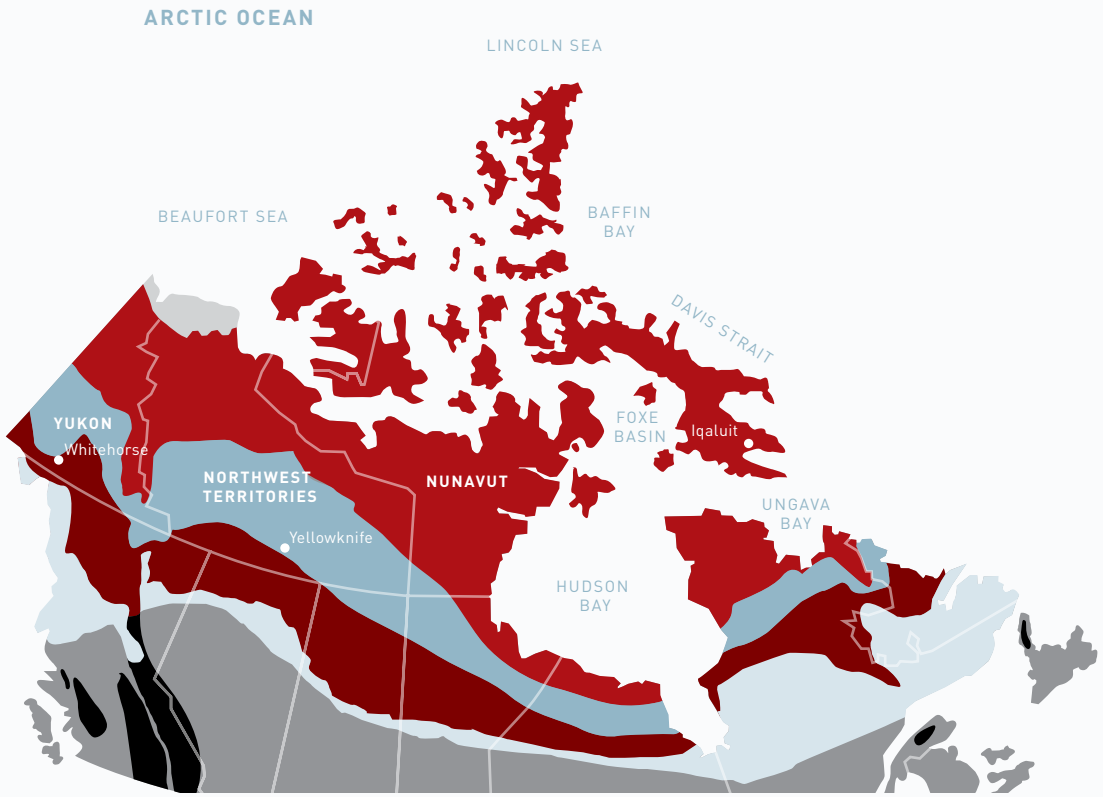
[10] Estimates are from Natural Resources Canada, Canada Centre for Remote Sensing, GeoAccess Division (2001). See http://atlas.nrcan.gc.ca/site/english/learningresources/facts/surfareas.html.

[11] Furgal and Prowse (2008).

[12] Environment Canada, *State of the Environment Infobase.* http://www.ec.gc.ca/soer-ree/English/Framework/Nardesc/canada_e.cfm accessed June 2, 2009.

[13] Environment Canada, *Canadian Climate Normals 1971-2000.* http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html accessed June 2, 2009.

FIGURE 3: The NRTEE program focused on Canada's territorial North



Political boundaries of Canada's North, superimposed on a map of permafrost zones.
Source: derived from Atlas of Canada -- Permafrost map *(http://atlas.nrcan.gc.ca/site/english/maps/environment/land/permafrost) and Atlas of Canada* -- The Territories *(http://atlas.nrcan.gc.ca/site/english/maps/reference/provincesterritories/northern_territories).*

Permafrost: Permafrost and associated ground ice is a major influence on natural processes (e.g., formation of landscapes, streams and river systems) and human activities (e.g., infrastructure development, energy and mining activity) in Canada's North. Continuous permafrost, sometimes hundreds of metres in thickness, underlies the northern parts of the region; the extent and thickness of permafrost becomes more irregular in southern parts (see Figure 3).

Freshwater: Canada's North contains abundant freshwater resources: by area, about 37 per cent of the Canadian total; 20 per cent of Canada's wetlands; and the largest river basin in the country (the Mackenzie River basin, covering 1,805,200 km^2).[14] Ice cover develops on lakes and rivers on a seasonal basis. In some parts of the Far North, the ice does not fully thaw and builds up over time.

Marine Environment: Northern seas include the Arctic Ocean, the Beaufort Sea, Hudson Bay, Foxe Basin, Baffin Bay, the Lincoln Sea, and the channels and straits in the Arctic Archipelago (see Figure 3). These waters encompass three of Canada's five marine *ecozones*, ecologically distinct zones with characteristic plant and animal life and physical features.[15] Northern seas remain frozen on a seasonal to multi-year basis, in some cases developing sea ice several metres in thickness.

Terrestrial Environment: As a final example of the biophysical diversity of Canada's North, the region includes eight of Canada's fifteen terrestrial ecozones, encompassing a range of plants, wildlife, climate, and landforms. Table 4 illustrates key characteristics of the three ecozones in which the three territorial capitals are located.

[14] Estimates are from Natural Resources Canada, Canada Centre for Remote Sensing, GeoAccess Division (2001). See http://atlas.nrcan.gc.ca/site/english/learningresources/facts/surfareas.html

[15] Environment Canada, *State of the Environment Infobase* http://www.ec.gc.ca/soer-ree/English/Vignettes/Marine/marine.cfm accessed April 2, 2009.

TABLE 4: Portraying the region's natural diversity

	Boreal Cordillera	Taiga Shield	Northern Arctic
Examples of settlements	Most of Yukon's population, including the City of Whitehorse	Yellowknife (Northwest Territories), Uranium City (Saskatchewan), and Churchill Falls and Labrador City (Labrador)	About twenty of Nunavut's communities, including the City of Iqaluit
Landforms	Extensive mountains with glacier-covered plateaus and valleys separated by wide lowlands	Rolling hills of ancient bedrock, dotted with millions of lakes and wetlands	Barren plains, broad plateaus in the interior. Permafrost is pervasive
Climate	Long, cold winters and short, cool summers At higher elevations (above the tree line), cold, windy, and snowy	Subarctic climate of long, cold winters; short, cool summers; and low to moderate precipitation	Very cold and dry Snow on the ground for most of the year
Wildlife & plants	Moose, woodland caribou, mountain goat, stone and dall sheep, willow ptarmigan White spruce, sub-alpine fir, pine and aspen. Scrub birch and willows at higher elevations	Barren ground caribou, black and grizzly bear, snowshoe hare Open forests of black spruce, jack pine, paper birch, and trembling aspen. Lichen and shrubs on bare outcrops	Muskox, Peary and barren-ground caribou, polar bear, snow geese, arctic hare, collared lemming Sparse vegetation – includes sedges, mosses, lichens, Arctic poppy

Sources: Furgal and Prowse (2008); Environment Canada — State of the Environment Infobase: Ecozones of Canada.

People and Economies

Where people live and how they earn their living are central considerations in any region's capacity to adapt to climate change. The population of Canada's North is sparse but more or less distributed across the land base, with coastal and navigation access dominating settlement patterns. About 108,000 people live in the three northern territories, representing about 0.3 per cent of Canada's population.[16] Territorial capitals account for about 45 per cent of the population of Canada's North, although the population density in capital cities differs among the three territories. Seventy per cent of Yukon's population lives in Whitehorse, whereas only about 20 per cent of Nunavut's population lives in Iqaluit. In fact, the majority of Nunavut residents live in settlements of fewer than 1,000 people.[17] Coastal and navigation access has shaped settlement patterns, with two-thirds of northern communities currently located along coastlines. In Nunavut, all communities but one are coastal.

The population of Canada's North is younger than Canada's as a whole. Median ages for Yukon, Northwest Territories, Nunavut, and Canada are 38, 31, 23, and 40 years respectively. Birth rates in the region have declined over the past 50 years, but remain high by national standards. At twice the national average, Nunavut's fertility rate has several implications for demands on public infrastructure, particularly schools, recreational facilities, and hospitals.[18] Population projections suggest that the Northwest Territories will experience the highest growth rates among the three territories in the next couple of decades.[19] From a community perspective, accommodating these rates of growth through new housing and services can be challenging. A rapid influx of people to a community because of a boom in economic activity is especially difficult to absorb.

Aboriginal representation in Canada's North is much greater than in Canada as a whole. About 85 per cent of Nunavut's population self-identifies as Aboriginal, 50 per cent in the Northwest Territories, and 25 per cent in Yukon, with the relative representation of First Nations, Métis, and Inuit differing across the three territories (Table 5, Table 6). The relative mix of Aboriginal to non-Aboriginal people in Canada's North, particularly in Yukon and the Northwest Territories, has changed considerably over the past 50 years due to industrial development and the transfer to the North of responsibilities to administer and manage northern lands, waters, wildlife and other natural resources.

[16] This is according to Statistics Canada's population estimates for 2009. See http://www.statcan.gc.ca/daily-quotidien/090623/t090623a2-eng.htm.

[17] Unless otherwise noted, the demographic statistics cited are estimates from *Statistics Canada's Census 2006 Community Profiles*.

[18] See Statistics Canada's *Canada Yearbook – Population and Demography* http://www41.statcan.gc.ca/2007/3867/ceb3867_000_e.htm accessed April 19, 2009.

[19] For further detail on population projections to 2030, see http://www.statcan.gc.ca/pub/91-520-x/91-520-x2005001-eng.pdf Accessed June 2, 2009.

TABLE 5: Aboriginal proportion of the North's population

	Canada	Yukon	Northwest Territories	Nunavut
Aboriginal	4%	25%	50%	85%
Non-Aboriginal	96%	75%	50%	15%

"Aboriginal" refers to people who self-identified with at least one Aboriginal group (First Nation, Métis, or Inuit) and/or have registered Indian status and/or have First Nations or band membership.
Source: Statistics Canada — Census 2006 — Community Profiles.

TABLE 6: Categories of Aboriginal cultural groups inhabiting the North

	Yukon	Northwest Territories	Nunavut
First Nations	83%	61%	0%
Métis	11%	17%	1%
Inuit	3%	20%	99%

Percentages may not add up to 100, as the table excludes responses other than those pertaining to the three major Aboriginal groups.
Source: Statistics Canada — Census 2006 — Community Profiles.

A number of socio-economic indicators both point to the diversity of situations across Canada's North and to constraints in the capacity of northerners, communities, and governments in planning for and effectively coping with change regardless of the source.

Health Status: The health status of Northern Canadians — Nunavut residents and Aboriginal northerners, in particular — is lower than the national average on a number of accounts. Life expectancy in Canada's North is lower than the Canadian average; infant mortality rates are higher in Yukon and Nunavut; and mortality rates due to accidental injury are 1.7 to 3.4 times the national average.[20] Greater participation in land-based activities partly explains the relatively high number of deaths due to accidental injury. Suicide rates in Yukon and the Northwest Territories are nearly double the rate for Canada. The situation is worse for Nunavut, where the suicide rate is close to nine times that for Canada.[21] Cultural traditions, personal habits, and changing diets also influence health status.

[20] Furgal and Prowse (2008).

[21] Estimated from Statistics Canada (2006). *Mortality, summary list of causes*, 2003. Health Statistics Division. Catalogue no. 84F0209XIE.

Access to Services: The provision of public services in Canada's North is costly. This relates to distances to markets, low population densities, relatively small pools of skills, limited transportation options, and associated diseconomies of scale. Elevated costs in turn affect availability of and access to services. For example, the availability of medical practitioners on a per capita basis is much lower in Canada's North than in any other Canadian region.[22] Table 7 compares expenditures in public services by local (municipal) governments, who, in the absence of a property tax base, largely depend on transfer payments and contributions from external sources.

TABLE 7: Cost of providing northern services

Local (municipal) government expenditures (2007)	Canada	Yukon	Northwest Territories	Nunavut
Total expenditures in 2007 ($ per capita)*	3,406	2,198	4,830	4,961
General government services	209	384	549	798
Protection of persons and property	333	341	196	164
Transportation and communication	420	465	570	1,096
Health	51	5	43	106
Resource conservation and industrial development	44	22	35	50
Environment	378	341	916	1,212
Recreation and culture	260	431	555	627
Housing	71	141	87	334
Regional planning and development	42	28	52	256

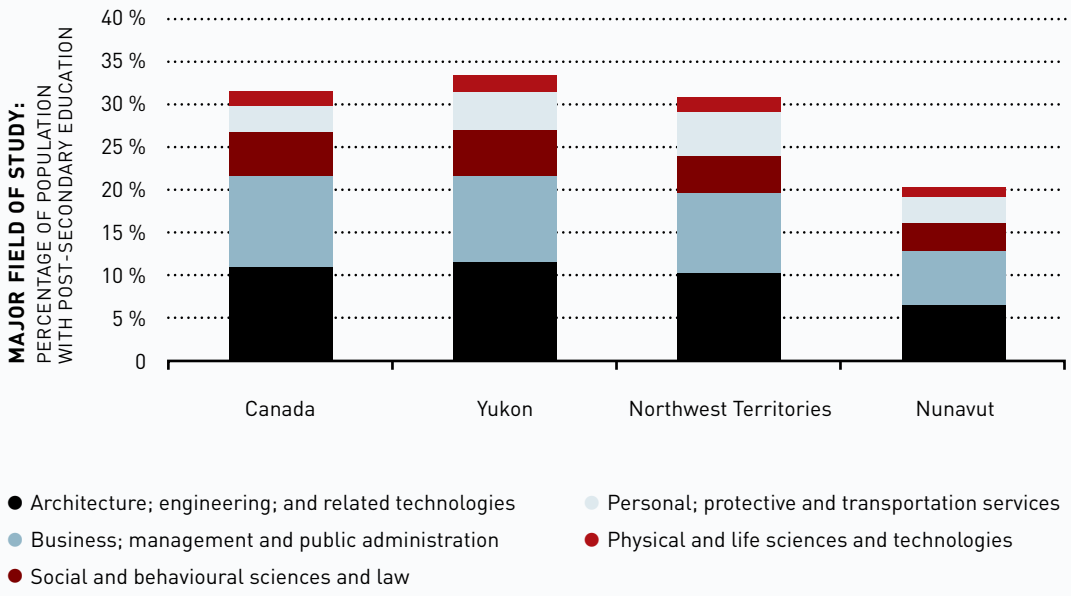
Source: Statistics Canada, CANSIM, table 385-0003, accessed April 19, 2009.

**The table shows total expenditures and a subset of specific expenditures.*

[22] Statistics Canada (2002). The health of Canada's communities. Catalogue 82-003. Health Reports, 13 (Supplement).

Education and Skills: Education levels and distribution of skills in Canada's North vary across the region. Education levels in Yukon are similar to those achieved nationally, but are lower for the Northwest Territories and particularly Nunavut. One of every two Canadians over the age of 15 completes some form of post-secondary education; in Nunavut, the figure is one in three.[23] In aggregate, the skills base in Canada's North in disciplines germane to physical infrastructure is comparable to the national make-up (Figure 4), with an under-representation in Nunavut of people trained in architecture, engineering, and related technologies; and business, management, and public administration. Inter-regional disparities in education and skills exist and should not be overlooked, particularly in the Northwest Territories and Nunavut. For example, post-secondary completion rates in Fort Good Hope (Northwest Territories) and Hall Beach (Nunavut), two communities of over 500 people, are far below the respective territorial averages. In addition to formal education and skills development, community residents apply local and traditional knowledge to resource management issues and in coping with environmental change.

FIGURE 4: Education and skills vary across Canada's three territories



The proportion of the labour force that has not completed post-secondary education is 49%, 46%, 53%, and 68% for Canada, Yukon, Northwest Territories, and Nunavut respectively.

Source: Statistics Canada - Census 2006 - Community Profiles.

[23] Estimated from: Statistics Canada – *Census 2006 – Community Profiles.*

Income, Employment, and Industry: Northern Canadians derive income from both wage-earning and traditional land-based renewable resource subsistence activities, and increasingly more so from the former. New government administration and the relatively recent development of global industries such as mining, oil and gas development, and tourism contribute significantly to the region's gross domestic product, including capital expenditures. Aboriginal economic development corporations are important contributors of wealth creation, participating in economic development as business owners, operators, investors, and joint venture partners. Economic indicators on a per capita basis surpass national averages; however, these are an inadequate indicator of wealth distribution (see Table 8). For example, local communities may benefit from employment opportunities, but many of the revenues from natural resource extraction flow elsewhere. Long-term unemployment rates for all three territories exceed the national average. Traditional subsistence activities, such as hunting and trapping, contribute to household incomes and are important to the social fabric of communities in all three territories.

TABLE 8: Northern socio-economic indicators contrasted with Canadian averages

	Canada	Yukon	Northwest Territories	Nunavut
Per capita Gross Domestic Product ($), 2007	46,637	54,202	109,793	44,281
Per capita public and private capital expenditures ($), 2008	10,387	18,272	41,561	40,936
Unemployment rate % (labour force 15 years and older), 2006	6.6	9.4	10.4	15.6
Earnings as a % of total income (labour force 15 years and older), 2006	76.2	83.9	90	86.5
Government transfers as a % of total income (labour force 15 years and older), 2006	11.1	8.7	6.1	11.2
Government transfers as a % of total income (Aboriginal labour force 15 years and older), 2006	18.1	15.5	11.7	17.5
Average value per pelt of fur produced from wildlife ($), 2006	24.6	76.3	54.5	53.1

Sources: Statistics Canada, CANSIM, table 384-0002 and Catalogue no. 13-213-PPB; Statistics Canada, CANSIM, table 029-0005 and Catalogue no. 61-205-XIB; Statistics Canada — Census 2006 — Community Profiles; Statistics Canada, CANSIM, table 003-0013 and Catalogue no. 23-013-XIE.

2.3 IMPACT DRIVERS

"Change over the past 50 years has been rapid. Modern transportation and communications, institutionalized education and participation in the wage economy have had a major impact on language and culture for many Northerners. Many of us have moved from living on the land to participating in the global economy. Others have become respected international spokespersons for the environment and the richness of our unique cultures. Old and new ways of life are continuously finding a modern rhythm — a testament to our resilience, innovative spirit and willingness to work in partnership."

- A Northern Vision: A Stronger North and a Better Canada (2007).

Canada's North has been subject to rapid transformation over the past several decades. It's important to place climate change in this context. Potential strategies and actions to adapt to climate change require consideration of three main factors: evolving northern governance and the role of Aboriginal peoples, a shifting geopolitical landscape with renewed issues of sovereignty and security, and new opportunities for economic development, which will bring additional stresses to both the natural and built environments.

Evolving Northern Governance

For the past few decades, governance and government institutions in Canada's North have undergone profound changes, characterized by the devolution of province-like powers to all three territories and land claims and self-governance agreements with Aboriginal peoples.[24] Constitutionally, territorial governments are subordinate to the federal Parliament and do not have exclusive legislative authority. Devolution of authority from the Government of Canada to the territories is a process that started with Yukon. The Government of Canada has now transferred to all three northern territories powers for many programs, including education, social services, health, transportation, local government, and economic development. Since April 1, 2003, the Yukon government exercises substantive administrative control — but not ownership — of surface and sub-surface natural resources on public lands in the territory. The governments of the Northwest Territories and Nunavut have yet to gain this right.

Comprehensive land claims and self-government agreements — modern treaties — are constitutionally entrenched pacts between northern Aboriginal peoples and Canada and, therefore, key components of northern governance. Their status varies across the territories, and many are in early stages of implementation.[25] In Yukon, the umbrella land claims agreement of 1993 served as a negotiating template for 14 First Nations. To date, all but three Yukon First Nations have concluded self-government agreements.[26] A few claims of First Nations from the Northwest Territories and northern British

[24] This section is based on *Northern Canada Consulting* (2007), a report commissioned by the NRTEE. *Governance* refers to societal or organizational processes guiding decision making, stakeholder involvement, and accountability (Institute on Governance: web content accessed on April 21, 2009).

[25] Indian and Northern Affairs Canada (INAC) summarizes the status of land claims and related provisions in: INAC (2007), available at: http://www.ainc-inac.gc.ca/al/ldc/ccl/pubs/gbn/gbn-eng.asp.

[26] For detailed information on individual First Nations Final Agreements, see the website of the Council of Yukon First Nations at http://www.cyfn.ca/ouragreementsfnfa?noCache=664:1246739574.

Columbia extend into Yukon jurisdiction. In the Northwest Territories, negotiations of land claim and self-government agreements have concluded in some cases, but others are still pending. In Nunavut, the Inuit land claim was negotiated in 1993 and gave rise to the creation of the territory itself in 1999. Through these modern treaties, Aboriginal peoples receive a range of rights and benefits that vary from agreement to agreement. These include representation on decision-making bodies to manage land, water, wildlife, and to assess the environmental and social impacts of development, and infrastructure-related responsibilities such as capital assets management and inspections.

The evolving nature of governance systems in Canada's North is unlike the situation in southern Canada, where relatively well-established municipal, provincial, and federal government institutions exist. This has several implications for climate change adaptation. For example, governments may need to determine who is responsible for building overall capacity to adapt and for paying for the implementation of adaptive measures. Inter-jurisdictional collaboration to avoid working at cross-purposes and to plan for and implement adaptive measures in areas of shared jurisdiction is also important. Assessing the potential consequences of the impacts of climate change on transboundary or resource-sharing agreements is another likely area of concern for northern stakeholders. Chapter 4 includes further discussion on roles of government in adaptation.

Shifting Geopolitical Landscape

Canada's North is no longer an isolated region at the periphery of the global economy, but rather a region poised to assume greater geopolitical and economic importance. A changing climate alters accessibility to the region's oil and gas resource potential and to enhanced navigation options through increasingly open Arctic waters. For Canada, both prospects raise a series of challenges related to gaps in scientific knowledge on the potential consequences of enhanced traffic and resource development on ecosystems, human health, and culture. Other challenges include potential gaps in policy and regulations (e.g., border controls, emergency response capacity), physical infrastructure, and in regional capacity to shape and deliver on new management regimes. For Canada and the other seven Arctic countries (Denmark, Finland, Iceland, Norway, Russia, Sweden, and the United States), the emergence of the Arctic as a policy arena is a matter of foreign, national, and regional policy.

In recent years, the Arctic story in Canada has tended to focus on questions of national control and resource exploitation. Media hype and, to a lesser extent, political discourse capture the imagination of the Canadian public in the south on two fronts: the opportunity to tap into the wealth underlying the region and in its oceans, and the perception of competition among Arctic nations in establishing and protecting sovereign interests. Headlines such as "Russia Ahead in Arctic Gold Rush" and political declarations of Canada as an "Arctic superpower" tend to downplay that international cooperation is essential to stewardship of the Arctic.[27] National action would not be enough to ensure marine transportation safety and secure lines of communication in support of resource extraction and shipping activities. Nor would unilateral action be a very effective or efficient way of monitoring and managing transboundary processes, such as movement of fish stocks and long-range pollution.

