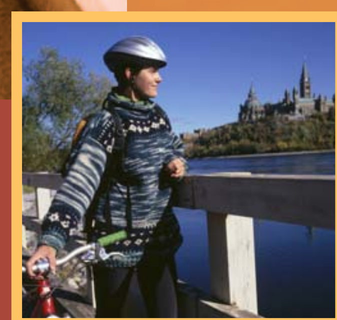

Adapting to

Climate Change

An Introduction for Canadian Municipalities

RECOGNIZING THE NUMEROUS FORMS OF LOCAL GOVERNMENTS ACROSS CANADA, OF WHICH MUNICIPALITIES ARE ONE, THIS INTRODUCTION ADDRESSES LOCAL GOVERNMENT ISSUES AND CHALLENGES IN VIEW OF ADAPTING TO CLIMATE CHANGE. THEREFORE, WHILE THE INTRODUCTION REFERS TO MUNICIPALITIES, THE ISSUES AND EXPERIENCES OUTLINED WILL PROVIDE VALUABLE LESSONS TO ALL FORMS OF LOCAL GOVERNMENT.

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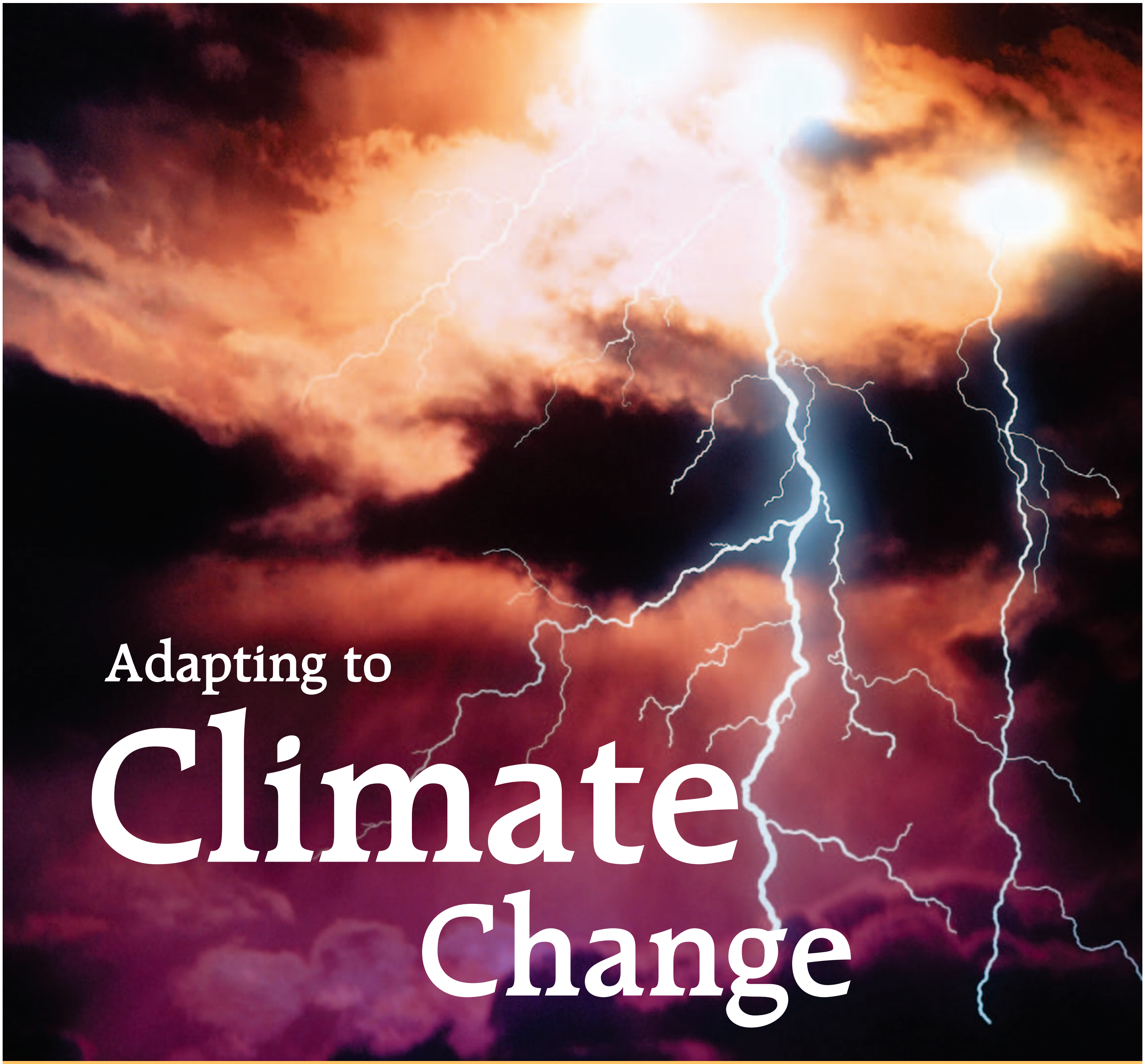
CANADIAN CLIMATE IMPACTS AND ADAPTATION RESEARCH NETWORK (C-CIARN)