[27] "Russia ahead in Arctic Gold Rush", Paul Reynolds, BBC, 1 August 2007. http://news.bbc.co.uk/2/hi/in_depth/6925853.stm accessed April 22, 2009.

A few examples reveal the cooperative approach of Arctic nations on scientific and policy fronts. The International Polar Year built on existing joint scientific work on Arctic issues, supporting the collaborative development of maps depicting different physical and biological features of the Arctic Ocean.[28] Much of this and related work continues, which is important considering the key role a common scientific basis plays in facilitating consensus across jurisdictions on tough policy issues. Arctic nations, including Canada, have stated their commitment to work on shared policy goals through existing institutions such as the Arctic Council and multi-lateral and bi-lateral channels. For example, the 2008 *Ilulissat Declaration* underscores the commitment of the five Arctic coastal nations to abide by the provisions in the *Law of the Sea*, including "rights and obligations concerning the delineation of the outer limits of the continental shelf, the protection of the marine environment, including ice-covered areas, freedom of navigation, marine scientific research, and other uses of the sea."[29] In some cases Arctic coastal nations work together to acquire the data to support their claims.

Countries lacking direct ties to the Arctic are interested and engaged in Arctic processes, and this speaks to the region's geopolitical importance. Italy, Japan, South Korea, China and India are among the growing list of interested countries.[30] In addition to carrying out Arctic research, South Korea, for example, sees opportunities in commercial shipping and marine transportation.[31] Both South Korea and Japan are seeking observer status at the Arctic Council.[32] As another example, Canada and the United Kingdom recently signed a memorandum of understanding for collaboration on polar (Arctic and Antarctic) research, to include scientific exchanges and sharing of research infrastructure.[33] The European Union has issued an Arctic policy statement and strategy, in recognition of the rapid environmental change in the region and related implications for *"international stability and European security interests."*[34] In general, international interests fall in three main areas: exploring the role of natural Arctic processes in driving global climate change; learning about the potential adverse effects on ecosystems, human activities, human security, as well as opportunities from the impacts of climate change in the Arctic; and positioning themselves to capitalize on economic opportunities.

The federal government recently announced *Canada's Northern Strategy*, outlining a new vision for the North as a "healthy, prosperous and secure region within a strong and sovereign Canada."[35] It builds on the federal *Integrated Northern Strategy* and related investments to address gaps in knowledge,

[28] Examples of products include the Arctic Geology map recently released (available at http://apps1.gdr.nrcan.gc.ca/mirage/db_results_e.php Map Number 5816) and the Arctic Ocean Bathymetry map (available at http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html.

[29] http://www.oceanlaw.org/downloads/arctic/Ilulissat_Declaration.pdf accessed April 22, 2009.

[30] Minister Cannon Outlines Canada's Arctic Foreign Policy, March 11, 2009. accessed April 22, 2009. http://w01.international.gc.ca/minpub/Publication.aspx?lang=eng&publication_id=386927&docnum=67.

[31] http://www.koreatimes.co.kr/www/news/special/2009/04/176_29902.html. accessed April 22, 2009.

[32] http://www.yomiuri.co.jp/dy/national/20090420TDY03104.html. accessed April 22, 2009.

[33] http://www.ainc-inac.gc.ca/ai/mr/nr/j-a2009/nr000000183-eng.asp accessed April 22, 2009.

[34] The European Union's policy priorities with respect to the Arctic are available at http://ec.europa.eu/maritimeaffairs/arctic_overview_en.html.

[35] Government of Canada (2009). http://www.northernstrategy.ca/index-eng.asp accessed August 10, 2009. The four priorities identified in the strategy are: exercising our Arctic sovereignty; protecting our environmental heritage; promoting social and economic development; and, improving and devolving Northern governance.

physical infrastructure, and military capacity. Going forward, strengthening northern capacity to play an important role on the international stage while furthering sustainable regional development interests is likely. Existing institutions give scope to this kind of co-management approach. The Nunavut Land Claims Agreement acknowledges the Inuit contribution in asserting Canada's Arctic sovereignty, with provisions for enhancing monitoring and management of the offshore.

Growing Opportunities for Economic Development

Rising global demand for energy and other resources enhances opportunities for economic development in Canada's North. Long-term trends in global energy consumption indicate a continued demand for fossil fuels with a greater portion of the demand coming from emerging economies reliant on energy imports.[36] Canada's North could contribute to supplying this growing demand with its significant conventional oil and natural gas deposits (see Table 9).[37] Efforts to advance the production of reserves in the Mackenzie Delta and Beaufort Sea and the construction of one or more large-diameter gas pipelines in the Mackenzie Valley and along the Alaska Highway began almost five decades ago. These could be in place and operational in the latter part of the next decade. Aside from fossil fuels, the region holds significant hydroelectric potential. The Northwest Territories, for example, has developed less than one per cent of its potential.[38]

TABLE 9: Northern oil and gas resources

Crude oil (millions of barrels)	Yukon	Northwest Territories	Nunavut
Production 2005 (mb/yr)	None	7	None
Production forecast 2020 (mb/yr)	None	7	None
Proven reserves	10	1,500	523
Natural gas (billion cubic feet)	**Yukon**	**Northwest Territories**	**Nunavut**
Production 2005 (bcf/yr)	7	18	None
Production forecast 2020 (bcf/yr)	No forecast	694	345
Proven reserves	84	11,000	12,300

Source: The Council of the Federation (2007).

[36] International Energy Agency (2008) http://www.worldenergyoutlook.org/docs/weo2008/fact_sheets_08.pdf accessed April 22, 2009.

[37] The table does not include figures for non-traditional reserves of natural gas, so-called gas hydrates, which are ice-like substances made of water and natural gas. Natural Resources Canada and other research organizations are investigating the challenges and opportunities of developing this resource. See http://gsc.nrcan.gc.ca/permafrost/arcticgas_e.php for more information on Arctic gas hydrate research.

[38] Government of the Northwest Territories (2009) http://www.iti.gov.nt.ca/Publications/2008/energy/HYDROSTRATEGY.pdf accessed August 10, 2009.

Canada's North is also home to abundant mineral deposits. Six mines are currently operating in the region, but they are hardly representative of the region's potential (see Table 10). In the last ten years, Canada has become the fourth largest global producer of high-quality diamonds from mines in the Northwest Territories and now Nunavut. Significant reserves of precious and base metals have been proven in all three territories, with deposits including gold, zinc, lead, copper, silver, barium, tungsten, uranium, and iron. In 2007, the three territories accounted for over 20 per cent of spending on mineral exploration in Canada.[39] Twelve mines are awaiting regulatory permits and over 200 mineral deposits are in the exploration phase. The proposed construction of a port and associated road at Bathurst Inlet in Nunavut would facilitate access to several of these deposits. The production of long-discovered high-grade iron mines on Baffin Island may also become more attractive if warmer temperatures help to lengthen the shipping season. The combination of new mining sites and shorter ice-road seasons will likely add to the pressure to develop all-season roads, as has taken place north of Baker Lake (Nunavut).

TABLE 10: Mining's continued significant role

	Closed sites	Operating mines	Under review	In exploration phase
Yukon	13	1	4	150
Northwest Territories	32-33	4	5	45
Nunavut	6	1 (under construction)	3	20

Sources: M. Burke, Yukon Geological Survey; *R. Silke,* Northwest Territories and Nunavut Chamber of Mines; *Goff et al. (2008).*

[39] For further information, see Natural Resources Canada's *Overview of Trends in Canadian Mineral Exploration 2008*. Available at: http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/cme-omc-eng.htm.

However, the prospects for an economic boom to materialize in the near term are questionable. Several barriers to further large-scale resource development exist, which translate into higher costs of doing business in Canada's North. These include challenges to operating in cold climates, lack of linking infrastructure, distance to markets, and, social, regulatory, and environmental risks. Uncertainty in decision-making timelines is an acute challenge, particularly in an era of global financial markets and competition in attracting capital for alternative projects elsewhere in Canada. Current measures to promote resource development include publicly funded geoscience activities, the creation of a cold climate innovation centre in Yukon, and investment incentives such as tax credits and low corporate tax rates.[40] The potential environmental and social consequences of large-scale development in the region also figure into the equation and may delay decisions and project implementation, as will considerations on the equitable distribution of benefits from resource extraction.[41]

The lasting impacts of the Alaska Highway project illustrate the range of social and environmental problems linked to large-scale development in Canada's North. In the early 1940s the United States Army built a highway via Yukon and northern British Columbia, connecting Alaska to the contiguous US. The project ended up including a pipeline and refinery to fuel highway construction. Construction took place over about a year, during which time the population of Whitehorse grew from fewer than 500 to over 20,000.[42] Such a rapid influx overwhelmed municipal services, fostering the spread of disease, and left a legacy of project-related buildings and equipment. For First Nations in the territory, the impacts of this project were mixed: they became a minority and less able to rely on their traditional ways, but they gained access to services such as health care. Wildlife populations declined significantly because of the project, both from increased hunting and destruction of ecosystems.

[40] For further information on marketing strategies and investment priorities, see the Government of Canada's Invest in Canada web portal: http://investincanada.gc.ca/eng/explore-our-regions/northern-canada.aspx

[41] A recent report of the Standing Senate Committee on Energy, the Environment, and Natural Resources, *With Respect, Canada's North*, concludes that northerners must play an integral part in decisions on future economic development in the region, including provisions for environmental and cultural protection.

[42] See http://www.alaskahighwayarchives.ca./en/index.php for further information.

As a strategy to promote stability in economic development through "boom and bust" cycles of large-scale resource development, northerners are also taking advantage of more sustainable and smaller-scale economic activity. Tourism, for example, is an emerging industry in Canada's North. The Government of Canada's *Invest in Canada* portal emphasizes investment opportunities in tour operations, restaurant and hotel management, and infrastructure investment, focusing on the region's cultural heritage and natural endowments. The territories' tourism promotion strategies highlight the pristine nature of the region and opportunities for experience-based tourism, which appeals to post-material values of wealthier travellers (Figure 5). Sustaining growth in the sector is not without challenges. Increasing inflows of tourists from Arctic cruises or of visitors to national parks place great demands on communities and the services that they can supply (e.g., Pond Inlet next to Sirmilik National Park). Increased navigability of Arctic waters resulting from a changing climate could increases cruise-shipping potential, although continued sea-ice hazards and public infrastructure requirements are factors that could curtail growth. Increased access to northern tourism amenities and enhanced visitation also poses threats to sensitive ecosystems, an important consideration for any tourism promotion strategy and park management plan.

FIGURE 5: Nature and culture figure prominently in tourism promotion

www.travelyukon.com

www.spectacularnwt.com

www.nunavuttourism.com

2.4 CONCLUSIONS

Our brief overview of the region and its peoples, indicators of northern adaptive capacity, and pressures that northern stakeholders are experiencing, allows us to make a few observations relevant to climate change adaptation:

- Strategies to address the impacts of climate change targeting Canada's North must be flexible enough to accommodate the incredible cultural, social, political, and economic diversity represented in the region. In some cases, pan-northern strategies may be less appropriate than efforts to leverage action across north-south borders.
- Because of the enormous distances between settlements across the region and sometimes unreliable or limited supply of goods and services, enhancing community-level resilience in the face of change is key.
- Governments, communities, and businesses operating in the region may defer the implementation of adaptation strategies, instead investing financial resources and human capacity in addressing priorities that are higher in profile. Mainstreaming adaptation into existing or newly formed institutions, such as regulatory processes, asset management plans, resource management, and community plans, can help prepare for the impacts of climate change alongside other priorities. Evidence shows that mainstreaming is already starting to take place.
- Given constraints in human capacity and finances, investments in adaptation strategies or actions that yield social, environmental, or economic benefits regardless of climate change should be a priority, as should opportunities to learn from and contribute to international initiatives.

"We feel vulnerable here. We have no place to take refuge; no hills to climb, our airport does not accommodate larger planes, and we do not have a helicopter available to us."

– Participant at October 2007 NRTEE program meeting in Gjoa Haven, Nunavut

"I have heard southerners say, 'Well, they know how to adapt [to climate change] in the North.' Well, yes, if we were out living on the land, but our younger generation does not live out on the land, and it is harder to adapt to what is going on around the world and in the community. The people who say we know how to adapt obviously do not study the mental, social, and economic changes that are arising."

–Participant at October 2007 NRTEE program meeting in Gjoa Haven, Nunavut

3.0

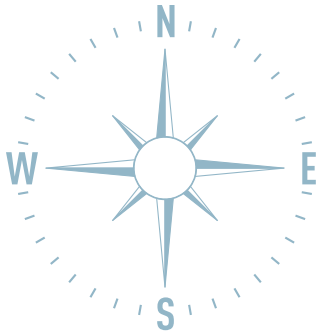
NORTHERN INFRASTRUCTURE VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

IN THIS CHAPTER

68° 45’ 44” N
81° 13’ 44” W

LOCATION: HALL BEACH, NUNAVUT

Weather extremes are likely to become more frequent and intense in a changing climate. Recent events highlight the vulnerability of northern infrastructure. In 2003, strong waves brought on by high winds damaged the recently built erosion control structure in Hall Beach, a community of about 650 located on the Melville Peninsula (Nunavut). Emergency repairs to the structure were necessary to protect nearby houses.



3.0 NORTHERN INFRASTRUCTURE VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

This chapter discusses the vulnerability of northern physical infrastructure and the importance of climate change adaptation in the context of the key roles that infrastructure systems play in securing the region's long-term sustainability. It reviews aspects of northern infrastructure that make it sensitive to the impacts of climate change; summarizes the likely implications of climate change for northern infrastructure; and discusses potential adaptation needs. Our focus is on five categories of infrastructure: transportation, buildings, communications, energy, and containment structures for storing waste rock and tailings from mining operations. The chapter draws from reviews of publicly available literature and qualitative research commissioned by the NRTEE, including information gathered from stakeholder workshops.

3.1 KEY ATTRIBUTES OF NORTHERN INFRASTRUCTURE

Infrastructure systems in Canada's North are uniquely vulnerable compared to southern counterparts. Permafrost and other ice regimes figure heavily into infrastructure design, construction, and maintenance. Construction and operating costs are high due to distance and isolation plus extreme cold.

Infrastructure deteriorates rapidly in extreme environments. Experience in Canada's North shows that, even after a brief interruption in operation, reopening infrastructure tends to be costly. The existing infrastructure deficit, the lack of options and "backups" in infrastructure services, and capacity constraints in the form of finances and human resources are all other pressures.

A changing climate presents additional challenges to the design, development, and management of infrastructure in the North and elsewhere in Canada. Physical infrastructure is "climate sensitive" — designed, built, and operated to provide useful service over decades within a prescribed range of site-specific climate and environmental conditions. The current stock of physical infrastructure and that built in the next few decades will be subject to climate conditions outside of historical experience, with changes likely intensifying over time. All infrastructure systems carry some risk of failure. However, unanticipated and rapid changes in their operating environment can increase this risk and overwhelm systems' coping capacity, with related financial losses, health and safety risks, and impacts on ecosystems.

Maintaining and enhancing access to reliable infrastructure that provides mobility, shelter, connectivity, power, and protection from toxic industrial waste is at the core of sustainable regional development and northern security. The complex interactions between climate change, growth of market-based economies, evolving governance regimes, and other factors influencing northerners' capacity to adapt to change, will shape the relative success of efforts to improve infrastructure systems in Canada's North. These efforts are unlikely to prioritize climate change adaptation above everything else, making it important to seek measures that address multiple objectives that contribute to resilience, such as efficient use of energy and shortening of supply lines.

In Canada's North and elsewhere, physical infrastructure exhibits three characteristics that are relevant to climate change adaptation: a generally long life, a fixed location, and complex design and operations. Design criteria establish the expected useful service life of infrastructure and its tolerance levels to climate-related events (e.g., 1-in-100-year flood). But a range of factors influences its actual useful life. These include use, modifications, maintenance, and other factors that are under the control of decision makers. External factors include regulations and technological advances that force or promote early obsolescence. The high capital costs of infrastructure and the need to design infrastructure in light of site-specific conditions essentially means that infrastructure is fixed once it is built, and is thereby locked in to its surroundings. Meeting societal expectations to avoid loss of life and property damage from infrastructure failure increases the complexity of its design and operations. Many infrastructure systems are large installations, consisting of parts built at different periods and where tolerance for failure may have been poorly defined, all of which makes their operations complex.

The lack of system "redundancies" or backups and isolation of many communities are key features that differentiate infrastructure systems in Canada's North from those of more densely populated parts of the south. In the event of infrastructure failure, some northern communities may not have access to backups or alternatives that many southern communities take for granted, such as an alternate road, a second hospital, and grid connectivity to other power stations. This lack of options can lead to service interruptions, lost productivity, and inability to meet basic needs. For example, in January 2008, a seven-day blizzard in Nunavut's Kivalliq region left store shelves bare in three communities because airports had to shut down. Through reliance on social networks and other coping strategies, northerners have learned to adjust to inconveniences or emergencies linked to interruptions of infrastructure services. However, exposure to constant change and multiple sources of stress over the long-term could undermine these types of coping strategies.

The relatively sparse population, remote geography, weather-dependent construction season, and high costs of labour and materials make northern infrastructure construction and maintenance a costly undertaking. Constraints in capacity that prevent timely maintenance and replacement of infrastructure can also contribute to long-term costs. For example, a lack of local capacity to maintain or repair technical equipment in some communities means that maintenance may occur less regularly than should be the case. Failures can result in prolonged interruptions in service partly due to the limited supply of technical expertise. In many cases, construction material comes from outside the region, as does specialized equipment. Due to either climate-related phenomena, regulatory changes, or increased rates of use, enhanced maintenance efforts add to the cost of services delivered by infrastructure. In some cases, service continuity is a business driver and changes in operating environments, including changes in weather patterns, can provide an incentive to make incremental adjustments in infrastructure management.

Much of the infrastructure in Canada's North relies on permafrost, snow, and ice for its stability and utility (see Box 2 and Box 3). For example, containment structures, which protect the environment from toxic mine tailings and other materials, often rely on the integrity of permafrost to prevent the movement of toxic mine waste and industrial process waters. Because frozen earth material, such as rock, sediment, and organic matter, has a stronger load-bearing capacity relative to non-frozen ground, building design is typically based on preserving frozen conditions or limiting thaw. However, about half of Canada's permafrost zones are moderately or highly sensitive to thawing in warmer climate conditions, terrain with high water content being particularly susceptible to collapse if disturbed. "Warm" permafrost underlies areas of major industrial development, such as the Mackenzie Basin.

Other frozen systems are also important. For example, winter roads built over frozen lakes and rivers serve many remote communities and mineral exploration camps or mines, particularly in the Northwest Territories.

BOX 2: Cold climates present engineering challenges and lead to creative solutions

In Canada's North, accounting for the physical state of permafrost and other frozen systems in the design, construction, and maintenance of infrastructure is an engineering challenge, and experience has led to a variety of practices and technologies adapted to cold climates. Frozen ground provides a stable surface for buildings, roads and airstrips, pipelines, transmission towers, and for waste containment. In design, building, and maintenance protocols, northern engineering firms rely on environmental data, such as weather and climate data, and customized climatic design values supplied by the Government of Canada (Environment Canada). Often, practitioners make adjustments to account for observed trends, assumptions about expected environmental changes, and related site-specific implications for permafrost and ice systems. Engineering strategies to date favour maintaining frozen conditions and limiting thaw in order to constrain infrastructure movement to within tolerable levels. The choice of foundation and overall design is therefore a function of both infrastructure loads and thermal conditions of the ground.

Aside from the choice of foundation, such as the use of shallow versus deep foundations, the application of "thermosyphons" supports infrastructure integrity. This technology is effectively a heat exchanger, transferring heat from the ground to the surface, ensuring stability of frozen conditions for different types of infrastructure. Comprehensive technical guidance to determine the optimal use of thermosyphons or specific standards to meet do not yet exist. Engineers operating in the North typically provide these kind of recommendations in conducting site-specific geotechnical studies. Since 1985, over 100 thermosyphon systems have been installed in Canada's North, including industrial, commercial, and institutional applications, such as in Aurora College (Inuvik, Northwest Territories) and Cambridge Bay School (Cambridge Bay, Nunavut). A 2008 national engineering vulnerability assessment by Engineers Canada included a case study exploring the performance of thermosyphon systems across ten foundation sites in the Northwest Territories. They concluded that these installations are likely to be resilient to warming in the near-term contingent on factors such as proper maintenance, monitoring, and rates of future climate warming.

Many other factors influence engineering practices and related choices in Canada's North. These include the extreme cold conditions that infrastructure and embodied construction materials must withstand, health and safety of workers, the short construction season, challenges of transporting construction material, delays in procuring specialized equipment, and an undersupply of labour. Entrepreneurial initiatives — corporations like Nuna Logistics and the recently established Yukon Cold Climate Innovation Centre — are turning technical and supply-chain challenges into opportunities. The Canadian Institute of Planners highlighted practices and new technologies for transport and logistics in cold climates in its June 2009 national conference.

3.2 NORTHERN INFRASTRUCTURE CATEGORIES

The NRTEE program explored five categories of infrastructure: transportation, buildings, communications, energy, and containment structures for storing waste rock and tailings from mining operations. These types of infrastructure are, in some cases, lifelines for northern communities, providing the basic services of mobility, shelter, connectivity, power, and protection from pollution. Combined, these services also enable effective responses to emergencies. Table 11 provides a breakdown of each category by territory, compiled from various sources. What follows is a brief description of the types of infrastructure studied, including issues with the current stock and future prospects.

Transportation: Transportation infrastructure varies considerably across the three territories, reflecting important historical, geographic, and demographic differences. Yukon has the most developed and expansive permanent road network of the territories, providing all-weather road access to all communities but one. The road network in the Northwest Territories includes all-weather roads and winter roads complemented by vehicle ferries and ice crossings. In Nunavut, nearly all travel between communities within the territory and to external locations is via air transport, whereas goods provision and cargo transport is by vessel or barge. Geographic remoteness and extreme cold conditions make it costly to build and operate transportation infrastructure in the region, with a clear recognition at the territorial level that significant upgrading needs to take place to meet existing demand, to keep pace with and even facilitate resource development, and to prepare for emerging issues linked to international sovereignty interests. The proposed *Bathurst Inlet Port and Road* and the *Nunavut-Manitoba Road* projects would boost the capacity to service mines, and provide alternative and shorter routes for resupply of fuel and goods to communities in the area.[43]

"Northern safety, security, and environmental integrity are dependant upon transportation infrastructure. Currently this infrastructure is completely inadequate to respond to environmental emergencies, natural disasters, non-environmental accidents, and increasing threats to Canada's sovereignty."

- Governments of Yukon, Northwest Territories, and Nunavut, 2008. *A Multi-Modal Transportation Blueprint for the North*

Buildings: A deficit of housing and public buildings currently exists in Canada's North. The level of overcrowding in private dwellings, measured as a percentage of dwellings with over one person per room, is significantly higher in Nunavut and in the Northwest Territories than in Canada as a whole (18 per cent, 4.6 per cent, and 1.5 per cent, respectively).[44] The level of reported disrepair of household dwellings in the region is also remarkable. In Canada as a whole, about one in 13 occupied dwellings requires major repairs; in Yukon, the Northwest Territories, and Nunavut, those numbers are one in 7, one in 6, and one in 5. New construction projects and refurbishments are likely to take place over

[43] For further information on these projects see: http://www.nu-mbrss.snclavalin.com/ and http://www.nunalogistics.com/projects/clients/bathurst/index.html.

[44] From Statistics Canada – *Census 2006 – Community profiles*.

the next few decades driven by a combination of necessary retirement of capital stock, energy costs, demographic trends, and projected and potential resource development. These trends will likely generate a critical need for constructing a range of buildings — from homes and schools, to community centres, airport terminals, and hospitals. Energy costs are a big driver for current refurbishments in Yukon, including upgrades in building envelopes and fuel substitutions for space heating focusing on biomass.

Communications: Communications infrastructure contributes to the effective delivery of services and provides connectivity to the outside world. For a small community such as Gjoa Haven (Nunavut), the latter aspect of this type of infrastructure makes it critical. Northwestel, a private company, is the primary provider of communications services in Canada's North (as well as twelve northern communities of British Columbia and Alberta) and the owner of all communications infrastructure. Enhancing communications infrastructure and related services has the potential to overcome geographic barriers in providing access to knowledge, information, and in developing skills. These are key ingredients for participation in a knowledge-based economy.[45] The recent establishment of the Nunavut Broadband Development Corporation indicates a growing recognition of the need to support service expansion and related development of this infrastructure type. It is a not-for-profit organization dedicated to providing access to reliable and affordable broadband services across the territory.[46]

"Soil erosion is a big issue, resulting in — for example — the failure of foundations. We are experiencing increases in engineering costs and the climate challenges ratchet up. We are also seeing a lot more in the way of infrastructure failure rates. If these trends continue and intensify, we may have to totally change the foundation systems we use."

–Participant at October 2007 NRTEE program meeting in Gjoa Haven, Nunavut

[45] According to the OECD, characteristics of a knowledge-based economy include *"trends in advanced economies toward greater dependence on knowledge, information and high skill levels, as the increasing need for ready access to all of these by the business and public sectors."* http://stats.oecd.org/glossary/detail.asp?ID=6864 accessed on April 23, 2009.

[46] For more information, see http://www.nunavut-broadband.ca/access.htm.

TABLE 11: Inventory of northern infrastructure illustrating unique regional traits

Infrastructure type	Yukon	Northwest Territories	Nunavut
TRANSPORTATION			
All-weather roads 2008 (length)	4,800 km With the exception of the most northerly community (Old Crow) all communities are connected to the road system	2,200 km About 20% of residents have year-round highway access; 65% of residents currently lack highway access for two months out of the year during the seasonal transition between ferry service and ice crossings; 13% of residents rely on winter roads for land-based transportation; the rest do not have access at all	With the exception of a 21-km road between the mining community of Nanisivik and Arctic Bay, no road infrastructure exists to link communities in this territory
Winter roads 2008 (length)	No major winter roads	1,450 km of public winter roads Over 570 km of private winter roads for oil and gas development and mine resupply	Few private winter roads for mine resupply
Airports 2008 (#)	29 (13 airports and 16 aerodromes) The Yukon government operates all facilities	27 community-based airports plus several privately-operated air strips	All communities (26) rely on air transportation system for essential needs. Only two airports have paved runways
Marine 2008	No existing marine infrastructure (Alaska ports are strategic link)	Rail / truck to barge marine resupply system for communities and industrial operations. Four communities depend on this resupply system for bulk commodities. Infrastructure is privately owned	All communities have beach landing sites. The sole port is not connected to a community

TABLE 11: Inventory of northern infrastructure illustrating unique regional traits (continued)

Infrastructure type	Yukon	Northwest Territories	Nunavut
BUILDINGS			
Housing 2006 (# of private dwellings)	12,610 ~30% tenancy	14,235 ~50% tenancy	7,855 ~80% tenancy
COMMUNICATIONS			
Microwave radio (length), fibre optic cable (length), satellite (# of communities)	Northwestel, a private company, is the primary service provider and owner of communications infrastructure. Infrastructure includes a 7,354 km network of microwave radio, 3,250 km network of fibre optic cable serving southern Yukon and Northwest Territories, and satellite services covering 43 communities (all communities in Nunavut plus northern and eastern communities in the Northwest Territories)		
ENERGY			
Hydro-electric dams	4 large dams	5 large dams ~75% of energy generation comes from this source	Not applicable (all electricity is from fossil fuel imports)
Diesel facilities	19	26	27 stand-alone diesel plants in 25 communities; Qulliq Energy Corporation is the provider (owned by the Government of Nunavut)
Energy transmission	2 electricity transmission lines; 1 natural gas pipeline originating in the Northwest Territories, picking up gas from 3 Yukon wells, and taking gas into British Columbia	2 electricity transmission lines 1 major oil pipeline from Norman Wells to Alberta	Not applicable

TABLE 11: Inventory of northern infrastructure illustrating unique regional traits (continued)

Infrastructure type	Yukon	Northwest Territories	Nunavut
CONTAINMENT STRUCTURES			
Operating mines (for simplicity, # of containment structure corresponds to # of mines)	1	4	1 under construction
Closed (for simplicity, # of containment structure corresponds to # of mines)	13	32-33	6

Sources: Northern Connections (2008); Northwestel (2007); Statistics Canada — Census 2006 — Community Profiles; Nunavut Housing Corporation (2004); Council of the Federation (2007) — Energy Transmission and Generation; Government of Yukon — Energy Solutions Centre; M. Burke, Yukon Geological Survey; R. Silke, Northwest Territories and Nunavut Chamber of Mines; and, Northwest Territories Geoscience Office (2008).

Energy: Energy generation in the three territories comes from a limited number of sources. Hydroelectric generation is the dominant source of energy production in Yukon and the Northwest Territories, with the balance coming from diesel and natural gas–fired units. Nunavut depends almost entirely on imported oil, diesel, and other fossil fuels for its energy needs. Continued dependence on these sources for electricity needs is likely, as connecting distant communities to a central electricity system is cost-prohibitive. In northern communities where diesel fuel is the source of all electrical power, the integrity of both the generating plant and its fuel supply depot are critical to human health and safety. Wind and solar power account for a minimal amount of the power generated in Canada's North, although a Government of Canada program is in place to support growth in small-scale renewables.[47] Exploring options for increasing the uptake of renewable energy sources is also part of territories' energy strategies.[48] The northern energy infrastructure system also includes under- and above-ground fuel containers, electricity transmission lines and isolated distribution systems, and oil and natural gas pipelines in Yukon and Northwest Territories. Box 3 below briefly discusses the challenges in planning, designing, building and maintaining linear structures across permafrost terrain. Northern energy infrastructure is likely to grow in the future, however, largely to export oil, gas, and electricity to southern markets (see Chapter 2).

[47] For more information on the *ecoENERGY for Aboriginal and Northern Communities Program*, see http://www.ainc-inac.gc.ca/enr/clc/pra/ovr-eng.asp.

[48] See the *Yukon Energy Strategy* (http://www.emr.gov.yk.ca/energy/energy_strategy.html), the *Energy Priorities Framework of the Northwest Territories* (http://www.iti.gov.nt.ca/energy/EnergyPrioritiesFramework.shtml), and the *Government of Nunavut Energy Strategy* (http://www.gov.nu.ca/documents/energy/EnergyStrategy_ENG.pdf).

BOX 3: Unstable permafrost is a risk to linear structures such as energy pipelines

Designing, building, and maintaining linear structures such as energy pipelines on permafrost terrain presents major challenges and related economic, environmental, and social risks. Originally considered in the 1970s, proponents of the Mackenzie Valley Pipeline project broke new technical ground in pipeline design, construction, and operations. Some of the technical approaches were then integrated in the Norman Wells pipeline project, Canada's first energy pipeline buried in permafrost terrain.

Permafrost is problematic for a couple of reasons. Permafrost is insulated by an "active layer" of soil and organic matter that melts every summer and freezes in the winter. Pipeline construction and operation has the potential of disturbing this layer, transferring heat, and causing progressively more ponding, melting, and erosion with each successive summer. Disturbance can be a result of digging the trench to lay down the pipeline in the first place. Building in winter and insulating the pipeline trench with material such as wood chips are measures to address this problem. A pipeline operating at normal temperatures would also radiate heat to the surrounding frozen ground. Chilling the hydrocarbon to temperatures below zero is a way to address the heat transfer issue, and is the approach used in the Norman Wells pipeline.

Ensuring pipeline integrity is also a challenge. Chilling the hydrocarbon, for example, is a problem for portions of pipelines underlain by discontinuous permafrost and unfrozen areas. In these parts, the effect of a chilled pipeline would be to gather moisture and cause ice-lensing, exerting pressure on the pipeline itself (frost heave) and increasing the possibility of pipeline fracture. In the case of Norman Wells, significant effort has gone into limiting frost heave across transitions between frozen and unfrozen terrain.

Sources: Natural Resources Canada – Geological Survey of Canada – Norman Wells. Pipeline Research (http://gsc.nrcan.gc.ca/permafrost/pipeline_e.php); Page (1986).

Containment structures: Earth dams — containment structures that lie in natural depressions — serve several functions throughout the lifecycle of mining operations, including holding mine tailings and industrial waste, protecting water supplies, and retaining solid tailings after mine closure.[49] In cases where dams rest on permafrost, thawing could endanger the dam's foundation and lead to seepage; changes in precipitation, both in averages and extremes, also affect the proper functioning of these structures. Compromised structures present significant social and environmental risks given

[49] Although the NRTEE's research focused on containment structures for mining applications, other types exist including solid waste facilities and sewage lagoons.

the toxic nature of some of their contents. Most at risk are structures associated with mines that have already closed, because there is less flexibility in managing them. New containment structures follow the opening of new mines. Given the extensive exploration underway in all three territories and growing global demand for commodities, the numbers of this infrastructure type are likely to increase markedly over the next few years. Across Canada's North, twelve mining projects are currently under regulatory review, and over 200 are in the exploration phase.

3.3 ASSESSING VULNERABILITY OF NORTHERN INFRASTRUCTURE AND COMMUNITIES

The direct impacts of climate change can significantly affect the design, maintenance, and overall management of infrastructure in Canada's North. Direct impacts include warmer temperatures; changes in amount, timing, and type of precipitation; reduced sea ice; changes in streamflow patterns; permafrost degradation and changes to other ice systems; and, enhanced coastal erosion and storminess. As noted earlier, permafrost conditions greatly influence the choice of foundation systems. Addressing warming and degradation of permafrost over time involves designing the system to be able to withstand the expected conditions and building in the flexibility to make adjustments over time, such as the refurbishment of artificial cooling technologies or building in the ability to re-level structures in response to differential settling. Other options include accepting suboptimal performance and premature retirement of the structure.

Just to illustrate further, consider the interaction between the effects of climate change on heating, ventilation and air conditioning (HVAC) systems and operational and management choices. Warmer temperatures may require the introduction of cooling systems in some buildings, adding to the costs of construction and operations as well as increasing summer-time energy demand. In large buildings where responsibility over components of the building system lies with many parties, design decisions, if not taken holistically, may lead to suboptimal outcomes. More intense and frequent precipitation and wind events also influence decisions on structural design and building materials, in turn affecting building safety and durability of the building envelope and façade.

Indeed, operations and maintenance practices are important influences on infrastructure vulnerability. This was a finding of Canada's first *National Engineering Vulnerability Assessment of Public Infrastructure*, which emphasized climate change as a factor that threatens infrastructure resilience (see Box 4). Examples on the ground show that ongoing operational and maintenance practices can compromise a building's structural and envelope integrity, even if its initial design and construction is sound. For example, a five-year-old birch tree that had grown into the roof membrane of the Yukon government legislature building was not an effect of changing climate conditions, but highlights issues in ongoing operations and maintenance that makes infrastructure susceptible to failure today. A changing climate is likely to increase the need for ongoing attention to maintenance.

BOX 4: Canada's first National Engineering Vulnerability Assessment of Public Infrastructure highlights threats to infrastructure resilience

Engineers Canada (the Canadian Council of Professional Engineers) and its partners published in 2008, Canada's first *National Engineering Vulnerability Assessment of Public Infrastructure*. Based on a series of case studies on different types of infrastructure, the assessment reached the following conclusions for Canada:

- Some infrastructure components have high engineering vulnerability to climate change.
- Improved tools are required to guide professional judgment.
- Infrastructure data gaps are an engineering vulnerability.
- Improvement is needed for climate data, development of updated and improved climatic design values, and climate change projections used for engineering vulnerability assessment and design of infrastructure.
- Improvements are needed in design approaches.
- Climate change is one factor that diminishes resiliency.
- Engineering vulnerability assessment requires multidisciplinary teams.

The impacts of climate change combined with regional and community characteristics and external social and economic forces can amplify existing risks and create new ones. For example, the drive to increase regional economic wealth in order to increase housing options and health services is a powerful incentive to attract investment in the enormous resource development potential that climate change is helping make more accessible. However, the pace of development could overtake careful planning and appropriate risk assessment. The prospect of rapid development could also be an incentive to expedite regulatory processes, with long-lasting effects for communities. Rapid processes reduce the likelihood of building to standards or making forward-looking adjustments in the design and construction of infrastructure, such as the consideration of projected climate change. Infrastructure designed and built in haste to facilitate a boom of resource development could thus represent a vulnerable asset from the start.

The legacy of resource booms is already playing out in Canada's North. For example, the Town of Faro (Yukon) is facing the management of a large stock of infrastructure abandoned and exposed to northern climate conditions for over 10 years since the final closure of the Faro mine. The town's utility systems were designed to accommodate a community over 10 times larger than what they currently service, and are expensive to maintain. This constrains investing in other priority infrastructure areas, including channelling additional resources into enhancing infrastructure resilience to climate change.

Table 12 summarizes potential risks and opportunities that a changing climate poses to northern infrastructure, which were highlighted in Canada's 2008 scientific assessment of climate change impacts and adaptation.

TABLE 12: Risks and opportunities of climate change

Sector	Example of risk / opportunity
Infrastructure (general)	• In the short term, the effects on permafrost from ground disturbance and construction pose more risks than climate change • Structures built before 1990s, those on ice-rich soils, and those built on shallow foundations are most at risk • Newer major structures starting to consider life-cycle effects of climate change in engineering design • Risks from changes in precipitation patterns (snow, rain, freezing rain), and freshwater systems (e.g., exposure to flooding), and from changing patterns of freeze/thaw (e.g., exposure to ice jamming) • Increased risk of wildland fires has adverse implications for a variety of infrastructure types, including houses in towns and communication towers in remote areas
Transportation (winter roads)	• Reduced reliance on winter roads, with implications such as supply chain disruptions for mining operations; loss of access in and out of remote communities reliant on winter road networks; pressure to build all-season roads
Transportation (marine)	• Potential for new Arctic shipping routes, longer summer shipping; ice hazards continue in winter for next decades • Increased large vessel traffic through Hudson Bay and Beaufort Sea present risks to coastal communities and small vessels
Transportation (freshwater)	• Potential for longer shipping season for Mackenzie barges, contingent on optimal lake and river levels • Reduced reliance on river transport systems for resupply due to low water levels
Energy (hydro-electric development)	• Challenges in meeting increased demand with changing natural storage • Operational risks (flooding) linked to changes in river-ice regimes and formation of ice dams

TABLE 12: Risks and opportunities of climate change (continued)

Sector	Example of risk / Opportunity
Energy (oil and gas)	• Operational risks to exploration activities (e.g., effects of enhanced wave action and storm surges on offshore drilling) • Risk of release of drilling waste linked to permafrost melting and ground instability • Risks to the integrity of linear structures, such as oil & gas pipelines, connected to differential settlement across permafrost terrain • Enhanced exploration potential under reduced sea-ice conditions
Mining	• Supply chain disruptions related to reduced winter road availability • Risk of release of waste-rock, tailings from containment structures, linked to permafrost melting and ground instability • Operational risks from changing patterns of severe weather (especially snow, blizzard and wind conditions) • New deep port (Bathurst Inlet) and related gravel road network could present growth opportunity

Source: Furgal and Prowse (2008).

NRTEE research revealed specific issues of concern to northerners and a number of instances where current infrastructure vulnerability and the industries and populations that these systems service is already evident. In particular, six main climate impacts require consideration:

- Warmer temperatures and changing precipitation patterns, including snow, rain, and freezing rain conditions
- Permafrost degradation
- Flooding and stream flow changes
- Sea-ice loss and coastal erosion
- Changing weather extremes
- Wildfires

These climate impacts are of relevance to the five categories of infrastructure discussed earlier: transportation, buildings, communications, energy, and containment structures.

Warmer temperatures and changing precipitation patterns

- Rising temperatures and changing precipitation patterns have the potential to affect all infrastructure types and related services. With rising temperatures, air moisture will increase, giving rise to higher snow and ice loads, higher humidity (fog) and changes in snow-to-rain ratios. Fog affects air travel, and higher moisture levels add to deterioration and increased maintenance costs of airport runways. In parts of Canada's North, buildings, energy, and communications infrastructure were designed and built for low snowfall conditions; in other parts of the region infrastructure is exposed to high snow loads because of snow drifting. Increased snow and warmer temperatures causing freezing rain events, and rain on existing snow cover are already resulting in infrastructure failure. Snow is also wetter and therefore heavier.

- Warmer temperatures are resulting in shorter winter road seasons. The mining industry, which is a main user of winter roads, may be able to adapt to their reduced availability by concentrating the shipping of supplies in a shorter season or considering all-season roads, albeit at a cost. Northern communities — particularly in the Northwest Territories — may also be able to adapt but are likely to bear increased costs for the delivery of food and other supplies. The Diavik Diamond Mine has had to take expensive measures to compensate for ice roads that have failed to freeze thick enough to allow resupply. In May 2006, the company resorted to using a large helicopter to airlift stranded heavy equipment to its mine 300 km northeast of Yellowknife. Reducing reliance on goods from distant suppliers can increase coping capacity and enhances resilience. For example, reducing communities' and mines' demand for fossil fuels either through energy efficiency or renewable energy applications as an adaptation option has a few benefits. It reduces the risks in transporting and storing the fuel, decreases dependence in resources that may becoming increasingly unpredictable to secure, and has the potential of reducing GHGs.

- Freeze/thaw cycles are another climate change impact affecting different types of infrastructure. In Gjoa Haven (Nunavut), alternating cycles of warm and cold temperatures coupled with rain events contributed to a dike failure in 2005. In Inuvik (Northwest Territories), freeze/thaw cycles have contributed to ground slumping at the airport, requiring emergency repairs in the wintertime. Warmer winter weather is also leading to a phenomenon known in the Northwest Territories as *overflow* and as *glaciation* in Yukon. Most common in small streams, it refers to meltwater flowing over frozen rivers and roads, subsequently freezing on the surface.

- Ice jamming and unusual breakup patterns of river ice trigger serious damage to infrastructure. In 2009, large blocks of river ice drove into and around structures in the Dawson and Faro areas (Yukon) and Eagle (Alaska), causing extensive damage. Risks from seasonal flooding and ice jamming along major river channels and coasts are important considerations in siting and operating industrial facilities. The design of artificial islands developed for oil production at Norman Wells (Northwest Territories) took into account high-water levels caused by ice jams along the Mackenzie River.

Permafrost degradation

- Communities that are dependant upon airport runways and all-weather roads are likely to experience ever-increasing maintenance costs due to the gradual loss of structural integrity.[50] Communications towers and energy transmission infrastructure located in remote permafrost areas are becoming increasingly susceptible to the risk of failure and, since accessibility may also be an issue and the cost of redundancy is prohibitive, the threat posed by this hazard will become increasingly significant.

- Energy pipelines built over permafrost terrain could be at risk of rupture and leakage if design and maintenance protocols do not account for the potential for permafrost thawing, related settlement, and frost-heave.[51] Permafrost thawing and freeze-thaw cycles also present challenges to the long-term safety of underground fuel storage tanks. Tank stability and integrity is critical in preventing fuel leaks and fires. Governments and insurers are providing incentives to owners of underground storage tanks to switch to safer, more reliable applications.

- The integrity of containment structures built on frozen foundations may be at risk over the next five decades unless refurbishments of existing thermosyphon systems take place or new ones are installed. Release of toxics from containment structures, such as mining tailings ponds, could be environmentally and socially disastrous, causing irreversible degradation of sensitive habitat and human health impacts.

Flooding and streamflow changes

- The potential for increased flooding is a concern for communities located on floodplains. Washouts can affect highways, as has already been observed along parts of the Dempster Highway (Yukon). In Yukon, fibre optic cables for communications systems are located along highways adjacent to rivers, with significant areas susceptible to flooding.

- Community relocation is one option to deal with persistent flooding and bank erosion. The community of Aklavik (Northwest Territories), located on the banks of the Peel Channel, experienced severe erosion, permafrost degradation, and disastrous flooding in the 1950s. This prompted the Government of Canada to build the settlement of Inuvik and relocate the community to a location with lower flood risk, with mixed success. Several hundred community members stayed in Aklavik, currently linked to Inuvik and other communities via winter roads and air access.

- Increased flooding and runoff will contribute to silt buildup resulting from erosion. Communities on floodplains may experience increased costs of maintaining river infrastructure because of increased

[50] Permafrost degradation is also an issue for transportation infrastructure in northern portions of some provinces. In Tasiujaq, Ungava Bay, Quebec, permafrost degradation affected the functioning of the airport runway, disrupting the community's access to essential goods and services, such as food and medical attention (Bourque and Simonet, 2008).

[51] Other linear structures affected by permafrost degradation include rail lines, such as those serving the Port of Churchill (northern Manitoba). Continued permafrost degradation will add to operating and maintenance costs, potentially requiring early replacement of this infrastructure (Sauchyn, and Kulshreshtha 2008).

silting. Communities that rely on water transportation may find increased silting of navigation channels causing difficulties for access of ships/barges, and may require additional capital expenditures for dredging. Silting or decreased flows have already disrupted navigation in some places. The Porcupine River at Old Crow (Yukon) used to supply the town, but silting and already low summer water levels are causing serious restrictions in boat traffic.

Sea-ice loss and coastal erosion

- Coastal communities have observed the loss of sea ice, greater wave action, and the resulting erosion of coastlines. Coupled with land instability from permafrost degradation, intensified storm surges connected to higher sea levels, changes in storm intensities and tracks, and sea-ice loss may force the relocation of whole communities in the future. Tuktoyaktuk (Northwest Territories), a community of under 1,000 people located at the edge of the Arctic Ocean, has experienced some of the fastest rates of coastal erosion and permafrost melt in Canada, estimated at about six feet a year. Already a local school and the Royal Canadian Mounted Police headquarters have had to be relocated further inland when the shoreline was washed away. The community has spent nearly $6 million over the past 10 years transporting rocks for shoreline protection.