FEBRUARY 2006



Adapting to Climate Change

An Introduction for Canadian Municipalities

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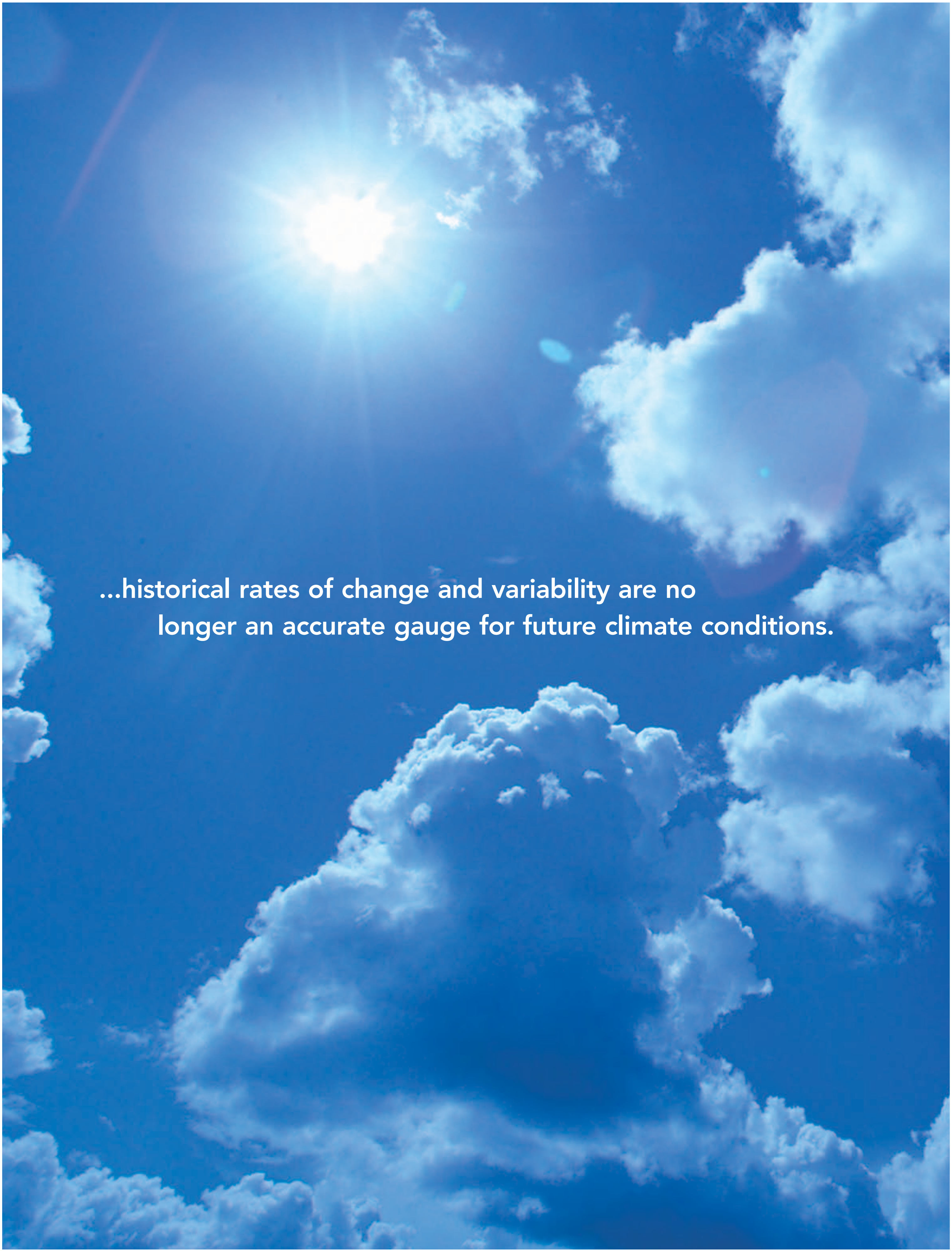

…historical rates of change and variability are no longer an accurate gauge for future climate conditions.

Contents

Preface

Our climate is changing. Scientific understanding of climate change indicates that Canada will experience significant shifts in weather patterns over the span of a single generation, a trend that will most likely continue for the next several centuries or longer.

Among the anticipated impacts of climate change are droughts; diminished and lower quality surface water; a higher incidence of vector-borne diseases; more frequent heat waves with high discomfort in urban centres; and an increase in storm surges in coastal regions. The magnitude of warming is expected to be greater in the North compared to the rest of the country. Resourced-based communities, which generally have economies that are closely connected to the climate, will be more vulnerable. For most municipalities, the change in the frequency of extremes in weather, such as intense precipitation, heavy winds, or ice storms is one of the greatest concerns.

One strategy to reduce a community's vulnerability to the effects of climate change is to anticipate and adapt. This Introduction is a first step in providing municipal decision-makers information to understand the need for climate change adaptation and how to put such measures in place.

The Introduction is intended for elected municipal officials and senior staff. It outlines decision-making processes to adapt to climate change and showcases municipal adaptation measures implemented across the country. The goal is to help municipal governments make informed decisions and take appropriate action. For those municipalities that are already developing adaptation measures, this document can help enhance an understanding of climate change adaptation among elected officials, staff and the broader community.

Acknowledgements

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1

AN INTRODUCTION TO CLIMATE CHANGE IMPACTS AND ADAPTATION

The Earth's climate is changing. Some of this change is due to natural variations that have been taking place for millions of years, but increasingly, human activities that release heat-trapping gases into the atmosphere are warming the planet by contributing to the "greenhouse effect". According to the Intergovernmental Panel on Climate Change (a global scientific body of expertise on climate change), the world's average surface temperature is expected to increase by 1.4 to 5.8°C over the period 1990-2100 (IPCC, 2001). This projected rate of change is without precedent in the last 10,000 years. As a result, historical rates of change and variability are no longer an accurate gauge for future climate conditions.

GREENHOUSE GAS EMISSIONS

Human-induced climate change is caused by an increase in the emissions of several important greenhouse gases (GHGs), including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Releasing these heat-trapping gases into the atmosphere increases the natural greenhouse effect that is responsible for the Earth's surface air temperature.

The use of fossils fuels in transportation, manufacturing, heating, cooling, and electricity generation is the biggest source (70-90 per cent) of GHGs. The rest comes from land use activities, such as agriculture and forestry.

In 2003, total GHG emissions in Canada amounted to 740 megatonnes. Municipalities are directly and indirectly responsible for almost half of those emissions.

Learn how municipalities across Canada are reducing greenhouse gas emissions through the Federation of Canadian Municipalities' Partners for Climate Protection Program. **WWW.FCM.CA**

In Canada, six of the warmest years on record occurred between 1995 and 2005. Climate change affects each region of the country in various ways (Figures 1 and 2) and almost every economic sector.