Weather extremes

- Storms are likely to become more frequent and intense, and with wetter and warmer winters, northerners may be facing more severe snowstorms. Emerging evidence from communities points to the vulnerability of buildings to such heavy snow events. Over 20 per cent of public access buildings in the Northwest Territories are at risk or have been reinforced to account for increasing risk of roof collapse related to snowstorms.

- In 2003, strong wave action brought on by high winds in Hall Beach, a community of about 650 people located on Melville Peninsula, damaged the recently built erosion control structure. Emergency repairs to the structure were necessary to protect nearby houses.

- In 2008, snowmelt and intense rainfall over two days led to flooding in Pangnirtung (Nunavut), causing erosion of permafrost terrain in an area supporting bridge structures. This event damaged two bridges and bridge-access roads, affecting the community's access to essential services.

Wildfires

- A changing climate is likely to affect patterns of forest disturbances (such as wildfires and insect outbreaks), and this is a major concern for community infrastructure below the tree line. The communications sector recognizes this is a serious issue for remote microwave stations. Similarly, in the energy sector, wood structures are at risk from fire as well as from insect infestations.

- An interruption in communications services from wildfires is significant because of the lack of system redundancies. In Inuvik (Northwest Territories), for example, the network of cash machines and bank information systems rely on the continued performance of one communications tower. If it breaks down, delays in repair (and, consequently, in restoring service) are likely because technicians for the tower reside outside of town.

- In 2004, a record forest fire season in central Yukon added to changes in the sensitivity of the permafrost ground, resulting in a large number of landslides in the Dawson area. The slides compromised transportation routes in the region and affected building structures considerably.

4.0

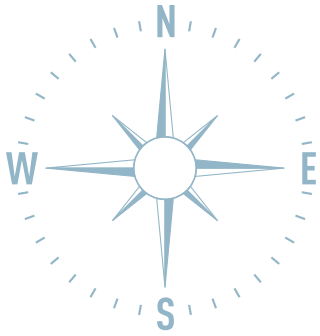
THE ROLE OF GOVERNMENTS IN CLIMATE CHANGE ADAPTATION

IN THIS CHAPTER

66° 08’ 40” N
65° 42’ 55” W

LOCATION: PANGNIRTUNG, NUNAVUT

The vulnerability of northern infrastructure to weather extremes was highlighted in 2008 in Pangnirtung (Nunavut) when snowmelt and intense rainfall over two days led to flooding, causing erosion of permafrost terrain in an area supporting bridge structures. This event damaged two bridges and bridge-access roads, affecting the community’s access to essential services.



4.0 THE ROLE OF GOVERNMENTS IN CLIMATE CHANGE ADAPTATION

Governments, businesses, communities and individuals all have a role to play in adapting to climate change. Our focus here is on the roles for governments. Governments are stewards of public assets, lands, and natural capital, and are responsible for making related management decisions that are in the public interest, including taking action to minimize risks posed by a changing climate. In doing so, the government needs to systematically assess climate risks in the context of desired goals or outcomes; take action to address risks; monitor, evaluate, and report on the actions taken; and adjust actions according to experience. This essentially describes a cycle of *adaptive management*, an approach useful when dealing with uncertain, long-term, and complex issues. It captures government's role as an *adaptor*. Second, governments can signal and support "climate-wise" decisions by providing information; shaping existing institutions, such as regulations, fiscal measures, and markets; and removing barriers to adaptation. This describes government's role as a *facilitator* of adaptation across society.

This chapter discusses the broad roles of Canadian governments in climate change adaptation. It includes analysis commissioned by the NRTEE, information collected during the NRTEE program activities, and information from publicly available sources. It briefly discusses how the roles of governments might

differ in Canada's North in comparison to other regions of the country, in the context of the changes taking place in northern governance regimes. The chapter ends with a summary of mechanisms that governments can use to promote mainstreaming of adaptation thinking in infrastructure decisions.

4.1 PERSPECTIVES ON GOVERNMENT ROLES

In 2005, representatives from Canada's federal, provincial, and territorial governments completed a *National Climate Change Adaptation Framework*, which outlined government roles in adaptation and potential areas for inter-jurisdictional collaboration on the issue. Although the document was not adopted within federal policy, the process and its contents have influenced subsequent provincial and territorial plans and strategies. The generic roles for governments that the framework suggests remain valid and useful, falling into two broad categories: government as adaptor and government as facilitator.[52]

Table 13 builds on these roles, and illustrates a range of levers governments have at their disposal to move forward on adaptation. It highlights the importance of collaboration in advancing adaptation. Adaptation is a horizontal issue, of direct and indirect relevance to several areas of sustainable development, requiring information of different types, from a range of sources and disciplines, and for a variety of needs. For a given issue, say infrastructure adaptation, one level of government can both be an adaptor and facilitator of adaptation, the role depending on mandates and obligations of departments or ministries.

In areas of shared interest and jurisdiction, nurturing engagement and collaboration from the highest political levels to the local level is key. Examples of collaborative approaches for adaptation include; the community adaptation planning process taking place in Nunavut; a partnership between BC Hydro and the Government of British Columbia focused on augmenting hydrological data and trends; multi-stakeholder research consortia such as Ouranos; the federal government's *Regional Adaptation Collaboratives*,[53] and its partnership with the Government of Yukon to develop a regional capacity in climate change scenarios. Collaboration across geopolitical boundaries is important for sharing knowledge, addressing equity concerns, and promoting the resilience of integrated systems, including ecosystems and integrated economic sectors.

[52] Policy Research Initiative (2009) - *Prioritizing Climate risks and Actions on Adaptation*. http://www.policyresearch.gc.ca/page.asp?pagenm=2009-0007_03 Accessed July 2, 2009.

[53] Natural Resources Canada delivers the *Regional Adaptation Collaboratives* program. Program information appears at: http://adaptation.nrcan.gc.ca/collab/index_e.php.

TABLE 13: Government's roles in adaptation

Government as *adaptor*	
Stewardship	• Land • Natural capital • Physical infrastructure • Transboundary issues
Policy development and implementation / provision of public goods and services	Social, economic, environmental, cultural well-being – *Examples of policy areas*: coastal and flood defence; disaster management; health; safety; natural resources, ecosystem, environmental management; cultural preservation and heritage; innovation; trade; economic development; international development *Examples of public goods and services*: long-term environmental observations and monitoring (e.g., hydrology, weather, permafrost); climate science and modelling; natural and social science; inventories of human built assets and natural capital
Government as *facilitator*	
Data and information	Reliable, high-quality information on climate change impacts; climate design values for engineering codes and standards; regional / sectoral vulnerability; social and economic trends
	Tools to support risk assessment, planning, and decision making
Institutions	*Examples*: liability rules, regulations, permits, codes and standards, guidelines, land-use planning processes, markets, taxes
Financial incentives	*Examples*: subsidies for private sector research and development, micro-financing
Leadership by example	Demonstration of processes, techniques
	Procurement (to stimulate market creation)
Provision of "safety nets"	Targeted attention to vulnerable populations. *Examples*: broaden access to risk-spreading mechanisms; reinforce informal networks

Desired behaviour and state:

Effective management of climate change-related risks, by, for example —

- accepting impacts and bearing losses
- sharing losses
- preventing negative impacts
- increasing understanding (risks and responses)
- exploiting opportunities

Leads to human and natural systems that are more resilient to a changing climate

Sources: Intergovernmental Climate Change Impacts and Adaptation Working Group (2005), Stern (2006), Conference Board of Canada (2007), IPCC (2001) (after Burton 1996).

4.2 GOVERNMENT ROLES IN CANADA'S NORTH

Adapting to the impacts of a changing climate will involve cooperation across all levels of government in Canada's North — local, Aboriginal, territorial, and federal. However, delineating roles and responsibilities may be challenging.[54] As discussed in Chapter 2, governance systems are in different stages of development across the region. Intergovernmental issues, including lines of responsibility, accountability, representation, and financial and human capacity remain unclear in some cases. Capacity issues alone may make the success of any new rules and processes in Canada's North dependant on the formal and informal relationships between and among the various levels of governments.

As already emphasized, an effective approach to adaptation is to consider climate risks in existing planning and decision-making processes. This assumes that effective planning and decision-making processes are already in place, and that implicated stakeholders are clear on roles, responsibilities, and property rights. Although this is not necessarily the case in Canada's North, all orders of government have an interest in developing and enhancing institutions, clarifying the regulatory environment, and building inter-jurisdictional relationships for the advancement of local, regional, and national goals. While this process is likely to require significant financial and human resources, it also presents an opportunity to consider the implications of a changing climate in the negotiation and implementation of agreements, and as new institutions, working relationships, and partnerships develop. In some cases, however, Aboriginal peoples may deem some climate change adaptation strategies, such as community relocation or abandonment of traditional wildlife harvesting activities, as unacceptable cultural changes.

[54] This section draws primarily from *Northern Canada Consulting* (2007), a report commissioned by the NRTEE program.

Northern governments and regulatory bodies operating in Canada's North are likely to perform, and are already performing in some cases, many of the generic roles set out in Table 13. However, capacity constraints and competing priorities may present barriers to undertake strategic review of policies and plans, to develop and deploy measures to make infrastructure "climate wise," to disseminate adaptation-relevant information, to provide incentives, and to set and enforce regulations geared toward managing climate risks. Coordination and collaboration among governments is essential for efficient and effective governance, to reduce overlap and duplication, to achieve the best program and service delivery for all residents, and to ensure that lines of accountability are clear.

The regulatory framework for oil and gas development in the Northwest Territories, Nunavut, and Eastern Arctic offshore is an example of ongoing inter-jurisdictional collaboration, which now also needs to consider adaptation. The National Energy Board (NEB) has regulatory responsibilities for oil and gas exploration and activities in much of Canada's territorial north. Project authorizations and approvals for oil and gas exploration and production are subject to environmental assessments, the process dependent on the location of the project. Environmental assessment processes are overseen by a range of regulatory agencies, including the Mackenzie Valley Land and Water Board, the Gwich'in Land and Water Board, the Sahtu Land and Water Board, and the Wek'eezhii Land and Water Board in the Northwest Territories, and the Nunavut Impact Review Board for Nunavut. Environmental assessments generally require proponents to consider the impacts of climate change to the project. Despite a recognition of and concern about the rapid rates of environmental change taking place in the region, coping with adaptation needs presents challenges to the NEB, territorial, and Aboriginal governments.

Box 5 illustrates stakeholder perceptions in Canada's North on possible government roles and responsibilities in promoting adaptation in the region, based on qualitative research conducted by the NRTEE.

BOX 5: Northern stakeholders have a range of views on government roles and responsibilities in promoting adaptation in Canada's North

During the course of the program on Climate Change Adaptation Policy, the NRTEE commissioned research on the role of government in adaptation, specifically in Canada's North. As part of this work, the research team conducted telephone interviews with northern stakeholders in April 2007. The interview format consisted of open-ended questions relating to the roles of various orders of government. The following boxes present the aggregate results of interviews. Results are not statistically representative of northern populations. They provide an indication of northerners' perceptions on the issue at the time of the interviews.

Responses to the question "What should be the main roles and responsibilities of the federal government in promoting climate change adaptation in the North?" included the following:

- demonstrate leadership
- provide funding
- fund training and capacity building through partnerships
- assist Aboriginal governments in developing the capacity and human resources to adapt
- transfer information to territories to help them educate the public
- undertake (climate) research and modelling
- make sure climate information is available, accessible, and up to date
- develop best practices
- set the regulatory agenda
- convene, coordinate, co-operate, talk with us
- take an arm's length role and empower us

Responses to the question "What should be the main roles and responsibilities of the territorial governments in promoting climate change adaptation in the North?" included the following:

- develop internal capacity and then educate the northern public
- demonstrate commitment to action by: increasing personnel and budgets to address adaptation; revising climate change strategies
- facilitate community action — for example, develop adaptation templates for the communities
- get more involved in ongoing initiatives (e.g., Arctic Council's adaptation projects)
- develop partnerships with other governments

Responses to the question "What should be the main roles and responsibilities of Aboriginal governments in promoting climate change adaptation in the North?" included the following:

- get land claims agreements implemented properly
- find out what it all means
- raise awareness of climate change as a new and growing threat
- work with others to develop capacity to adapt to climate change
- press for partnerships with the territorial and federal governments
- use science and traditional knowledge to make decisions
- move forward with community plans that address adaptation

When asked "What should be the main roles and responsibilities of municipal governments in promoting climate change adaptation in the North?" respondents highlighted specific gaps in capacity instead of providing direct answers to the question, as in the previous three cases. The gaps and needs that respondents related to community readiness and technical support included the following:

- communities are not ready to adapt
- communities are already struggling with change
- communities require technical support before anything else is possible (e.g., technical support for energy planning, integrated community planning, and vulnerability assessments)

Responses to the question "How can governments in the North work together to deal with climate change adaptation?" included the following:

- by pursuing meaningful partnerships — an example of a successful partnership model that arose was the Northern Contaminants Program
- by taking northern issues to national fora and meetings of federal/provincial and territorial ministers (environment, energy, resources)
- by recognizing that there is no "silver bullet" on adaptation and that this is why we must work together
- governments can work together, but there is no substitute for federal leadership

There is particular relevance in considering the federal government's role in climate change adaptation in Canada's North. By virtue of the mandate of Indian and Northern Affairs Canada, the federal government has a "direct role in the political and economic development of the territories, and significant responsibilities for resource, land and environmental management."[55] The federal government's international obligations are equally paramount, as climate change has significant circumpolar ramifications. Coupled with responsibilities for forecasting weather and sea ice, performing scientific assessments, and maintaining the knowledge base of Canada's landmass, and regulatory responsibilities in northern oil and gas development, the federal government plays a vital role in shaping an integrated climate change adaptation strategy for Canada's North.

4.3 INSTRUMENTS FOR INFRASTRUCTURE ADAPTATION AND CURRENT INITIATIVES

Governments have a range of levers at their disposal to promote adaptation. They can rely on voluntary measures, such as information provision, or command and control measures, such as regulations. They can also use markets, financial incentives, liability rules, and fiscal or tax measures to dissuade or encourage citizen or business activity or behaviour. Within the context of what governments perceive to be politically acceptable at the time, they base the selection of instruments on criteria such as economic efficiency and likely effectiveness in achieving the stated goal, which can encompass multiple objectives. For reasons such as resource constraints or perceived lack of salience, governments can also choose to do nothing.

Several instruments of relevance to climate change adaptation exist. The OECD recently reviewed some of them, focusing on insurance and market mechanisms, private-public partnerships, microfinance schemes, regulations, and incentives for research and development (R&D). Minimizing problems related to moral hazard and negative externalities are two important considerations. Moral hazard is the case where people or businesses take greater risks with the expectation of government bailout due to political pressure. An example of a negative externality is the effect of a household decision to reinforce their sea front, exacerbating erosion on the sea front of a neighbouring household. Table 14 is a summary of some possible adaptation options and instruments applicable to physical infrastructure, which includes the three instruments evaluated in the next chapter.

[55] For further information on the mandate, roles, and responsibilities of Indian and Northern Affairs Canada, see http://www.ainc-inac.gc.ca/ai/arp/mrr-eng.asp accessed July 2, 2009.

TABLE 14: Potential use of well-known policy instruments to promote adaptation

Climate impact	Adaptation option	Potential instrument
Flood and storm damage to coastal infrastructure through sea surges and enhanced coastal erosion	*Prevent the loss* through: • structural options: coastal defence, such as beach armouring ; design and build structures to be "flood proof" • on-site operations: beach nourishment, sediment management • institutional options: land-use planning, emergency planning, clarifying accountabilities *Change location* using set-backs, relocation strategies	• Regulatory nature: zone planning, all-hazards requirement for disaster/emergency management • Markets: differentiated insurance premiums • Financial incentives: public-private-partnerships (PPPs) or financing for shoreline defence • Liability rules: changes to legal liability to internalize risks and costs of adapting coastal infrastructure
Flooding after severe rainfall and snowmelt events Change in volume, timing, and quality of water flows More frequent and severe water shortages	*Prevent the loss* through: • structural / technological options: increase reservoir capacity, dredging, increase water drainage infrastructure • institutional options: water reallocation, risk management to address rainfall variability • market-based options: water permits, water pricing *Changing activity* through diversification (e.g., less reliance on hydroelectric generation) and conservation	• Financial incentives: adjustments to terms of PPPs (e.g., water efficiency requirements), subsidies for technology deployment • Markets: water pricing, trade in water permits • Information and leadership by example: awareness campaigns and demand-side management programs
Reduced infrastructure performance due to changes in average climate conditions and extremes Reduced space heating demand, but increased cooling linked to warmer temperatures	*Prevent the loss* through: • Structural options: designing and building "climate-wise" housing stock and other infrastructure • Institutional options: changing maintenance requirements; reviewing safety and energy efficiency standards	• Regulatory nature: building codes & standards, zone planning, adjustments to project approval process (e.g., environmental impacts assessment process), adjustments to licences (e.g., condition licence to adaptation) • Markets: adaptation-dependent insurance premiums; insurance schemes

TABLE 14: Potential use of well-known policy instruments to promote adaptation (continued)

Climate impact	Adaptation option	Potential instrument
	• *Share the loss* through market-based options: such as insurance • *Change location* using zone planning and siting decisions • *Increase understanding* through monitoring impacts / responses	• Financial incentives: adjustments to terms of PPPs, R&D incentives targeting innovative technologies for adaptation • Information or leadership by example: monitoring protocols, technology demonstration pilots, training and skills development of infrastructure practitioners
Greater frequency and severity of extreme weather events, and related damage to infrastructure Disruption of economic activity, and indirect health effects (e.g., food spoilage, water contamination)	*Share the loss* through risk-spreading options beyond the insurance industry *Prevent the loss* through: • institutional or administrative options: early warning systems, enhanced disaster/emergency management • structural options: flood barriers, flood proof infrastructure, lightning protection, installation of internal sprinklers *Change location* using zone planning and siting decisions	• Regulatory nature: building codes & standards, zone planning, adjustments to project approval process (e.g., environmental impacts assessment process), adjustments to licences (e.g., condition licence to adaptation) • Markets: adaptation-dependent insurance premiums; insurance schemes • Financial incentives: mobilize private finance or PPPs for defence structures

Source: Adapted from OECD (2008), includes information gathered during stakeholder consultations of the NRTEE program.

Northern stakeholders are increasingly concerned with the manifest impacts of climate change and those likely to come. Since the launch of the NRTEE program in 2006, the profile of and investment in northern adaptation has increased. Climate change adaptation is a theme in the *Northern Vision* of the three territories, which outlines activities to build on and opportunities for collaboration to advance adaptation. Territorial climate change plans or strategies include adaptation objectives and initiatives, mainly focused on getting a better understanding of expected impacts, community and sectoral vulnerability, and viable adaptation responses. Through a partnered approach, some northern communities are starting to develop and implement adaptation strategies. The Government of Canada has two adaptation programs specifically targeting Canada's North, and delivered by Indian and Northern Affairs Canada and Health Canada. Box 6 highlights some adaptation initiatives of governments, communities, and industry in Canada's North and of relevance to infrastructure adaptation.

BOX 6: Canadian governments, communities, and industry are already taking action on infrastructure adaptation

INITIATIVES THAT BUILD ADAPTIVE CAPACITY

Federal funding programs, territorial legislation, and provisions in Aboriginal self-governance agreements require proponents of major infrastructure projects to study and disclose the anticipated environmental and social impacts of the project. Specifically, new infrastructure projects, such as a new mining operation or a major oil and gas pipeline, require an environmental assessment. Processes and regulatory requirements differ among jurisdictions. Federal processes, for example, require proponents to consider the impacts of climate change to the project, with guidelines on how to do this available through the Canadian Environmental Assessment Agency. Stakeholders in the private sector have suggested that information gaps such as projections of climate change and changes in other environmental conditions pose challenges to meeting this legal requirement. Territorial boards are also grappling with how to address adaptation. The Yukon Environmental and Socio-economic Assessment Board, for example, is already allocating considerable financial and human resources to the task.

The *Northern Vision* of the three territorial governments outlines priority adaptation activities relevant to infrastructure, including assessing the vulnerability of community infrastructure and studying ways to adjust engineering practices and codes and standards to incorporate climate change impacts.

Two out of four goals in Yukon's 2009 Climate Change Plan address climate change adaptation, including activities focused on infrastructure.

The Government of Northwest Territories is undertaking a series of activities to enhance the resilience of buildings under changing climate conditions. For example, Public Works is integrating the implications of higher snow loads in building design, and disseminating this information in a brochure. This department is also working in partnership with the Public Infrastructure Engineering Vulnerability Committee of Engineers Canada on guidelines for the use of thermosyphons.

Nunavut's Department of Environment, Natural Resources Canada, and the Canadian Institute of Planners are working with communities to identify vulnerabilities to climate change, undertake scientific assessments, and develop adaptation strategies. About ten communities have engaged in this process to date, including Clyde River, Hall Beach, and Iqaluit.

The three territorial governments, Manitoba, Quebec, and the federal government are funding the development of a best practices guide for the construction, maintenance, and rehabilitation of transportation facilities in permafrost regions.

Indian and Northern Affairs Canada manages a $14 million northern adaptation program. Among others, it funds and supports community risk and vulnerability assessments and the development of tools to support decisions on adaptation.

BOX 6: Canadian governments, communities, and industry are already taking action on infrastructure adaptation (continued)

Health Canada manages a $7 million program for climate change and health adaptation in northern and Inuit communities. Activities include supporting community-based research of climate change impacts on health and viable adaptive responses, producing and disseminating research results in culturally appropriate formats.

The Canadian Standards Association is developing national guidelines for managers of northern community infrastructure focusing on permafrost and climate change.

IMPLEMENTATION OF ADAPTIVE RESPONSES

Changing permafrost patterns and related ground instability has led to the use of innovative building material to support structures.

In response to soil erosion from permafrost thaw, communities are reinforcing shorelines and moving buildings inland.

Several major infrastructure projects have taken measures to address permafrost warming and minimize ground settlement, such as the installation of thermosyphons.

At the same time, infrastructure development and renewal has emerged as a policy priority, presenting an incredible opportunity to phase in climate change adaptation as infrastructure planning and investments unfold. Statements and investments by federal and territorial governments in the past few years link infrastructure to the advancement of regional and national policy goals, and trends covered in previous sections of this report suggest a likely boom in infrastructure development in the region.[56] Infrastructure development and renewal presents a window of opportunity to adjust processes guiding infrastructure funding, design, construction, and lifecycle management to account for a changing climate. Doing so would be adaptation mainstreaming in action.

Yet, governments appear to be failing to fully exploit this opportunity. The 2008 infrastructure framework agreements between the Government of Canada and the Governments of Yukon, Northwest Territories, and Nunavut require that territories develop a long-term vision and approach to the management of public infrastructure. Among other provisions, these infrastructure plans must include a description of the infrastructure stock's current state, and highlight challenges and pressures foreseen over the next 10 to 15 years. However, they are not specifically required to identify or address climate change impacts and adaptation issues. Instead of a strategic and coordinated approach to adaptation of infrastructure, the integration of climate change considerations as a risk factor in infrastructure management will likely be at the discretion of the many decision makers involved, according to their capacities, needs, and interests.