Addressing climate change requires two complementary actions: reducing greenhouse gas emissions and adapting to climate change. Canadian municipalities have demonstrated leadership in reducing greenhouse gas emissions through energy-efficiency measures and the use of alternative energy sources. But the challenges of adapting to climate change have received far less attention.

WHY MUNICIPAL DECISION-MAKERS NEED TO CONSIDER CLIMATE CHANGE
One of the greatest concerns is an expected increase in climate variability and in extreme weather, causing floods, droughts and storms (NRCan 2004). As the climate changes, it is anticipated that even small shifts in climate normals will have potentially large ramifications for existing infrastructure (Auld and McIver, 2005). This will affect municipalities large and small, urban and rural, and will have positive and negative implications for the various types of municipal infrastructure: **built systems**, e.g., roads and bridges; **natural systems**, e.g., watersheds and forests; and **human systems**, e.g., health and education.

Built systems are likely to endure greater exposure to extreme events in the future, resulting in increased demand for maintenance and upgrades. Energy transmission networks, such as towers and their supports, may suffer damage from severe windstorms, or ice storms. Water and sewage networks may need to accommodate more intense precipitation. Municipalities need infrastructure that can withstand future climate conditions to ensure it is dependable and maintain safety (for example, milder winters are likely to bring about more freeze-thaw cycles, which trigger pot-hole development on roads). On the other hand, changing weather conditions may have a positive impact, for example, lower snow-clearing costs in milder winters.

Natural systems are expected to adapt to shorter winters and earlier springs, which will alter ecosystems and species' lifecycles. Increased risk of pests, diseases and forest fires are likely to occur in a warmer climate. Rising urban temperatures and heat waves frequently cause smog and diminished air quality, both of which affect the health of plant and animal species. On the other hand, a milder climate could present new opportunities for tourism and recreation by extending the growing season for vegetation in parks and other recreational areas.

Human systems, such as welfare, social aid and medical systems, are likely to be affected by climate change, especially in resource- and tourist-based communities, which have a strong link between climate and economic prosperity. Demands on human systems are expected to increase in response to emergency management of extreme physical discomfort, life-threatening conditions and stress-related illness. For example, health services may need to accommodate vulnerable segments of the population during more frequent heat days. On the other hand, fewer cold snaps in winter are likely to signify fewer treatments of cold-related illnesses. Municipalities make investments in infrastructure that are required to last for many decades. Generally, infrastructure design is based on past climate conditions. However, given the climate changes expected over the next century, these historic conditions are no longer accurate indicators for planning,


NOVA SCOTIA DEPARTMENT OF TRANSPORTATION AND PUBLIC WORKS

TO FIND OUT MORE…

The federal report titled *Climate Change Impacts and Adaptation: A Canadian Perspective* provides an overview of the key climate change concerns for several major Canadian sectors, including natural resources, transportation and health. The Web site also offers a series of posters of the regional impacts of climate change in Canada.

ADAPTATION.NRCAN.GC.CA/PERSPECTIVE_E.ASP

A few Canadian communities have started to adapt; see section 3, Examples.

maintenance and upgrades. Municipal infrastructure needs to adapt to new climate risks to ensure safety and quality of life, as well as reduce long-term costs.

Some municipalities are facing particular challenges, such as northern communities where the magnitude of climate change is expected to be greatest, and Aboriginal communities where traditional ways of life, tied closely to the natural environment, remain important. Communities that rely on climate-related economies, such as agriculture, forestry and fisheries face significant risks.

Already, some downstream communities are more aware of reduced water supplies as glaciers melt; some cities are facing less snow days; and some coastal communities are witnessing more severe storms and greater erosion. But every municipality will be challenged by climate change as it affects municipal services, assets and infrastructure.

WHAT IS CLIMATE CHANGE ADAPTATION?