[56] See Appendix 7.4 for federal policy drivers and commitments linked to northern infrastructure since 2006. These commitments would amount to about $1.4 billion in federal investments toward infrastructure development in Canada's territorial north over the next seven years. Expanding northern infrastructure systems is also a priority under the *Northern Vision* of the three territorial governments.

The economic evidence to rationalize investments in proactive adaptation is scant, but this is a growing area of interest to many stakeholders in Canada's North and elsewhere. Compared to climate change mitigation, which has been the object of economic and quantitative policy analysis for over two decades, efforts to understand the potential magnitude of adaptation required and the phasing of investments based on economic efficiency have only begun in the past few years.

A factor influencing progress to date on infrastructure adaptation to climate change is cost. Examples of studies pertaining to infrastructure that are relevant to Canada's North suggest that adaptation will likely be expensive. At the same time, they indicate long-term benefits to adapting proactively, in the form of reduced costs from climate change damage:

- A study by Larsen et al. (2007) on the economic costs of expected climate change impacts on public infrastructure in Alaska illustrates the high sectoral costs expected in the region. Under conservative assumptions of impacts and costs, the authors estimated that a changing climate added 10 to 20 per cent to an infrastructure operating budget of $56 billion through 2080. Integrating climate change adaptation into infrastructure planning could reduce costs by up to 13 per cent between now and 2030, and by as much as 45 per cent between now and 2080. The infrastructure types expected to result in the most costly impacts were roads and airport runways, which represented about half of the costs.

- A study conducted by Zhou et al. (2007) at Natural Resources Canada focused on residential and commercial buildings in the Northwest Territories. They estimated potential savings from undertaking timely adaptive measures on building foundations, taking into account a range of projections of permafrost conditions. Their results indicated that, in light of potential permafrost degradation from now until 2069, proactive adaptation could imply savings of up to 70 per cent compared to non-adaptation scenarios. They also found that adapting all vulnerable buildings across the Northwest Territories could cost about $230 million. These estimates are likely conservative, as one community alone (Inuvik) is facing costs of approximately $140 million to repair buildings affected by permafrost degradation.[57]

Scientific assessments conclude that a degree of climate change is likely unavoidable due to the buildup of atmospheric GHG emissions from human activities now and into the future, making adaptation a critical response over the next few decades. However, there may be limits to our ability or willingness to undertake adaptation – as it either becomes prohibitively expensive (e.g., relocation of several settlements) or exceeds human capacity (e.g., scarce resources lead to confrontation instead of collaboration). Global efforts to stabilize GHG emissions can reduce the need for adaptation in the long term, which is particularly important to lessen the impact and enhance the resilience of long-lived assets and the underlying services they provide to society.

[57] Angus and Mitchell (2009). Standing Senate Committee on Energy, the Environment, and Natural Resources.

5.0

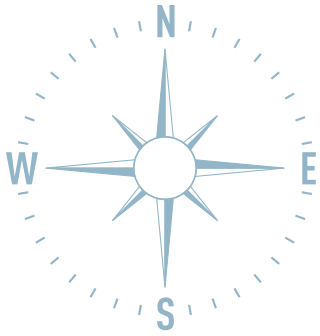
RISK-BASED MECHANISMS FOR CLIMATE CHANGE ADAPTATION

IN THIS CHAPTER

64° 03’ 36” N
139° 25’ 55” W

LOCATION: DAWSON, YUKON

A changing climate is likely to affect patterns of forest disturbances (such as wildfires and insect outbreaks). In 2004, a record forest fire season in central Yukon affected areas of permafrost, resulting in a large number of landslides in the Dawson area. The slides compromised transportation routes in the region and affected building structures considerably.



5.0 RISK-BASED MECHANISMS FOR CLIMATE CHANGE ADAPTATION

The NRTEE's program on *Climate Change Adaptation Policy* selected three risk-based mechanisms to evaluate in light of their potential to enhance the management of climate risks to northern infrastructure and minimize related losses and hardships to communities, businesses, and the environment. The three mechanisms are (1) codes, standards, and related instruments (CSRIs); (2) insurance; and (3) disaster management. Based on research commissioned by the NRTEE, which relied heavily on stakeholder input, this chapter evaluates how the three mechanisms might be adjusted, strengthened or restructured to capitalize on their potential to drive the management of climate risks in Canada's North. That is, whether and how these risk-based mechanisms could be vehicles for adaptation mainstreaming.

We selected these mechanisms for three reasons. The three are well established in Canada and we have considerable experience in employing them to manage risk. Significant scope exists for government intervention in shaping these mechanisms as solutions in meeting broader Canadian objectives, such as advancing adaptation to climate change. Although the nature of the three mechanisms differs, important inter-relationships and feedbacks exist among them.

For each mechanism, the chapter describes current characteristics, gaps, and challenges in their application in Canada's North, particularly in the context of a changing climate. It then highlights interrelationships among the three mechanisms that are important in promoting adaptation.

Our evaluation used the following framework to compare mechanisms and draw conclusions:

- Extent of coverage
- Clarity of roles and responsibilities
- Flexibility and application
- Role of climate-related information
- Consideration of changing climate

5.1 DEFINITIONS

Codes, standards, and related instruments (CSRIs) such as guidelines and best practices play a critical role in society by helping to "set the bar" in relation to the processes and materials that shape the quality of our physical infrastructure. Their primary objective has been to safeguard human safety and health throughout the full infrastructure lifecycle, constituting for society one of the most basic mechanisms for risk management. As a lever for governments, CSRIs can fall into "command and control regulations." That is, they are rules and restrictions specifying behaviours, courses of action, or performance requirements.

Insurance is a financial mechanism with the main purpose of supporting society's management of risk through the pooling of risk. Insurance providers measure and put a price on risks, such as the risk of property damage to a specific building due to extreme weather. Households, businesses, and governments that purchase insurance effectively transfer agreed-upon risks to insurance providers.

Disaster management includes all activities and risk-reduction measures that improve and ensure capacity for effectively dealing with natural and human-caused hazards. Disaster management includes activities supporting prevention and mitigation (avoiding or proactively minimizing loss or suffering), preparedness, response, and recovery. A disaster is *"a social phenomenon resulting from the intersection of a hazard with a vulnerability that exceeds or overwhelms the ability to cope and may cause harm to the safety, health, welfare, property or environment of people."*[58] A related and relevant concept is emergency, defined as *"a present or imminent event that requires prompt coordination of actions concerning persons or property to protect the health, safety or welfare of people, or to limit damage to property or the environment."* Emergency management is a relevant concept, a function that is closer to the local level and nested within the national framework of disaster management. Both disaster and emergency management have a public good character, and governments themselves are responsible for funding or delivering related activities.

[58] Definitions related to disaster management come from Gartner Lee Limited (2008) — a report commissioned by the NRTEE.

5.2 CODES, STANDARDS, AND RELATED INSTRUMENTS

Extent of coverage: Codes and standards are the most common forms of CSRIs.[59] Generally, a code is broad in scope covering a wide range of issues, while a standard is narrow. Through adoption by federal, provincial, territorial, or municipal authorities, both codes and standards can receive the force of law. Some standards do not become legal requirements but practitioners use them as the recognized articulation of good practice. Legally adopting a code that references several standards gives those standards the force of law. For example, the National Building Code of Canada references more than 200 standards. Guidelines and best practices are less binding and less formal, involving techniques or methodologies proven successful through experience and research.

Use and coverage of CSRIs differ across infrastructure types. For example, provinces and territories have responsibility for adopting through legislation and applying the national building, fire, and plumbing codes developed by the Canadian Commission on Building and Fire Codes and supported and distributed by the National Research Council. Best practices and guidelines are more common for development in the transportation sector and the mining sector (e.g., mine tailings facilities).

Clarity of roles and responsibilities: Processes to develop and renew CSRIs differ markedly. The Standards Council of Canada (SCC), a federal crown corporation reporting to the federal Minister of Industry, coordinates and oversees the efforts of organizations that develop many of the codes and standards used in Canada under the National Standards System (NSS). Among other roles, the SCC accredits organizations that develop standards in Canada, such as the Canadian Standards Association. The SCC also manages Canada's participation on international voluntary standards processes, such as the International Organization for Standardization (ISO). Provincial and territorial non-regulatory standards, international standards, model specifications, best practices, guidelines, national model codes, among others, fall outside the scope of the NSS. Both development and renewal of the content of a code or standard is normally a consensus-based process that relies on the voluntary contributions of standing committee, task group members, and the public.[60] In contrast, development and renewal processes for many guidelines may be largely under the control of one or two stakeholders with expertise on the related topic. Government departments may develop guidelines, typically in conjunction with external expert review.

Although critical to the ultimate performance of a code, standard, guideline or best practice, gaps in inspection and enforcement exist in Canada's North. For example, ultimate responsibility for paying for verification, inspection, and enforcement is sometimes unclear. Legal frameworks for northern infrastructure do not always assign clear responsibilities for improper use of CSRIs either. In addition, the limited financial and human resources to undertake inspections and enforce CSRIs is emerging as a serious challenge for territorial, municipal and — with land claims settlements — Aboriginal jurisdictions. Recent years have seen a decline in the number of enforcement and technical support staff in northern jurisdictions. Furthermore, there are currently no national standards for training inspectors,

[59] The section on CSRI draws from Steenhof and Mortimer (2008) — a report commissioned by the NRTEE.

[60] For an example of a standards development process that the Canadian Standards Association follows, see http://construction.csa.ca/dev_process.asp.

and territorial governments may lack the resources to establish their own accreditation programs. With increasing exposure of infrastructure to the impacts of climate change, the risks intensify. Existing gaps in inspection, enforcement, and, ultimately, proper deployment of CSRIs is likely to erode capacities to adapt and meet sustainable regional development goals.

Flexibility and application: Although reviews and updates of codes and standards do take place, northerners are at a disadvantage in terms of participating in these national processes and in getting their concerns on the national agenda. Two main issues influence review schedules and priorities. The first is the time involved in reaching consensus among a group of stakeholders with differing perspectives and opinions concerning key objectives. The second is the demand for reviewing and updating a given instrument. Although in general terms the process for developing and updating standards and codes is consensus-based, the extent of representation of various interest groups in the development process ranges from superficial reviews to comprehensive consultations.

As revealed through the NRTEE program, northern infrastructure practitioners often feel marginalized from these processes. Several reasons are behind this. Territories often do not have the capacity in terms of staff or financial resources to participate fully in CSRI technical committees. Even provinces have a tendency to put the greatest effort in dealing with the regions within their jurisdictions where the codes will have the greatest impact — usually in the populated south and industrial heartlands. National codes are meant to be national in scope, and northern factors do not seem to carry the same weight as southern ones in these committees. Given that many CSRIs are market-driven, backed by those with a stake in a certain technology or process, the resulting emphasis on southern issues in the CSRI process is both predictable and apparent.

Participation by northerners in these national-level processes is critical from a number of perspectives. First, risk tolerance and attitudes regarding uncertainty differ among stakeholders. This is a fundamental argument for ensuring balance in the makeup of the committees involved in the development of CSRIs and, in particular, for including northern interests and experts at the table. Second, for some northern issues, such as building in permafrost, a consolidated body of knowledge or set of best practices to reference does not yet exist, meaning that experienced practitioners are the best resources in this regard. Third, the usefulness of CSRIs is contingent on reliable and efficient enforcement and inspection. As discussed in the above section, many areas of Canada's North have capacity issues in this regard, which need to be communicated at CSRI committee tables. For example, NRTEE research and consultation revealed that territorial codes and standards bodies are asking for climate and climate change data and information for updated codes and standards that reflect the realities of their changing climate.

A changing climate and the need to adjust CSRIs accordingly is likely to further widen the gap between the adequacy of national CSRIs in addressing northern circumstances and needs, potentially placing a great strain on the creativity, capacity, and decision-making ability of northern infrastructure practi-

tioners. In the past decade or so, northern infrastructure practitioners have generally done an excellent job in managing climate-related risks to infrastructure. But, as the number of companies establishing and working on infrastructure in Canada's North increases in the coming years, codification of the experiences of northern practitioners in CSRIs will become increasingly important. As an example, Canada currently lacks formal guidance on the application or maintenance of thermosyphons, a permafrost-related technology of wide application in parts of Canada's North.

"Most of what I do is not governed by codes and standards. Most hinges on experience. There is very little that dictates what we must do in our practice. It was ten years ago that the first guideline came out. Though it is now dated, the framework is still useful."

– Participant, Meeting of the NRTEE program in Yellowknife (Northwest Territories), January 2008.

Role of climate-related information: Integration of climate information in the development of CSRIs and the design, construction, and management of infrastructure takes place largely through the establishment and application of "climate design values." These values include calculated return periods for extreme weather (such as intense rain, wind, snow, extreme cold, freezing rain) of varying intensities and durations, as well as through the consideration of long-term averages. Since the 1920s, Environment Canada (or its historical equivalent) has provided climate design values for codes and standards. Design values reflect historical conditions for a given geographical location.

Several trends of national relevance are affecting the quality and relevance of climate design variables as inputs into CSRIs. First, over the past 15 years or so the capacity of the federal government to produce the sorts of updated climate data and information required by CSRIs has declined. Canada's North was particularly hard hit by cutbacks in monitoring capacity, with the number of monitoring stations dropping markedly between 1994 and 2008, in a region already affected by the sparseness of monitoring coverage in time and space and inconsistencies in data collection techniques. Second, federal capacity to review and revise climate design values diminished over this period as well. The first comprehensive review of design values across Canada will take place for the 2010 National Building Code of Canada (excluding snow loads). For some northern areas, this means that mean annual temperatures reported in the design values have been as much as 2°C behind current averages. Third, efforts to enhance monitoring capacity in remote parts of Canada's North using automated systems remain less consistent in measuring certain climate indicators in comparison with traditional methods. This could diminish the ability to understand the progression of climate change and the development of adequate climate design values in some regions.

The implications for Canada's North concerning monitoring capacity and reduced federal involvement in developing and updating climate design values are many. These trends affect the timeliness and relevance of climate design values, since they are only as good as the quantity and quality of the data informing their calculation. Northern infrastructure practitioners are obliged either to use significantly outdated, and potentially limited, values cited in CSRIs, or to contract with an outside party to produce

new design values separate from those referenced in CSRIs. At the same time, organizations responsible for developing and updating CSRIs typically show reluctance to use climate design values derived by any group except Environment Canada, which they perceive as an expert, reliable, neutral third party.

Data and information on permafrost conditions are also important to CSRIs and management of infrastructure in Canada's North, yet gaps exist in this regard. Reliable sources of permafrost data are disparate across Canada's North, the data gathered and information produced does not respond to the needs of infrastructure practitioners. Natural Resources Canada monitors and models permafrost conditions, but much of the activity focuses on ongoing or imminent megaprojects or studies of the changing climate itself, such as methane release from thawing of permafrost terrain. Northern infrastructure practitioners are seeking better information and guidance on building under changing permafrost conditions, particularly in areas of so-called warm permafrost that are highly affected by a warming climate.

Traditional knowledge presents a largely untapped source of climate-related information and input for decision making. Development of CSRIs has not tended to incorporate this source of data and information, yet northern residents are a critical and often unaccounted for source of information. Recent examples of activities to harness traditional knowledge of climate exist. In Nunavut, governments, academia, and communities are working together to complement historical weather records with recollections from Aboriginal residents. The inclusion of traditional knowledge can also help integrate unique cultural and social attributes of local populations, attributes that could have an influence of the application and eventual enforcement of a code or standard, as well as the performance of the infrastructure. Traditional knowledge can contribute to the characterization of the resilience of a population and to the identification of requisite measures for adapting to the impacts of climate change.

Northern infrastructure practitioners and others could benefit from increased access to existing data, analysis, and information pertaining to climate and other biophysical trends and indicators, and from regular updates in climate design values. Considerable information on changing climate conditions is held by a range of federal, provincial, territorial, and municipal government agencies. Some of these agencies, such as territorial water boards, collect raw data but lack the resources to conduct detailed analyses that would be helpful to infrastructure practitioners. Private sector corporations, including proponents of major resource and construction projects that have undertaken research as part of environmental assessment and regulatory permitting processes, also hold significant amounts of data and information. For example, mining companies and engineering consulting firms often collect their own data on ground temperature, permafrost conditions, snow, wind, and other indicators. However, data and information sharing is inconsistent and little, if any, coordination of collected data and information takes place across northern Canada. Standardized approaches to data management or a central repository or website are unavailable.

Consideration of changing climate: In Canada, awareness and understanding of the implications of a changing climate for infrastructure engineering practices and related institutions is growing, although levels of understanding and response vary (see Box 7). Awareness of the vulnerability of infrastructure to climate change tends to differ by community, largely in proportion to its size and resources. Evidence also suggests that segments of the engineering community have yet to be convinced of the potential seriousness of climate change.

BOX 7: According to the Canadian Standards Association knowledge and awareness levels of climate change adaptation issues differ among infrastructure practitioners

The Canadian Standards Association (CSA) manages about 400 standards directly associated with infrastructure, including oil and gas, pipelines, bridges, concrete, and other construction materials. Recently, the CSA reviewed its delivery of services and products in relation to climate change mitigation and adaptation needs, focusing on the professionals involved with infrastructure planning, design, and engineering. This work explored the current state of knowledge of climate change and the level of awareness by infrastructure engineers as it pertained to their day-to-day work. The study surveyed over 2,000 licensed infrastructure engineers, inquiring about their current level of awareness of technical issues related to climate change, their perspectives on needs and priorities to address climate change issues, and implications for university engineering curricula and professional development programs aimed at infrastructure engineers.

Among other results, the study found a gap between the recognition of the need to adapt routine practices and decisions to account for a changing climate and actual change in behaviour among infrastructure practitioners in this regard. Results underscored the importance of raising awareness and understanding of climate change and the techniques and mechanisms, such as codes and standards, available to address adaptation issues.

Source: Canadian Standards Association (2007).

With respect to CSRIs, formal recognition or integration of climate change impacts as a business risk does not appear to be happening at high levels. For example, the Standards Council of Canada itself has yet to incorporate climate change risk management into its strategic or corporate plans. The Council's corporate plan for 2009–2010 mentions climate change, but only in the context of GHG mitigation.[61] Nor is a changing climate yet included as a factor in the National Model Codes. In other cases, policy documents, strategies, or guidelines state the importance of addressing climate change

[61] See the Standards Council of Canada's *Summary of Corporate Plan 2009-2010 to 2013-2014* at http://www.scc.ca/Asset/iu_files/SCC_CorpPlan_E_Summary.qxd_Layout_1.pdf.

impacts, without providing direction on how to integrate climate change considerations into ongoing practices. For example, territorial mine closure and reclamation guidelines are prepared for Yukon by the Government of Yukon, and for the Northwest Territories by Indian and Northern Affairs Canada. Both sets of guidelines identify climate change as an issue to consider, but do not provide options on approaches for integrating climate change–related trends in the closure design of a project.

Factoring climate change into CSRIs presents a challenge for those involved in providing the scientific evidence base, taking the science and translating it into inputs to inform CSRIs, and using this information to make infrastructure-related decisions. Given the relatively rapid rate of climate change in Canada's North, CSRIs influencing the planning, design, maintenance, and renewal of physical infrastructure clearly should be informed not only by historical and current climate and environmental trends and indicators, but by new sorts of forward-looking information as well. Increasingly meteorologists, geotechnical engineers, and others are contemplating how climate design values might begin to factor in what climate models and climate trends analyses are telling us: that design values based on long-term climate "normals" may no longer hold.[62]

Consultations with northern infrastructure practitioners over the course of the NRTEE's research confirmed both the need and the appetite for more guidance on the development of adaptive and forward-looking climate design values, and for the incorporation of this guidance, or the values themselves, into the relevant CSRIs. At the same time, infrastructure practitioners and other users of climate-related information for infrastructure design will need to recognize the limitations of basing decisions on climate conditions projected by models. Instead of a focus on optimizing design based on some estimation of future climate conditions, better strategies might be to consider adjustments to safety or other factors for elements where the scientific evidence and impacts conclusively support adaptive actions now, and to design infrastructure to be robust under a range of plausible change in climate conditions.

The potential for legal liability has been cited as a barrier to factoring climate change into CSRIs (see Box 8). Infrastructure practitioners may continue to see climate change–related risks as overly ambiguous and therefore difficult if not impossible to manage, exposing them to legal liability. Such parties would likely resist returning to the CSRI committee table and committing to a process that could potentially result in higher standards of due diligence and accountability. Although lessons from forensic studies could facilitate the new generation of "climate-wise" CSRIs, parties may be reluctant to disclose specific infrastructure failures linked to changes in climate conditions. This is because disclosure of such cases does not come with the assurance of indemnification, opening up the potential for other parties to the failed project to sue.

[62] Climate "normals" summarize the observed climate conditions of a particular location over a particular time period. Environment Canada estimates climate normals based on a 30-year horizon, a period considered long enough to even out year-to-year variability (Lemmen et al. 2008).

BOX 8: The prospect of legal liability could promote or deter climate change adaptation of infrastructure

Climate change awareness is increasing insight about the prospect of legal liability related to adaptation. Failure to adapt to known and expected climate change realities may expose businesses, communities, and governments to legal actions by individuals or others for property damage and personal injury. Beyond financial compensations, the implications of this heightened exposure to legal liability include investor risk aversion, decreased confidence in governments, backlogs in infrastructure projects, and erosion of community adaptive capacity.

What we examined

We examined common law rules and statutes in Canada that could drive key decision makers to integrate climate risks in the planning, design, construction, operation, and management of infrastructure. Key decision makers include governments — as owners and operators of infrastructure assets, providers of planning approvals, inspectors in infrastructure projects, and parties responsible for the health, safety, and environmental protection of their constituents. Also included are private owners and operators of infrastructure assets, and infrastructure practitioners who design and build infrastructure, such as architects, engineers, and contractors.

What we found

Legal liability for failure to adapt infrastructure to climate changes derives from the common law principles of *negligence, nuisance, strict liability,* and *occupier's liability* legislation. For example, a government agency may be found negligent if it demonstrated awareness of a particular climate risk, such as the risk that melting permafrost will result in the failure of an above-ground water system and affect water quality, but did not address the risk. As for public nuisance, liability depends on how critical the infrastructure is to the public, whether methods exist to avoid the risk at a reasonable cost, and what the prevailing practices are in comparable situations.

Government exposure to liability is greater in operational decisions than in policy decisions. For example, a government can decide not to create a disaster management plan, and this would be regarded as a policy decision and unlikely to attract common law liability. However, once a government develops a disaster management plan covering climate risks to infrastructure, it owes a duty of care to anyone affected by the negligent implementation of such plan.

For infrastructure practitioners, reliance on existing codes, standards and related instruments (CSRIs) would likely prove an insufficient defence against negligence, particularly if it is known that CSRIs are inadequate under changing environmental conditions. In determining whether to design, build, and operate an infrastructure asset to a greater standard than the relevant CSRIs, decision makers would need to consider factors such as how prescriptive are the CSRIs, whether reliable information exists to support making adjustments, and whether others are already doing so. Infrastructure practitioners also need to be aware of potential changes in professional liability insurance as the impacts of climate change intensify.

BOX 8: The prospect of legal liability could promote or deter climate change adaptation of infrastructure (continued)

What we conclude

Although Canada does not have legislation that specifically addresses obligations or responsibilities on climate change adaptation, it may well be no longer reasonable for infrastructure decision makers to seriously dispute the significance of climate risks, and ignorance or silence about the risks may not guarantee immunity to legal liability. The prospect of legal liability is likely to be a significant driver of climate change adaptation and of how we respond to the challenge.

Adapted from: Torys LLP (2008). Legal Liability as a Driver of and Barrier to Climate Change Adaptation in Infrastructure Projects. *Report commissioned by the National Round Table on the Environment and the Economy.*

"A code is meant to reflect what we should be doing. If you are building anything outside of Yellowknife or Whitehorse, you don't really need to comply with any codes. You can do what you want. We have a good handle up here on what works and what doesn't in the existing code. We need to make these calls ourselves, using largely professional judgment."

– Participant, Meeting of the NRTEE program in Yellowknife (Northwest Territories), January 2008.

5.3 INSURANCE

Extent of coverage: The NRTEE research focused on *property* and *liability* (also known as *casualty*) insurance.[63] Property insurance offers financial protection from damage to physical property, such as buildings and industrial facilities. Policies are typically on a twelve-month cycle of renewal, allowing for the incorporation of new information on risks upon renewal. Liability insurance protects individuals, businesses, or governments against civil suits for damage or harm alleged to have resulted by their actions or products to third parties or to third-party property. Coverage typically extends over many decades, providing less opportunity for ongoing adjustment as new information about risks and potential losses emerges. Property and liability insurance covers "sudden and accidental losses," as opposed to losses from gradual, slow-onset phenomena.

[63] Although our focus is on property and liability insurance, a range of alternative risk transfer mechanisms exist. In traditional insurance markets, the buyer of coverage pays the insurer a premium in exchange for indemnity against a certain category of risk or for a particular loss. In contrast, alternative risk transfer mechanisms rely on capital market instruments such as derivatives, futures, options, swaps, financial reinsurance, finite risk reinsurance, sidecars, or catastrophe bonds. International climate change discussions are currently examining the potential role for alternative risk transfer mechanisms, such as weather-indexed insurance, in protecting people and livelihoods in developing countries from climate risk. See http://www.climate-insurance.org/upload/Climate_Society_Final.pdf.

Insurance is not a property warrantee or a means of financing routine property maintenance. The intention is to return the insured to the financial state that existed immediately prior to the loss, without creating moral hazard or the expectation of economic gain. The focus on coverage of abrupt and inadvertent losses means that standard property and liability insurance policies do not cover losses due to ground subsidence, for example, because structures that sink or settle often do so incrementally. In this case, the expectation is that property owners will regularly assess and rebalance foundations. Property and liability insurance covers most climate-related risks to buildings and other physical infrastructure. This includes winter storms, wildland fire, lightning, and a number of other hazards. The risk of flood damage is covered for businesses but not homes. Damage due to shifting permafrost is generally not covered, but insurers have the option of offering coverage under special circumstances, like a pipeline or other structures designed to withstand this impact.

Insurance coverage is available across Yukon, Northwest Territories and Nunavut, with regional differences in market activity. As measured by total premiums over gross domestic product, market penetration of property and liability insurance in 2006 was 2.7 per cent in Yukon, 1.6 per cent in the Northwest Territories, and 1.1 per cent in Nunavut — at or below the national average of 2.7 per cent.[64] The number of insurance companies active in the larger centres of Whitehorse and Yellowknife is 30 to 40 per cent greater than that found elsewhere in the territories, which is consistent with greater competition in urban centres across the country.

Despite higher insurance costs in Canada's North, the majority of homeowners and businesses purchase property and liability insurance. Average insurance claims in Canada's North are more than double the national average, although the proportion of those making the claims is lower. Higher costs reflect both higher operating costs of insurance companies and their assessment of risk. Most private corporations and homeowners purchase private insurance against most climate risks, whereas the purchase of insurance protection for public infrastructure is less common. Many tenants do not purchase insurance. Property and liability insurance is widely available for mines, pipelines, and other major projects in Canada's North, where the use of sophisticated risk management programs determines the cost-effectiveness of insurance relative to alternatives that include self-insurance and preventative measures.

Clarity of roles and responsibilities: The insurance industry is part of the financial sector, governed by rules pertaining to licensing of insurance companies, independent brokers, and other industry professionals, and on market conduct. The federal Office of the Superintendent of Financial Institutions monitors the financial solvency of most insurance companies, including those licensed to operate in Canada's North. Governments across Canada, including each of the territories, have established programs to supervise market conduct and ensure the financial capacity of insurance companies to pay claims. Insurance legislation and market conduct practices in the territories are similar to those in the provinces. Superintendents of Insurance are responsible for enforcing territorial insurance legislation and regulations, and monitoring consumer complaints, of which there have been few recurring ones.

[64] This section mainly draws from Kovacs et al. (2008) — a study commissioned by the NRTEE.

The Insurance Bureau of Canada — a national association representing the majority of Canada's insurers — identifies emerging issues and opportunities for the industry and advocates for policy changes benefiting the industry and its customers.

In part due to the extent of public ownership of buildings and other types of infrastructure in the region, the governments of all three territories also play a role in insurance provision. The Yukon government self-insures public buildings and other infrastructure, where funds are set aside each year and paid into a pool covering losses due to fire, theft, liability, and other hazards. Both Nunavut and the Northwest Territories use a form of private-public partnership to extend insurance coverage to municipalities. Coverage and mechanisms differ, but both approaches effectively transfer emerging knowledge about risk and loss control to local communities in Canada's North.

Finally, in cases where private insurance coverage is not available to households and businesses, federal, provincial, and territorial governments act as "insurers of last resort." Federal, provincial, and territorial disaster/emergency management legislation in Canada seeks to clarify that public disaster relief will not be paid for damage due to natural disasters if private insurance coverage is in place or if affordable coverage is available. In effect, this establishes governments in Canada as the insurer of last resort, responsible for providing disaster relief when it is otherwise not available. In Canada, including Canada's North, this has been most evident for flood damage to homes.

Flexibility and application: Insurance is in the business of aligning its pricing with the risks assumed, thus the incentives for adjusting their internal practices are powerful. This includes searching for new information on risks and potential outcomes related to those risks, monitoring the effectiveness of past risk reduction measures, and integrating the new information in insurance policies. In the case of damage from wildland fires, for example, insurers are presently seeking scientific evidence to validate practices offering greatest protection, and to quantify resulting changes in risk levels. Quantifying the extent of savings from communities that follow the *FireSmart* program — a strategy of broad applicability in Canada — will take time and research. Governments seeking greater involvement by the insurance industry could support greater research in this area.

Insurance companies are also highly motivated to help households and corporations reduce the actual losses experienced, as this directly increases insurers' profitability. Insurance companies have a tradition of promoting loss control, providing information, and other types of incentives to encourage customers to adjust their behaviour toward risk reduction. Insurance companies operating in Canada's North monitor a number of local risks, and provide incentives or can waive additional charges if the property owners regularly replace their roof and properly maintain a wood burning stove, for example. In the case of underground storage tanks, insurance companies have refused to renew policies unless owners replaced them with above-ground tanks. In the United States, extensive wind damage in Florida and Oklahoma led insurance companies to lower the cost of insurance for property owners with buildings constructed to be resilient to severe wind damage. In drought-prone areas of California

and Australia, insurance practices are changing due to huge losses from wildland fires. In Canada, the 2003 fires in Kelowna (British Columbia) resulted in insurers' involvement in public education. Finally, incentives are evident in coverage provided to large corporate operations, like mines, as part of their overall risk management practices.

In general, the interests of insurance companies in promoting loss control and risk reduction generally aligns with the interests of households and businesses in minimizing losses and suffering, but risk tolerance and political acceptability play a role here. Insurance costs tend to be a very small part of spending by households and businesses, and, in some cases, may not provide a strong enough incentive to alter risky behaviour. Assuming the cost of insurance appropriately reflects the risk of damage, property owners willing to assume greater risk of loss pay more for insurance coverage. Issues may arise when the cost of providing insurance increases due to rising risk levels and related premium hikes result in public outcry. Government decision makers may respond by providing subsidies, thus inadvertently promoting risky behaviour among their constituents.[65]

In Canada, private insurance competes with a number of federal government programs offering disaster relief free of charge to territorial, provincial, and municipal governments. This includes programs run by Indian and Northern Affairs Canada, Infrastructure Canada, and Public Safety Canada. For example, damage to municipal infrastructure caused by a flood, a wildland fire, or other climate-related natural disasters can be partially recovered from federal funding programs like the *Disaster Financial Assistance Arrangements (DFAA)*, where the federal government reimburses a certain amount of losses. The purchase of private insurance reduces the recoveries eligible under the *DFAA* dollar for dollar.

Role of climate-related information: Data and information to estimate risks and expected losses are critical to the business of insurance, including climate-related information. In general, recent historic experience underpins cost estimates and assessments of potential risks facing each potential customer. Prices quoted by insurance companies often vary considerably, largely because of differences in information available to each company.

A changing climate presents some challenges to the industry's pricing practices, especially where gaps in local weather data exist. Insurers have recently begun to develop climate risk models to anticipate high consequence but low probability risks, to support decision making by insurers and their clients. Insurance practitioners have raised concerns about the absence, or poor quality, of local weather data across Canada, particularly in northern Canada. Although better data and information would support efforts by the insurance industry to model its potential future losses, determine the appropriate price to charge, and other insurance terms and conditions, collaborative efforts to share information with other key communities of practitioners, such as the CSRI community, are lacking.

[65] See the April 19, 2009 story by Lehmann in E&E Reporter, *Insurance: State regulators repeatedly clash on national plan for catastrophes.*

Finally, as underwriters of liability insurance for physical infrastructure and infrastructure practitioners, the insurance industry has a vested interest in ensuring that CSRIs communicate to infrastructure practitioners how best to take climate change into account.

Consideration of a changing climate: Insurance leaders and other experts consulted during the course of the NRTEE program indicate that a changing climate is unlikely to result in a material dislocation in property and liability insurance markets for owners of homes and buildings in northern Canada over the next five to ten years. Insurance costs associated with climate-related risks in northern Canada are very small in relation to non-climate related risks like urban fires, theft, and liability. In contrast to other areas in Canada, little empirical evidence exists for Canada's North on trends in extreme weather events. As a result, the insurance industry anticipates that changes in northern climate risks will have little effect on the availability and affordability of insurance in Canada's North in the near future.

However, our research highlighted some new, emerging implications of a changing climate related to insurance in Canada's North:

- Permafrost degradation could contribute to increased exposure to liabilities linked to pollution. In communities with above-ground water and sewer systems, permafrost melting could rupture the systems causing widespread contamination. Owners of the water and sewer systems may be held liable for damage, cleanup costs, and for failure to upgrade existing infrastructure. Energy pipelines built over permafrost terrain could be at risk of pipeline rupture and leakage, with resulting contamination of land and possibly watercourses, and high cleanup costs. Abandoned and orphaned mining operations in Yukon and Northwest Territories with containment structures (e.g., tailing dams) reliant on frozen permafrost might be at risk of breaching and releasing toxic tailings.

- Consistent with international trends in corporate social responsibility, climate change disclosure is becoming more common. Companies that are affected by climate change but do not themselves contribute to it could be vulnerable to class action lawsuits if they do not make changes to avert negative impacts of climate change on their operations.

- Use of new shipping lanes, including an open Northwest Passage, may raise issues of marine liability. For example, what would be the implications of a vessel carrying hazardous materials striking ice and releasing toxic materials? The cleanup of fuel alone in cold and distant waters would be both difficult and costly, while environmental and social impacts could be significant. And with increasing tourism activity, the risk of tour ships foundering may pose great challenges. Aside from potential liabilities, these include greater resources for rescue and evacuation efforts and the possibility of overwhelming the service capacity of small communities.

5.4 DISASTER MANAGEMENT

Extent of coverage: Conventional definitions of "disaster," developed for insurance or other financial compensation needs, emphasize the catastrophic effects of single events. The relative number of people disrupted, the value of assets destroyed and the publicity an event garners in the media, all factor in to what is labelled as a disaster. By this definition, relatively few natural disasters have taken place in Canada's North, and consequently the region's experience with disaster management per se is limited (see Table 15). A widely distributed population with a relatively low density of high value assets reduces the probability of any one large natural event being considered a disaster or emergency in Canada's North.

When it comes to Canada's North and climate change, a new understanding of what constitutes *disaster* is required. Instead of catastrophic losses from weather events or other natural hazards, communities may be concerned with the slow processes of permafrost degradation and melting of sea ice and the potentially disastrous outcomes that may become apparent either suddenly or over time. For example, several communities in the Northwest Territories and Nunavut rely upon country foods to some degree, so that the shifting of or reductions in caribou herds, or the inability to access traditional hunting areas due to sea-ice loss are local disasters that result in both economic and cultural hardship. The disaster is real and apparent but not sudden and catastrophic.

Disaster management includes both structural and non-structural approaches to support risk reduction, involving the "hardening" of structures in the former case and education, better land-use planning, and insurance in the latter. Infrastructure can play a critical role in disaster/emergency management.[66] Given our dependence on its services, and hence vulnerability to failures or reductions in service levels, infrastructure can also be the lynchpin in triggering disasters or emergencies in the first place.

TABLE 15: Incidents of weather-related disasters exposing local vulnerabilities

YEAR	EVENT AND LOCATION	REPORTED FINANCIAL COST
1925	Flood: Dawson, Yukon (YT). Severe flooding up to 1.5 m high caused by ice jamming on the Klondike River and subsequently on the Yukon River.	None given
1963	Flood: Hay River, Northwest Territories (NT). Major flooding caused by ice jamming in Old Town and Indian Village required evacuation of the community of Hay River.	$5,709,191

[66] Examples include redundancy in the energy grid and provision of backup power (prevention / mitigation); transportation routes that enable rapid delivery of emergency supplies (preparedness); ports from which to initiate oil spill clean-ups (response); emergency shelter for housing during recovery (recovery).

TABLE 15: Incidents of weather-related disasters exposing local vulnerabilities (continued)

YEAR	EVENT AND LOCATION	REPORTED FINANCIAL COST
1974	Flood: Hay River, NT. Flooding caused by ice jamming required evacuation of West Channel residents.	None given
1974	Storm: Southeast Yukon. Heavy rainfall over two days caused sections of highway and bridges along the Alaska Highway to be washed away.	$4,884,345
1979	Flood: Dawson, YT. Severe flooding up to 2 m high caused by ice jamming on the Yukon River, affecting 80% of Dawson's buildings.	$4,303,928
1982	Flood: Hay River, NT.	$969,327
1982	Flood: Aklavik, NT. Spring runoff and ice jams cause flooding and extensive damage.	$239,296
1985	Flood: Hay River, NT. Record high flows of the Hay River and ice jams caused serious flooding, requiring the evacuation of West Channel residents. One injury was reported.	None given
1988	Flood: Norman Wells, NT. Two severe flood events occurred in the Laird and Mackenzie River Basins.	$7,800,000
1989	Flood: Liard River, NT. Flooding, caused by severe ice jams near Three Mile Island, damaged the community of Fort Liard, subsequently reaching and causing damages in Fort Simpson and Hay River. Personal, municipal and territorial property was damaged: over 50 homes were affected and 125 people were evacuated.	$1,094,778
1990	Forest fires: Old Crow, YT. Forest fires resulted in community evacuation.	$7,963,221
1991	Flood: Old Crow, YT. Ice jams caused the Porcupine River to overflow and flood the community, damaging over half its buildings including 32–40 homes, the church, the school, the nursing station, and the airport. Supplies, electrical systems and generators were also damaged.	$613,294
1992	Flood: Hay River, NT. Approximately 100 residents were evacuated due to extensive flooding caused by ice jamming at the mouth of the Hay River.	None given
1992	Flood: Yukon rivers (Upper Liard River basin, Teslin River basin, South Canol Area, Upper Lakes of the Yukon River basin, Stewart River and Bennett Lake). Above-average snowpack, rain, and warm temperatures caused record floods. Impacts included road washouts, damage to private property and reserves, as well as to water and sewer facilities. Upper Liard, Carmacks, Carcross and Teslin were the communities most affected.	$252,643
1995	Forest fire: Sahtu region of NT. A forest fire, started by lightening, spread from Fort Norman to Norman Wells, Yellowknife, and Deline, damaging territorial, municipal, and private property and resulting in evacuations.	$3,475,071

TABLE 15: Incidents of weather-related disasters exposing local vulnerabilities (continued)

YEAR	EVENT AND LOCATION	REPORTED FINANCIAL COST
1998	Forest fire: Tibbet Lake, NT. A forest fire reaching 140,000 hectares in size forced evacuations out the Ingraham Trail area, closure of Ingraham Trail to all traffic, and destroyed private property.	$12,044,118
1999	Forest fire: Burwash Landing, YT. A forest fire caused the evacuation of 69 residents and tourists, destroyed six houses and damaged other buildings, and shut down the Alaska highway between Beaver Creek and Haines Junction.	$922,323
2003	Forest fire: Norman Wells, NT. A forest fire, started by lightening, caused Norman Wells to declare a state of emergency and evacuate about 100 residents by plane and boat.	None given
2005	Flood: Fort Good Hope, NT. Rapid rise of Jackfish Creek and Rabbitskin River led to the evacuation of 10 families.	None given

Source: Public Safety Canada, Canadian Disaster Database version 4.4
Note that the listing only reflects disasters captured in the national database.

Clarity of roles and responsibilities: The mandate and responsibility framework for disaster management in Canada is stronger in clarifying accountabilities and processes in response and recovery than in other phases of disaster management. However, further rollout of the 2008 Canada's *National Disaster Mitigation Strategy* and dedicated federal investments in disaster mitigation infrastructure under *Building Canada* might change this.[67] In addition to providing compensation to provinces and territories for disaster response and recovery through *Disaster Financial Assistance Arrangements*, the federal government has significant disaster management responsibilities in its areas of jurisdiction. It often enters into partnership arrangements with other governments or organizations that are better placed to respond. Territorial governments are the most important focal points of accountability for emergency management in Canada's North, as codified in the emergency management legislation in place in each. In addition, territorial governments have established a number of regulatory bodies, some with responsibilities that relate to emergency management.

Territorial legislation delegates responsibility for emergency management to municipalities, with varying support for municipal emergency planning. Nunavut's updated emergency management legislation mandates its government organizations, municipal councils, and certain enterprises to identify risks as

[67] See Appendix 7.4 for financial commitments pertaining to *Building Canada*.

a part of their emergency management programs. In the Northwest Territories, the revised emergency planning template released in 2008 encourages hazard identification and the development of community risk assessments. The Yukon government requires all communities to develop sustainability strategies, which can include identification and assessment of risks.

The ongoing negotiation and implementation of land claim and Aboriginal self-government agreements across the territories is another important dimension of the responsibility and accountability frameworks for emergency management in Canada's North. As stipulated in land claim agreements, Aboriginal governments are owners of significant proportions of land, and co-managers in land and resource management, environmental review and land-use planning, allocating responsibility for adequate emergency management in these areas.

A number of private sector entities in Canada's North have important roles to play in emergency management. Industries, such as communications services, have a role in the protection of critical infrastructure and assurance of critical services. In addition to these industries, resource extraction industries are the single largest players with both assets and liabilities. Emergency management responsibilities arise in part from their business continuity planning and because of regulatory requirements, though the focus is on protecting their own assets and limiting liabilities.

As part of the NRTEE's program, a study team undertook assessments of critical infrastructure with three communities in Canada's North (Whitehorse, Yukon; Inuvik, Northwest Territories; and Gjoa Haven, Nunavut), which revealed potential weaknesses in current responsibility and accountability frameworks. There appear to be weaknesses in the management of risks of a systemic nature, resulting, for example, from interdependencies among infrastructure types and with the potential for cascading effects. The availability of redundancies in critical infrastructure, such as communications and power transmission networks, is a strategy to manage climate risks. From an emergency management perspective, it is unclear who would be responsible for determining appropriate levels of redundancy, and how this determination would take place. For example, what role would a private company like Northwestel — the major provider of communications services in the territories — play, as opposed to or in relation to government in assessing redundancy requirements? To whom would the cost of added redundancy accrue and how would this be determined? Would adding redundancies be considered a public good, requiring government investment and inter-jurisdictional collaboration?

Flexibility and application: In past decades, disaster management policy at the national level emphasized preparedness, response, and recovery over prevention and mitigation. Global recognition of a rising trend in losses from weather-related disasters has started to motivate a shift in emphasis, a recognition captured in the preamble to Canada's *National Disaster Mitigation Strategy* (NDMS): "Nationally

and internationally, the frequency of natural disasters is increasing. The cumulative effect of these disasters produces a significant personal, material and economic strain on individuals, communities and the fiscal capacity of all levels of governments."[68] Where once policy makers might have perceived investments in prevention and disaster mitigation as an opportunity cost, given the unknown payoffs in the short term, we are seeing an emphasis on the return on investment of preventative measures. Canada's NDMS underscores this by referencing cost-benefit ratios of flood prevention measures in Australia, the United States, and the United Kingdom.

Justifiable from a number of perspectives, such as humanitarian, economic, social, environmental, and cultural, risk-based approaches to disaster management prioritize prevention and mitigation. In Canada, the absence of a national strategy on disaster mitigation has been a barrier to the advancement of this approach in the past. Given its stated focus on natural disasters, the NDMS, if adequately funded, could be an important step in proactively addressing climate change impacts across Canada. The strategy establishes the shared inter-jurisdictional goal "to protect lives and maintain resilient, sustainable communities by fostering disaster risk reduction as a way of life," and it identifies climate change adaptation as an area for future cooperation. The NDMS also establishes a federal-provincial-territorial centre of mitigation excellence to facilitate implementation of initiatives of shared interest.

Funding is often an incentive to change the status quo. For example, the NDMS includes financial incentives to advance its goals nationally, with the *Building Canada* fund as a vehicle to finance major disaster mitigation projects. This has a couple of implications for Canada's North. The funding formula is on a per capita basis, meaning that the absolute allocation for low-density regions is small in comparison to high-density regions. Disaster mitigation is one among several types of eligible infrastructure; these types of projects are likely to be less attractive than hockey arenas and schools, for example. Ideally, though, governments would support the integration of climate change considerations for any type of infrastructure category. Evidence also suggests that the need to comply with detailed application procedures, maintain records over long periods of time, and comprehensive audit trails are a disincentive to northerners due to capacity constraints.

At a local level in Canada's North, constraints in human and financial capacity may present barriers to emphasizing proactive risk reduction in emergency management (see Box 9). The degree to which emergency prevention/mitigation are included in local plans varies across the territories and among communities. In general, local governments have little to no impetus to prioritize emergency/disaster prevention and mitigation, and typically lack the resources needed to implement risk reduction strategies. As an example, about seven communities of 33 in the Northwest Territories have been able to put emergency management plans in place, despite the fact that an emergency planning template has been available for over seven years. In small remote communities, capacity building and training to enable the development and review of effective emergency management plans and ensure adequate preparedness is critical.