Climate change adaptation refers to any action that reduces the negative impact of climate or takes advantage of potential new opportunities **Anticipatory adaptation** is implemented prior to a climate event. It is most effective as a guiding principle when several options are under consideration. **Reactive adaptation** occurs in response to the impact of a climate event. It most commonly takes place after a natural disaster. In most cases, anticipatory adaptation is the most cost-effective and efficient plan of action.

Planned adaptation can support either anticipatory or reactive adaptations. Successful adaptation measures enable communities to plan for and respond effectively to the challenges of climate-related events. They may also present other benefits, for example, water conservation measures will also lower energy costs related to treatment.

For more information on identifying adaptation strategies see section 2, Vulnerability Assessment.

Adaptation measures can be organized into five basic categories as described in Table 1. In most cases, the aim of adaptation is to increase the resilience of a municipality. The measures presented are examples of adaptations for a storm surge event and do not present an exhaustive list of possibilities. Each municipality will need to develop its own list of potential adaptations that are reflective of a community's circumstances.

TABLE 1: Types of adaptation measures that can be implemented for a storm surge event

CATEGORY	EXPLANATION	EXAMPLE OF ENSUING ADAPTATION
Business as usual	Do nothing to reduce vulnerability and absorb losses	Rebuild, or abandon, affected structures
Prevent the loss	Adopt measures to reduce vulnerability	Engineer structures to withstand greater winds, heavier precipitation, and more frequent flooding
Spread or share the loss	Spread burden of losses across different systems or populations	Purchase flood insurance
Change the activity	Stop activities that are not sustainable under the new climate, and substitute with other activities	Prevent development on coastal land below a set elevation, and rehabilitate natural vegetation
Change the location	Displace the infrastructure or system	Relocate coastal infrastructure further inland outside of risk zone
Enhance adaptive capacity	Enhance the resiliency of the system to improve its ability to deal with stress	Preserve or rehabilitate natural coastal systems that protect the shore

(Adapted from NRCan 2004)

2

CLIMATE CHANGE ADAPTATION AND MUNICIPAL DECISION-MAKING

PLANNING FOR CLIMATE CHANGE IMPACTS

Given the potential consequences of future climate events, incorporating climate change risk management into municipal decision-making is prudent.

One way to deal with the uncertainty of climate change is to identify no-regrets or low-regrets options (sometimes also referred to as "precautionary principal" or "risk aversion"), particularly for initial climate change adaptation measures. A no-regrets adaptation strategy provides benefits regardless of future climate changes. It neither disregards climate change nor makes it the determining factor in decision-making. Instead, the strategy ensures prudent risk management because it places additional emphasis on areas that are vulnerable to climate change.

NO-REGRETS INFRASTRUCTURE IMPROVEMENT

A no-regrets climate change adaptation provides benefits to the community whether anticipated climate changes materialize or not. For example, a municipality planning to reduce daytime temperatures in its urban centre may consider green roofs (planting trees and shrubs, or grass on rooftops) to create shade, reflect heat and reduce urban heat-island effects. Non-vegetated roofs can exceed temperatures of 50°C in July, while vegetated roofs remain at 25°C. The green roofs will help cool the urban core, as well as reduce the impact of heavy precipitation, beautify the area, improve air quality, and reduce energy costs. The upgrades are relatively inexpensive and benefits are realized regardless of the degree of climate change.

DETERMINING ADAPTIVE CAPACITY AND VULNERABILITY

Even though municipalities share responsibilities associated with infrastructure with other orders of government, any effect of climate change is ultimately felt locally, even if it originates outside local jurisdictions, such as disruptions in electrical power, petroleum and natural gas, or water supplies.

The degree to which a municipality is able to deal with the impact of climate change is often referred to as **adaptive capacity** or “the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences” (IPCC 2001). The vulnerability of infrastructure systems needs to be assessed as part of municipal risk management and decision-making. This also helps determine the level of adaptation required to decrease climate change vulnerability.