[68] http://www.publicsafety.gc.ca/prg/em/ndms/strategy-eng.aspx Accessed April 30, 2009.

A final type of incentive or disincentive relates to liability. Government liability for addressing risks arises only once a risk has been identified and noted in policy as a risk to be managed through the operations of government. In other words, while governments will not generally be held liable for a decision to prioritize the management of one source of risk over another, once a certain risk has been identified and a commitment made to manage it, a failure to do so can have repercussions. This issue can be especially acute at the local level of government, where a significant portion of operationally-based choices are made, though in Canada's North, territorial governments also play many significant roles in the delivery of local services. For example, the Government of Yukon provides project management services pertaining to infrastructure for unincorporated municipalities across the territory.[69]

BOX 9: Northern stakeholders have a range of views on capacity issues that could hinder climate change adaptation

During the course of the program on Climate Change Adaptation Policy, the NRTEE commissioned research on the role of government in adaptation, specifically in Canada's North. As part of this work, the research team conducted telephone interviews with northern stakeholders in April 2007. The interview format consisted of open-ended questions covering different aspects of climate change adaptation. The following presents aggregate results of answers to the question, "What are the most pressing capacity issues that you are or will be facing in relation to climate change adaptation?". Results are not statistically representative of northern populations. They provide an indication of northerners' perceptions on the issue at the time of the interviews.

"What are the most pressing capacity issues that you are or will be facing in relation to climate change adaptation?"

- lack of technical capacity is a huge issue
- we'll need more money
- traditional knowledge is being lost
- traditional knowledge isn't taken very seriously
- we'll need to invest in education to generate local expertise
- if we lose traditional knowledge and don't have formal education we will not fit anywhere and won't be able to adapt

During the course of the NRTEE's research, northern stakeholders confirmed the resistance of some local governments to formally identify or commit to management of certain risks. Discussions led to the identification of two types of related barriers. Some local governments are likely hesitant to confirm a potential risk to community assets, such as intensifying flood risks, because of the financial implications in managing that risk in the context of already stretched budgets. Fear of exposure to legal liability is also a barrier to formally recognizing a risk and taking action. In this case, local governments may not be confident in their capacity to successfully manage the identified risk. These findings suggest a likely need to realign incentives to encourage the management of climate risks by govern-

[69] http://www.community.gov.yk.ca/landdevelopment/index.html accessed April 30, 2009.

ments involved in operational decisions. Options could include adjusting statutes to mandate adaptive action and enabling private sector involvement in the provision of private services, where appropriate.

Role of climate-related information: At the community level, a first step in good practice in emergency management is to identify hazards and assess risks, which can form the basis for a community plan. A plan such as this can remain relevant for years, but the flexibility to integrate new information is key. In Canada's North and elsewhere in Canada, an emergency management plan would likely include climate-related hazards, the threats that they pose, and an assessment of the risk of each threat manifesting itself as a specific emergency or disaster.[70] Thus, emergency management practitioners use a range of climate-related information products, which can include observations of environmental change, projections of changes in climate conditions, and information on climate change impacts. Information on the infrastructure stock and interdependencies among infrastructure systems is also critically important.

The NRTEE's research revealed a number of concerns related to adequacy and accessibility of reliable climate-related data and information for emergency management. For example, stakeholders perceive factors such as the declining government commitment to observation and monitoring systems, the lack of information on permafrost change, and the limitations of climate change projections in terms of spatial and temporal resolution will have repercussions on emergency management planning. A challenge in this regard is the problematic nature of monitoring for extremes when the data collection system is geographically diffuse, poorly maintained, and limited in the weather parameters it is able to reliably assess. The sorts of extremes that can result in catastrophic failures of infrastructure systems sometimes occur within periods for which no monitoring is currently available. Similarly, current climate models have yet to be able to project extremes at the spatial scale that emergency and critical infrastructure managers would find most useful. Many also seemed to value the ability to generate the information locally and make it regionally accessible, likely requiring capacity building and training.

In Canada and internationally, discussions are starting to take place regarding the need for climate-related decision support and the kinds of information that underlie it. This is partly in recognition of the barriers encountered or perceived by decision makers in climate-sensitive sectors, such as disaster management, land-use use planning, and natural resource management, in accessing relevant information for climate change adaptation and integrating this information in plans and decisions. A lack of site-specific information is a common barrier cited. Given the uncertainties in projecting future climate conditions, the level of detail that information users demand is unlikely to be achievable. Practitioners will need to adjust their analytical and decision-making frameworks to accommodate uncertainty.

[70] Increasingly, provincial and territorial emergency management legislations require the identification of hazards and subsequent risks. In response to this trend, the federal government (Environment Canada) is developing climate hazards risk information for use by other levels of government. The Canadian Atmospheric Hazards Network website (www.hazards.ca) include data on climate and weather hazards, past events, their trends and will include, within the next year or two, guidance on potential hazards under future climate change.

Consideration of a changing climate: In the past few years, international recognition of the synergies and complementarities between climate change adaptation and (natural) disaster risk reduction has increased markedly, especially in the context of support for developing country efforts. The disaster risk reduction community and climate change adaptation community are starting to collaborate, with sharing of lessons learned as a first step.

In Canada's North (and likely across Canada), limited interaction between the disaster/emergency management and the climate change adaptation communities presents an impediment to the integration of climate change considerations in disaster/emergency management. Sound emergency/disaster management holds the potential to provide some of the measures and practices that governments need to proactively manage climate risks, that is, to help "mainstream" climate change adaptation. Although it is widely recognized that Canada's North is particularly vulnerable to the impacts of climate change, little systematic analysis has taken place to assess the potential for emergencies or other disasters under a changing climate.

Northern infrastructure practitioners and governments recognize the need to conduct more comprehensive risk assessments in light of climate change, as revealed in NRTEE consultations. Although participants were able to articulate expected climate change–related risks to the performance of critical infrastructure serving their communities, some reflected a lack of awareness regarding the types of climate change–related information, tools for decision support, and approaches to assess critical infrastructure-related risks. Levels of awareness in this regard differed by community, largely varying in direct relation with the size and resources of the community.

This lack of awareness among northern practitioners and government representatives may well reflect a broader awareness challenge of how to integrate climate trends and climate change information with the assessment and management of infrastructure-related risks. The insurance industry could be a very strong partner due to its expertise in risk management and, increasingly, the modelling of climate-related risks. It also shares with disaster/emergency management practitioners the aim of reducing losses in life and property damages. However, little if any evidence exists in Yukon, the Northwest Territories, or Nunavut (or in most provinces, for that matter) of meaningful engagement between disaster/emergency management officials and the insurance industry. A formalized arrangement could help governments monitor changes in coverage by the private insurance industry, including the portion of property owners who purchase coverage, new coverages introduced by the industry, or coverages where insurers anticipate changes in pricing or availability. If a business case exists in this collaboration, the motivation of the private insurance industry is likely to be high.

5.5 OBSERVATIONS AND IMPLICATIONS

The NRTEE's research, analysis, and stakeholder consultations lead us to identify several core challenges to the successful management of climate risks to northern infrastructure that need to be addressed:

- Limited feedback among science and data providers, infrastructure practitioners, and policy makers at several levels of decision making — a barrier to problem identification and application of solutions.
- Inadequate attention of national institutions, such as national codes and standards, to northern interests or conditions.
- Gaps in the availability and accessibility of data and information that form the basis for infrastructure risk management and loss prevention, such as current and projected impacts of climate change, and data on the stock of and demand projections for infrastructure.
- Uneven capacity across and within jurisdictions to assess climate risks to infrastructure, and to develop, deploy, and enforce standards and risk reduction measures.

Discussions below explore our observations for each of the three risk-based mechanisms. We also explore linkages across these mechanisms that could be better exploited.

CSRIs

Canada's North is disadvantaged by national CSRI processes and products. Economic assumptions and interests driving the creation of new and the review of existing CSRIs mainly pertain to southern conditions and players. National CSRIs do not adequately account for their implications on building materials in northern climates, environmental conditions, and socio-economic realities (affecting, for example, maintenance and repair schedules). Many CSRIs do not adequately clarify how approaches, methods, and processes may require adjustment for application in Canada's North. This leads to gaps in coverage of northern technologies and interests. Financial and human resource constraints are barriers to the participation of northern stakeholders in national CSRI processes.

Gaps in data and information to feed into CSRIs for Canada's North already exist. Because of the relatively limited economic development that has taken place in Canada's North to date and low population densities, the demand for more or better data and information was lacking. Climate change and an increasing geopolitical focus on the North are illuminating this weakness. Awareness and understanding of the importance of climate change adaptation among the Canadian engineering community is increasing; yet in terms of actual engineering design changes, work is still at an early stage. Information providers face the challenge of bringing CSRIs up to date to reflect current climate conditions, and develop processes that allow for more rapid CSRI evolution to account for future climate realities. At the same time, application of best practices and professional judgment may be inconsistent, and gaps in codification of these practices inhibit the transfer of lessons learned.

Reliance on less formalized CSRIs and experience grants northern infrastructure practitioners the flexibility to tailor their design, construction, and maintenance decisions to northern circumstances. Meaningfully tapping into traditional knowledge and northern communities, as sources of historical information and as actors in monitoring efforts, needs to be undertaken.

CSRIs have yet to play a role in driving the agenda on the management of climate risks, but this could change for a few reasons. To the extent that CSRIs are shown to be inadequate in a changing climate, their role in indemnifying infrastructure professionals from legal liability is diminished. Awareness of this issue could drive efforts to ensure CSRIs keep pace with changing risk profiles as the result of a changing climate. The insurance industry has a clear interest in this regard, potentially carving out a role in sharing risk management practices and decision-support tools in support of the integration of climate risks into routine practices.

Finally, Canada is not alone in its attempts to clarify the implications of a changing climate for infrastructure management, and CSRIs specifically. For example, the white paper on adaptation by the European Commission includes "exploring the feasibility of incorporating climate impacts in construction standards, such as Eurocodes" as one of many priority actions.[71] The opportunity exists for Canadian CSRI development bodies to take a leadership role in advancing adaptation solutions internationally.

Insurance

The insurance industry has a clear, long-term role to play in supporting climate risk management in Canada's North. Insurance is a generally well-understood and effective means to both assess potential risk and assign appropriate costs to it, thereby creating incentives to adjust behaviour and practices. Insurers have data and information of significant relevance to the evaluation of medium- to long-term infrastructure risks related to a changing climate, including the costs such risks may represent from a "public good" as well as private perspective. However, property insurance contracts are generally one year in length, and may therefore fail to convey the long-term signal needed to catalyze broader societal adjustments, such as a coordinated retreat from coastlines.

A general tendency exists to rely on the insurance industry as an efficient communicator of risk and, therefore, as a driver of "rational" or risk-based, decision making. However, the quality of data and information available to insurers to price premiums commensurate to risks heavily influences its usefulness as a risk reduction mechanism. Because of the remote and sparsely populated character of Canada's North, climate-related and physical risks to infrastructure and related services can be more difficult and costly to measure. This reality, coupled with the small size of the northern market relative to total underwriting in Canada, may prompt insurers to provide coverage that does not reflect the extent and magnitude of actual northern risks, including those related to climate change. Detailed exploration of how a changing climate and adjustments to insurance practices might influence the affordability, accessibility, and quality of coverage for households, businesses, and regional and local governments is key.

[71] European Commission (2009).

The potential for liability issues emphasizes the importance of engagement across communities of practice and private and public sectors. For example, research conducted for the NRTEE on the question of liability indicates most professional liability policies of today are likely to cover infrastructure-related risks linked to permafrost degradation, but this has yet to be tested in a court of law. From the perspective of property insurance, permafrost risk is currently uninsurable.

In Canada, neither the public nor private sector have yet to seriously consider the prospect of alternative risk insurance models such as public-private partnerships, or even the desirability of mandatory insurance coverage, to ensure continued insurance capacity in a changing climate. Governments' oversight of the insurance industry is limited primarily to considerations of a solvency nature. At the same time, the industry has not been a vocal proponent of improvements in environmental monitoring, analysis, or information sharing in Canada's North or elsewhere in Canada. Similarly, the industry has to date remained largely focused on its own models, rather than engaging with communities of practitioners whose risk-based decision making with respect to climate change will have a major bearing on the attainment both of insurance-sector and public-welfare objectives.

Disaster Management

In the context of social, economic, and climate changes taking place and projected for Canada's North, the benefits of strengthening approaches to prevention and disaster mitigation in the region are clear. The rate of warming and change in other climate parameters, the exposure of physical infrastructure to such changes, the limited amount of redundancy in many northern infrastructure systems, and the generally remote nature of many northern communities, are among the reasons supporting proactive disaster risk reduction.

Enabling processes for disaster prevention and disaster mitigation extend to the national level and can help the integration of climate risks into disaster management. Ensuring regional and local capacity to carry this out is critical. In Canada's North, where most communities take hours if not days to reach, disaster management planning must assume a greater degree of autonomy than would otherwise be the case in connected communities. However, many small and remote northern communities lack the necessary financial and human resources and access to relevant information for conducting the sort of hazard assessments and implementation of risk-reduction strategies recommended by disaster management practitioners. Levels of awareness of the types of information and approaches available or required to integrate climate considerations into disaster management also differ across communities.

Limited levels of redundancies in infrastructure systems present real constraints to effective disaster management, which climate change could worsen. A lack of redundancy in transportation, communication, and energy infrastructure in northern urban centres makes them less resilient to the potential effects of natural hazards than their southern counterparts. For example, a prolonged closure of the main land-based transportation artery into and out of either Yellowknife or Whitehorse, coupled with the simultaneous closure of the local airports, could be problematic for access to basic goods and

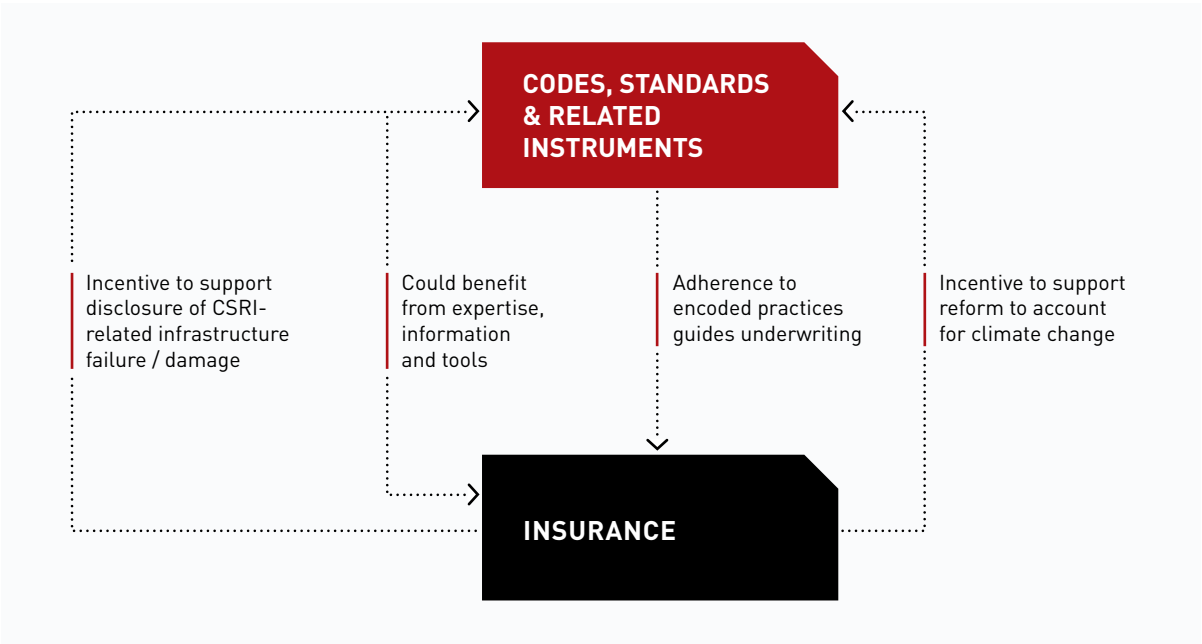
services. So too could the closure of a distant transportation hub upon which a northern community might be largely dependent for staging the delivery of goods, such as Vancouver for Whitehorse. In the context of a changing climate and related changes in weather extremes, clarifying adequate levels, roles, and responsibilities of infrastructure redundancy for Canada's North will likely become increasingly important.

Linkages among Risk-based Mechanisms

Each of these mechanisms has its own practitioner community and enabling framework. However, effective use of the three mechanisms can mutually reinforce adaptation and help foster a culture of climate risk reduction. A few examples highlight the inter-relationships.

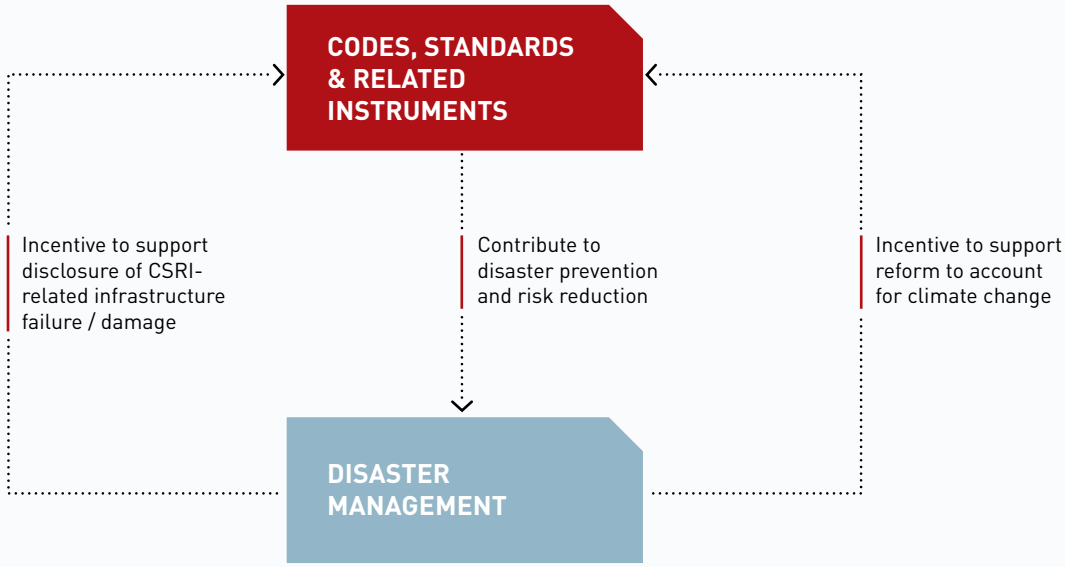
Compliance with CSRIs is the basis for liability insurance (Figure 6). Therefore, insurers have an interest in supporting efforts to adjust CSRIs to account for a changing climate as it has the potential to improve insurers' pricing and profiling of risk. At the same time, insurers are developing analytical tools to improve their assessment of risk in the context of changing patterns of weather extremes. Insurers could share these tools and information with CSRI communities so they can integrate climate risks into the development of codes and standards. Insurers, in turn, would benefit from tracking infrastructure failure and damage connected to ineffective deployment or enforcement of CSRIs.

FIGURE 6: Linkages between CSRIs and insurance



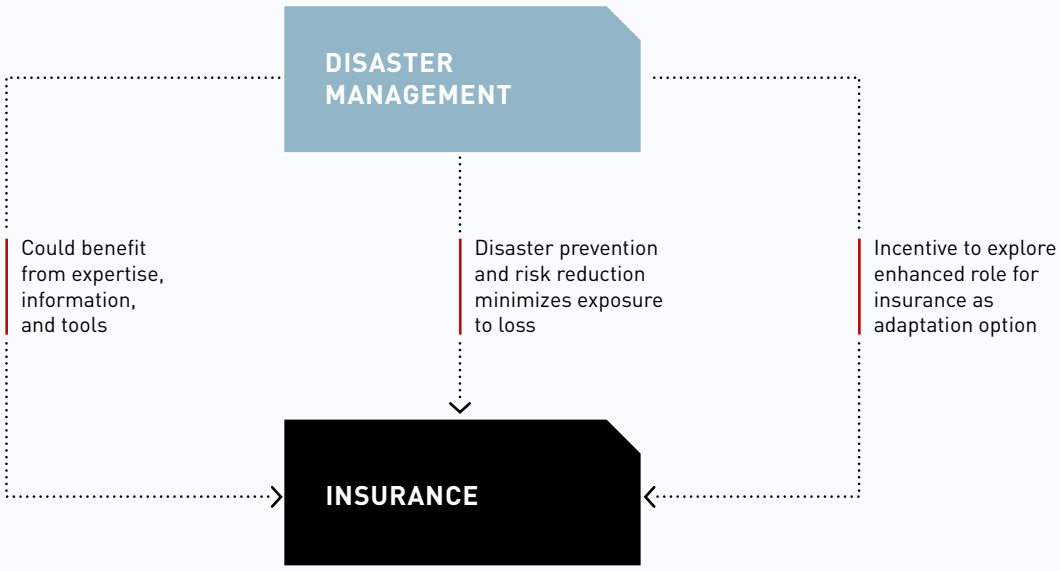
Effective deployment and enforcement of CSRIs reduces the risk of infrastructure failure and related harm to people and property, in the event of a disaster or emergency (Figure 7). Like insurers, disaster management practitioners have an incentive to support adjustments in CSRIs to better reflect changing climate risk profiles. Information, such as infrastructure failures and damage due to weaknesses in CSRIs, is helpful for developing and testing community emergency management plans, which emphasizes the importance of greater disclosure among CSRI practitioners.

FIGURE 7: Linkages between CSRIs and disaster management



Disaster management plans with an emphasis on prevention can minimize infrastructure exposure to economic and social losses, requiring fewer insurance payouts and thus would likely be of great interest to insurers (Figure 8). An additional motive for collaboration between disaster management and insurance communities is in the use of insurance as a mechanism to promote adaptive behaviour, such as the example of *FireSmart* brought up earlier. Finally, insurers' expertise in risk assessment, including climate risk assessment and use of new approaches to account for changing climatic conditions, could help in the development of disaster/emergency management plans.

FIGURE 8: Linkages between disaster management and insurance



6.0

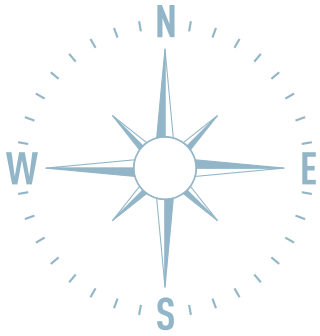
CONCLUSIONS AND RECOMMENDATIONS

IN THIS CHAPTER

68° 37’ 30” N
95° 52’ 40” W

LOCATION: GJOA HAVEN, NUNAVUT

Changes in freeze/thaw cycles are another climate change impact likely to affect different types of infrastructure. In Gjoa Haven (Nunavut), alternating cycles of warm and cold temperatures coupled with rain events contributed to a dike failure in 2005.



6.0 CONCLUSIONS AND RECOMMENDATIONS

Canada's North is on the frontline of climate change. The speed and magnitude of change in Canada's North and its uneven and limited response capacity to address this emerging risk highlight a clear gap in our allocation of resources and attention to this region of our country. This is clearly apparent with infrastructure vulnerability. Engineering in cold climates, a lack of redundancies in infrastructure systems, limited financial and human resources to assess risks, apply and enforce standards, are some of the characteristics that contribute to this vulnerability. A changing climate now adds to the complexity of managing risks to northern infrastructure — especially when combined with the social and economic transformations already occurring in the region. Driven by economic development and demographics and exacerbated by climate change, Canada's North is likely to experience unprecedented pressure on infrastructure systems.

Infrastructure is both a means for adaptation and at risk from the impacts of climate change, nowhere more so than in the North. As a long-lived asset, the risk profile of many infrastructure systems will intensify over time as climate change accelerates. Yet, their resilience will be essential for sustainable regional development and for safeguarding national and northern security interests for all Canadians. Therefore, it is in Canada's best interest to ensure that sufficient regional capacity exists to successfully manage climate risks to infrastructure, and that national processes and mechanisms work for the North.

Canada's capacity to adapt to a changing climate is enormous compared to many other regions of the world. If we are going to advance adaptation, we need to harness this capacity. But, barriers exist to mainstreaming adaptation within existing public- and private-sector policies and processes. Our research and consultations revealed four main barriers we need to overcome:

First, capacity constraints. *Capacity* refers to knowledge, technical skills, organizational and planning capabilities, decision rules, and finances that enable stakeholder participation in managing the risks of climate change. If capacity to solve problems and manage risks is already insufficient, adding the climate-change layer is likely to further strain budgets and human resource capacities. In Canada's North, gaps in human resource and organizational capacity add up to serious constraints on communities' abilities to adapt to a changing climate. Clarifying capacity needs for managing climate risk begins with the alignment of accountability and responsibility. Among others, capacity needs relate to:

- participation and prioritization
- application of knowledge, including traditional knowledge, and decision-support tools to specific situations
- implementation of strategies to manage climate risks, including capacity to monitor, learn from strategy implementation, and adjust strategies, as appropriate
- financial and human resources to support all of the above

Second, gaps in data and information. *Data and information* refer to inputs into strategic, operational and technical decisions. It includes information related to climate, other environmental factors, both data and projections. It also includes data and projections of a social nature, such as social and economic trends and behaviours that increase vulnerability. Infrastructure practitioners involved in the NRTEE's research and consultations all emphasized the need for appropriate and adequate data and information, and tools to support decision making, as basic ingredients for effective action on adaptation.

Canada's recent scientific assessment of climate change impacts and adaptation concludes that enough information exists to move forward on adaptation as a policy goal. However, important gaps remain when it comes to site-specific information for operational decisions. In Canada, several trends have contributed to weaknesses in climate-relevant data and information systems, including the following:

- *A declining commitment to long-term environmental monitoring, and a corresponding decline in public service capacity to analyze collected data*. Meteorological, ecosystem, and other types of monitoring efforts have decreased over the past 15 years. As noted in the 2006 report on climate change by the Commissioner for the Environment and Sustainable Development, federal budget reductions have constrained monitoring networks, as well as the archiving and analysis of data in support of decisions such as infrastructure design. Recent initiatives and commitments in Canada and with

collaborators — such as activities of the International Polar Year to retool several observation networks, the federal commitment to establishing the Canadian Arctic Research Institute, and the Sustainable Arctic Observatory Network — have provided a foundation on which to rebuild what has been lost.

- *Fragmentation in data collection and information dissemination efforts by governments.* Regional collection of climate-related data does take place, such as that through territorial water boards. However, their ability to provide information in useful formats for decision makers and practitioners is limited. Some economic sectors collect their own data, but this privately collected data too often remains inaccessible to other decision makers, including those in the public sector. Efforts to disseminate data and information and make it accessible, through central repositories or portals, for example, could greatly increase its use.

It is important to remember that data and information in support of adaptation is not only about climate. It also includes information on social and economic characteristics and trends that shape vulnerability to climate change, such as trends in land-use, the state of infrastructure assets, the combined effects of changes in climate and other trends such as aging population.

Third, lack of guidance. *Guidance* refers to agreed-upon approaches and methods to account for climate risks in routine planning and decisions. Guidance can apply to decisions at the policy, program, or operational level. Our research found that decision makers and practitioners need guidelines and methodologies to incorporate climate change–related information, such as trends and forward-looking projections, into their planning and decisions. Engineers, for example, continue to seek from government new or updated climate design values and approaches to apply to infrastructure-related codes and standards; but progress has been slow. This has a cascade effect. Poorly adapted CSRIs equate to a lack of basis for underwriting by insurers, which can result in artificially high insurance premiums, as insurers add a "safety cap" to account for unmeasured risk. Determining appropriate levels of monitoring, data generation and analysis, and development of decision-support tools is a collaborative effort between suppliers and users of these resources. Federal programs such as the *Regional Adaptation Collaboratives* and *Tools for Adaptation* delivered by Natural Resources Canada, promote this type of collaborative approach as an efficient and effective way to turn knowledge into action.

Fourth, issues of coordination. *Coordination* refers to the mobilization of decision makers and stakeholders toward shared adaptation goals. A major observation of the NRTEE's research is that decision makers face disincentives to incorporate climate risks into plans, strategies, and practices. Decision makers across society lack the high-level signal that adaptation is an issue to address today and that an effective approach to move forward is to internalize this reality alongside other objectives. Efforts to build capacity to adapt and to manage climate risks are taking place but they are occurring in response to specific pressures and events, according to existing interests and capabilities. The absence of an overall national framework or commitment results in piecemeal responses that are uncoordinated and run the risk of being ineffective and expensive.

6.1 RECOMMENDATIONS

The NRTEE makes the following recommendations to promote the resilience of northern infrastructure and its ability to adapt to a changing climate. Our recommendations have two objectives: first, make existing institutions work better now by mainstreaming adaptation into government policies, processes, and mechanisms and ensuring northern views are "at the table", and second, build northern climate change adaptation capacity in science and at the community level, so the region is more resilient, self-reliant, and less vulnerable in meeting the challenges of climate change adaptation in the years ahead.

MAINSTREAMING ADAPTATION INTO POLICY

1. Integrate climate risks into existing government policies, processes, and mechanisms.

We can tackle climate change adaptation effectively now by simply utilizing existing policies, processes, and mechanisms more effectively. We don't need to wait to invent new ones. What's needed is to take existing knowledge and mainstream adaptation perspectives into what we already do. This means making future infrastructure decisions on a climate-wise basis, integrating longer-term climate factors into planning, funding, building, and management decisions now. Specifically, the NRTEE recommends that:

- The Government of Canada use its infrastructure programming and related federal-provincial-territorial frameworks to leverage the integration of climate risks in new construction and rehabilitation of infrastructure, ensuring that the systems are in place to monitor and report on infrastructure performance.
- The Government of Canada, through the Standards Council of Canada, lead efforts to ensure the effectiveness of codes and standards for infrastructure design, planning, and management to address climate risks, and that this be regularly assessed in light of new climate information.
- Governments and the insurance industry collaborate to examine the role of private insurance in managing climate risks to infrastructure, potential changes in access to coverage of insurance as new climate risk factors emerge, and the need for mandatory disclosure of financial risks that climate change poses to the industry.
- Governments at all levels undertake a collaborative review of current disaster/emergency management frameworks as mechanisms to enable adaptation to climate change on a preventative basis.

2. Ensure northern interests are represented and implicated in the development of climate change adaptation solutions.

National processes and mechanisms do not adequately account for, or utilize northern perspectives in designing and updating important tools for climate change adaptation. This is essential if this region is going to prepare itself for what's ahead. Meaningful input from northern practitioners, experts, and communities in infrastructure planning, designing, and building needs to be organized and institutionalized on a regular basis. Specifically, the NRTEE recommends that:

- The Government of Canada promote dialogue and engagement between risk management practitioners (codes and standards, and related instruments; insurance; disaster/emergency management) operating in Canada's North and the climate change adaptation community.
- The Government of Canada consider expanding the relevant national model codes, such as the National Building Code of Canada, to provide direction to northern infrastructure practitioners on the integration of climate risks.
- Governments collaborate with northern infrastructure practitioners to develop design and engineering guidelines, or peer-reviewed best practices, specifically for Canada's North for each major category of infrastructure.
- Governments highlight expertise and experience in addressing climate risks to northern infrastructure at the circumpolar level, to share knowledge, learn from others, and enforce Canadian leadership as part of *Canada's Northern Strategy*.

BUILDING NORTHERN ADAPTATION CAPACITY

3. Strengthen the science capacity and information use in the North to support long-term adaptation efforts.

Science is at the heart of climate change knowledge and trends. We need to know more about the nature and extent of climate change in Canada's North and how it will affect infrastructure and communities. Data and information of this type can have wider utility and applications beyond government, supporting private infrastructure development and communities' capacities to adapt quickly and effectively. Specifically, the NRTEE recommends that:

- The Government of Canada invest in expanding the weather and permafrost data stations in Canada's North that it uses to collect this critical information in support of infrastructure adaptation decision-making needs.

- The Government of Canada ensure the continued investment in climate science and modelling, and in climate change impacts and adaptation research, taking advantage of partnerships with Arctic research institutes and innovative delivery mechanisms.
- The Government of Canada dedicate resources to reliably update and disseminate regionally relevant climate data and information, climate change projections, and climate design values to support infrastructure decisions.
- Governments, the private sector, and research organizations work together to make existing adaptation-relevant scientific and technical data and information more accessible and usable to northern infrastructure practitioners, owners, and operators.

4. Build community capacity to address climate risks to northern infrastructure and take advantage of opportunities.

Communities in Canada's North need stronger adaptive capacity to deal with climate change. The vulnerability of northern infrastructure and related services is plainly evident. Reliable infrastructure is central to sustainable regional development and human security. Yet, in many northern communities, the capacity to assess and manage the risks to infrastructure posed by climate change, as well as to seize opportunities, is very limited. Specifically, the NRTEE recommends that:

- Governments continue to support community-based infrastructure-risk reduction through activities such as building awareness of the linkages between disaster management and climate change adaptation, critical infrastructure mapping, and developing and tracking of vulnerability indicators.
- Governments support regional innovation in Canada's North by encouraging the development of new technologies and materials adapted to cold climates and enabling their commercialization.
- Governments work together to identify gaps and support regional skills development to address infrastructure needs in a changing northern climate, including ensuring local capacity exists to conduct risk assessments, and deploy and enforce risk reduction measures and standards locally and regionally.
- Governments, the private sector, communities and research organizations consider how to further tap into traditional and local knowledge as a unique contributor to building community and regional capacity for adaptation.

7.0

APPENDIX

IN THIS CHAPTER

62° 48’ 35” N
92° 05’ 58” W

LOCATION: RANKIN INLET, NUNAVUT

Due to their isolation and a lack of backup infrastructure, many northern communities are already vulnerable to climate-related challenges. For example, in January 2008, a seven-day blizzard in Nunavut’s Kivalliq region left store shelves bare in three communities because airports had to shut down.

7.1 ACKNOWLEDGEMENTS

The National Round Table on the Environment and the Economy benefited from the insights, perspectives, and advice of over 100 stakeholders in the shaping of this policy report. We would like to thank the government officials, experts, and other members of our Expert Advisory Committee for providing valuable input on the research and conclusions that form this report. The committee was co-chaired by NRTEE Vice-Chair David Chernushenko, and Ian Church, Chair of the National Committee of International Polar Year Canada. Special acknowledgements go to Heather Auld, Don Lemmen, and Bill Wyness, whose extensive feedback on scientific and technical issues, northern realities, and the application of risk-based mechanisms to infrastructure helped to strengthen our work. Dr. Robert Page, Chair of the NRTEE, and Robert Slater, Vice-Chair with David Chernushenko, helped guide the development of the final report and its recommendations on behalf of NRTEE members.

As part of our research, we visited and heard from experts and decision makers in Gjoa Haven, Inuvik, Yellowknife, Whitehorse, Toronto, and Edmonton. The NRTEE would like to thank all who participated in these stakeholder sessions. We wish to thank the three study teams that led the distinct research components for this report -- the Canadian Standards Association, the Institute for Catastrophic Loss Reduction, and Gartner Lee Ltd. -- as well as Torys LLP for its research on liability issues. We want to acknowledge and thank officials from Environment Canada, Indian and Northern Affairs Canada, Infrastructure Canada, and Natural Resources Canada, in particular, which provided expertise in support of our research. The views and conclusions expressed in this report do not necessarily represent those of the persons and stakeholders noted above.

Many thanks go to Denise Edwards, administrative assistant of the NRTEE, who tirelessly organized the numerous meetings of our stakeholders and experts.

The NRTEE would like to acknowledge the initial efforts of Erik Sparling, former Policy Advisor at the NRTEE, for his early direction and research for this program. Thanks also to Katherine Balpataky, NRTEE Research Associate, for her support in filling research gaps.

Finally, the NRTEE wishes to acknowledge and thank Jimena Eyzaguirre, NRTEE Policy Advisor, for her significant contribution in writing this report. She played an essential role in bringing together the research results, integrating the case studies, and working with experts and NRTEE members in the final development of *True North*. This report would not have been possible without her.

7.2 NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY: ABOUT US

Emerging from the famous Brundtland Report, *Our Common Future*, the National Round Table on the Environment and the Economy (NRTEE or Round Table) has become a model for convening diverse and competing interests around one table to create consensus ideas and viable suggestions for sustainable development.

The NRTEE focuses on sustaining Canada's prosperity without borrowing resources from future generations or compromising their ability to live securely.

The NRTEE is in the unique position of being an independent policy advisory agency that advises the federal government on sustainable development solutions. We raise awareness among Canadians and their governments about the challenges of sustainable development. We advocate for positive change. We strive to promote credible and impartial policy solutions that are in the best interest of all Canadians based on research, stakeholder engagement, and consideration by Round Table members.

We accomplish that mission by fostering sound, well-researched reports on priority issues and by offering advice to governments on how best to reconcile and integrate the often divergent challenges of economic prosperity and environmental conservation.

The NRTEE brings together a group of distinguished sustainability leaders active in businesses, universities, environmentalism, labour, public policy, and community life from across Canada. Our members are appointed by the federal government for a mandate of up to three years. They meet in a round table format that offers a safe haven for discussion and encourages the unfettered exchange of ideas leading to consensus. This is how we reconcile positions that have traditionally been at odds.

We also reach out to expert organizations, industries, and individuals to assist us in conducting our work on behalf of Canadians. These partners help spark our creativity, challenge our thinking, and generate the momentum needed for success.

The *NRTEE Act* underlines the independent nature of the Round Table and its work. The NRTEE reports, at this time, to the Government of Canada and Parliament through the Minister of the Environment.

The NRTEE maintains a secretariat, which commissions and analyzes the research required by its members in their work. The secretariat furnishes research, administrative, promotional, and communications support for NRTEE activities and operations.

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7.4 FEDERAL COMMITMENTS TO INVEST IN NORTHERN INFRASTRUCTURE SINCE 2006

Policy driver	Funding program / activity	Investment ($)	Time-frame	Other information
Support for Canadians and Their Families – Budget 2006	Northern Housing Trust	$300 million ($50 YT; $50 NT; $200 NU)	One-time payment	Paid into a third-party trust
A Vision for a New North — Supporting Fisheries in the North – Budget 2008	Commercial harbour in Pangnirtung, Nunavut	$8 million	Over 2 years	Construction, operations, and management costs of the initiative
A Vision for a New North — Protecting and Securing Canada's Sovereignty – Budget 2008	A new polar-class icebreaker	$720 million		For procurement of new vessel, given decommissioning of Canadian Coast Guard's current icebreaker in 2017
Action to Stimulate Housing Construction – Budget 2009	Northern housing	$200 million ($50 YT; $50 NT; $100 NU)	Over 2 years	Funding provided through the Canada Mortgage and Housing Corporation
Immediate Action to Build Infrastructure — Supporting Canada's Vision for the North – Budget 2009	Building a world-class high Arctic research station	$87 million	Over 2 years	To maintain or upgrade research facilities; projects to be completed by March 31, 2011. $2 million for Indian and Northern Affairs Canada for feasibility analysis of the station
Immediate Action to Build Infrastructure — Small Craft Harbours – Budget 2009	Construction of Pangnirtung Harbour in Nunavut	$17 million		
Building Canada Plan — Budget 2009 and earlier budgets	Canada-Yukon Framework Agreement	$274.61 million	Over 7 years (2007–2014)	Includes Building Canada Fund ($7.91 million); territorial base fund ($175 million); gas tax fund ($88.5 million); municipal rural infrastructure fund ($3.2 million)
	Canada-Northwest Territories Framework Agreement	$277.5 million	Over 7 years (2007–2014)	Includes Building Canada Fund ($10.8 million); territorial base fund ($175 million); gas tax fund ($88.5 million); municipal rural infrastructure fund ($3.2 million)
	Canada-Nunavut Framework Agreement	$274.28 million	Over 7 years (2007–2014)	Includes Building Canada Fund ($7.68 million); territorial base fund ($175 million); gas tax fund ($88.5 million); municipal rural infrastructure fund ($3.1 million)

Source: Government of Canada budget documents available on the website of the Department of Finance.

7.5 STAKEHOLDER PARTICIPATION

Note: As the NRTEE program took place over three years, some participants' titles and organizations might have changed. Information that appears here reflects that of the participants at the time of these meetings.

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Insurance Research

January 8, 2008: Toronto, Ontario
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8.0

GLOSSARY

58° 43’ 30” N
94° 07’ 00” W

LOCATION: CHURCHILL, MANITOBA

“Northern railways with lines passing through areas of permafrost, such as the one serving the Port of Churchill in northern Manitoba, will require frequent and significant repair, if not replacement, as a result of continued permafrost degradation.”

(Sauchyn, D. and S. Kulshreshtka, 2008, p. 304)

8.0 GLOSSARY

Adaptation
Adjustment in natural or human systems in response to actual or expected climate stimuli and their effects, which moderates harm or exploits beneficial opportunities. There are various types of adaptation, including anticipatory, autonomous, and planned adaptation. [1*]

Adaptive capacity
The whole of capabilities, resources, and institutions of a country, region, community, or group to implement effective adaptation measures. [2*]

Adaptive management
Management that is responsive to, or even anticipatory of, changing functions of natural and human systems, evolving management purposes, and changing contextual conditions. This management approach acknowledges uncertainty, designing and implementing actions that are deliberately experimental and focused on learning from the effects of management. It emphasizes monitoring and participatory approaches as well.

Climate
Climate in a narrow sense is usually defined as the average weather or, more rigorously, as the statistical description of mean values and variability of variables such as surface temperature, precipitation, and wind over a period of time ranging from months to thousands or millions of years. Climate in a wider sense describes the state of the climate system.[1*]

Climate change
Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period.[1*]

Climate design values
Statistics pertaining to weather and climate events that inform engineering design criteria. These values include calculated return periods for extreme weather (such as intense rain, wind, snow, extreme cold, and freezing rain) of varying intensities and durations. Climate design values generally reflect historical conditions for a given geographical location, an approach that is challenging in a changing climate.

Command and control
A type of policy instrument that relies on regulation (permission, prohibition, standard setting, and enforcement) as opposed to financial incentives to achieve a policy outcome.[3*]

Critical infrastructure
Physical and information-technology facilities, networks, services and assets that, if disrupted or destroyed, would have a serious impact on the health, safety, security, or economic well-being of a population or the effective functioning of governments.[4]

Disaster
Social phenomenon resulting from the intersection of a hazard with a vulnerability that exceeds or overwhelms the ability to cope and may cause harm to the safety, health, welfare, property or environment of people.[5]

Ecosystem
The interactive system formed from all living organisms and their physical and chemical environment within a given area. Ecosystems cover a hierarchy of spatial scales.[1*]

Ecozone
Ecologically distinct zones with characteristic plant and animal life and physical features.

Emergency
A present or imminent event that requires prompt coordination of actions concerning persons or property to protect the health, safety or welfare of people or to limit damage to property or the environment. [5]

Governance
The process whereby societies or organizations make important decisions, determine whom they involve, and how they render account.[6]

Incentives
Incentives broadly refer to mechanisms that encourage or discourage certain types of behaviour. Incentives can include relevant information, price signals, regulations, and financial rewards or penalties. Provision of or access to these incentives can be design or unintentional.

Infrastructure
The physical foundation of a society, community, or enterprise. Infrastructure comprises assets, installations, or systems used to provide goods or services.[7]

Institutions
Rules and norms that guide how people within societies live, work, and interact. Formal institutions are codified rules, such as the constitution, organized markets, or property rights. Informal institutions are rules governed by social or behavioural norms of a family, community or society.[8]

Knowledge-based economy
A term encompassing trends in advanced economies toward greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors. [9]

(Adaptation) Mainstreaming
The integration of adaptation considerations (or climate risks) such that they become part of policies, programs, and operations at all levels of decision making. The goal is to make the adaptation process a component of existing decision-making and planning frameworks.[10]

Mitigation
In the context of climate change, mitigation is an intervention intended to reduce adverse human influence on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks. Mitigation in the context of disaster management refers to sustained actions taken to eliminate or reduce risks and impacts posed by hazards well before an emergency or disaster occurs.[1*,5*]

Feedback
When the result of an initial process triggers changes in a second process that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it.[1*]

Permafrost
Ground (soil or rock and included ice and organic material) that remains at or below 0°C for at least two consecutive years.[11]

Redundancy
Duplication of critical components of a system in order to increase its reliability. As an example, buildings may be equipped with backup power generators to maintain essential services in case of power failure.

Resilience
The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the same capacity for self-organization and the same capacity to adapt to stress and change.[1]

Risk
A combination of the likelihood (probability of occurrence) and the consequences of an adverse event (e.g., climate-related hazard).[10]

Risk management
A systematic approach to setting the best course of action under uncertainty, by applying management policies, procedures and practices to the tasks of analyzing, evaluating, controlling and communicating about risk issues.[12]

Security
In the context of climate change and other global change drivers, security is more than protection of territory or national interests. Human security, for example, means protecting people from critical and pervasive threats and situations, building on their strengths and aspirations, through strategies of protection and empowerment. [13*]

Stakeholder
A person or an organization that has a legitimate interest in a project or entity, or would be affected by a particular action or policy.[1]

Tailings
Residue of raw material or waste separated out during the processing of crops or mineral ores. [14]

Traditional knowledge
A cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment.[15]

Vulnerability
Vulnerability to climate change is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability to climate change is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as its sensitivity and its adaptive capacity.[1*]

Weather
State of the atmosphere at a given time and place with regard to temperature, air pressure, humidity, wind, cloudiness and precipitation. The term is mainly used to describe conditions over short periods of time.[16]

GLOSSARY REFERENCES

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* Modified from source

9.0

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58° 42’ 00” N
69° 56’ 00” W

LOCATION: TASIUJAQ, QUÉBEC

“In Tasiujaq (Quebec), permafrost thawing was in part responsible for deformation of the airport runway causing considerable insecurity among residents who depend on air transport for food supplies and medical evacuations to hospitals.”

(Bourque, A. and G. Simonet, 2008, p. 203)

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