To better understand current and future vulnerability to climate, municipal governments can incorporate climate change considerations into existing vulnerability assessments such as those conducted for emergency management or other purposes. Focused climate change vulnerability assessments can also be conducted as one way to determine what actions a municipality may want to take to address changes in climate.

VULNERABILITY ASSESSMENT

One approach municipalities can use to plan their response to the effects of climate is to assess the vulnerability of their infrastructure (built, human and natural systems) to weather-related events, which will determine the degree of damage or loss that occurs when severe weather strikes. Understanding the level of vulnerability contributes to decision-making and policy development by providing a basis for establishing priorities (NRCan 2004).

A vulnerability assessment requires input from community stakeholders, historical data and experience, as well as future social and economic conditions, and climate scenarios.

For an explanation of climate models and their assumptions, see Appendix A.

Climate scenarios are one of several technical tools available to help municipalities identify the specific adaptation needs for their community. Climate scenarios present plausible future climate conditions; they are created for explicit use in investigating potential climate change impacts (Mearns et al. 2001). These scenarios are produced by institutions that work with climate models, and are used to provide an illustration of climate change and communicate some of the potential consequences (Barrow et al. 2004).

The Ouranos Consortium develops and adapts the necessary tools for providing decision-makers with detailed climate change scenarios on a regional scale. The Consortium also performs evaluations of expected sectoral impacts to optimize adaptation strategies. The Climate Simulations team at Ouranos develops and uses the Canadian Regional Climate Model to provide regional climate data.

WWW.OURANOS.CA

A vulnerability assessment involves five major steps as outlined below. These steps can be carried out by using resources from existing program funds (such as funds pertaining to emergency management risk assessment processes) or by finding new sources of funding (see text box, Sources of Funding). For smaller municipalities, regional alliances have proven cost-effective when executing this exercise.

SOURCES OF FUNDING

The Federation of Canadian Municipalities' Green Municipal Fund is a permanent $500-million revolving fund, established by the Government of Canada, to stimulate investment in innovative municipal infrastructure projects. The Fund supports partnerships to encourage municipal action to improve air, water and soil quality.
HTTP://WWW.FCM.CA/ENGLISH/GMF/GMF.HTML

In partnership with provincial, territorial and municipal governments, First Nations and the private sector, Infrastructure Canada has been helping rural and urban municipalities across Canada to renew and build infrastructure, through a variety of funding programs
HTTP://WWW.INFRASTRUCTURE.GC.CA

Vulnerability Assessment
STEP 1. Engage affected parties Engage and retain decision-makers and those affected by future climate change
STEP 2. Assess current vulnerability Use experience to assess impact and potential damage. Understanding adaptive capacity, critical thresholds and coping ranges is helpful
STEP 3. Estimate future conditions Use climate, environmental and socio-economic scenarios to determine future policy and development.
STEP 4. Estimate future vulnerability and identify adaptation strategies Use the two previous steps (current vulnerability and future conditions) to identify future vulnerability and adaptation strategies
STEP 5. Decisions and implementation Incorporate results into risk-management strategies and follow through with these.

(Source: NRCan 2004)

STEP 1 Engage decision-makers and those most involved in managing day-to-day community life in a scoping exercise to determine a municipality's current vulnerability to climate. The exercise would include people who would be affected by climate change in a particular sector and/or those who make decisions within that sector.

STEP 2 Identify current vulnerability of a municipality in all sectors: environmental (extreme weather), social (policy changes) and economic (market changes). Determine sectors or areas that need particular attention by reviewing where a municipality has been vulnerable in past climate events. A sector or area's current vulnerability to climate will likely increase in the future.

STEP 3 Introduce scenarios of social and economic conditions and future climate change provided by experts (see Appendix A) and consider potential effects on environmental, social and economic systems.

STEP 4 Ask municipal staff and community stakeholders to identify likely vulnerabilities given the scenarios provided in STEP 3 and determine how current vulnerabilities can best be addressed in this context. At this stage, adaptive approaches are developed as a response to increased vulnerabilities or new opportunities, and no-regrets adaptation strategies are identified.

STEP 5 Integrate adaptive approaches into existing programs and policies, recommend research where information gaps exist, and/or or develop appropriate new programs and polices.

The vulnerability assessment is an iterative process requiring on-going monitoring and periodic review to ensure adaptation is in tune with what is being experienced. New information needs to be integrated into decision-making and planning as it becomes available. By working through a vulnerability assessment, a municipality will have identified infrastructure areas that require attention in terms of policy changes, partnership needs and potential opportunities. Once vulnerable areas have been determined (i.e. through past experiences or by conducting a vulnerability assessment) full climate change adaptation measures can be developed and implemented.

FIGURE 1: Changes in mean temperature (°C) between the 2050 horizon and the actual climate, for each season
(from an ensemble of CRCM climate change projections, November 2005)

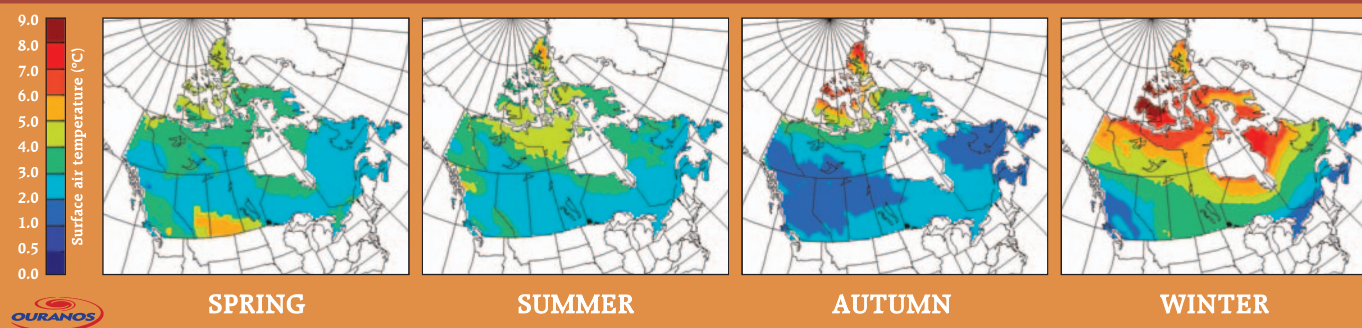
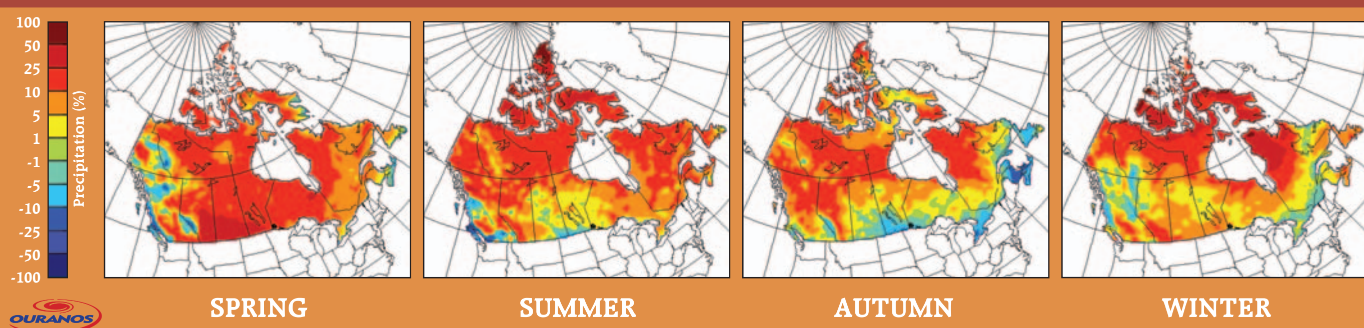


FIGURE 2: Changes in mean precipitation (%) between the 2050 horizon and the actual climate, for each season
(from an ensemble of CRCM climate change projections, November 2005)



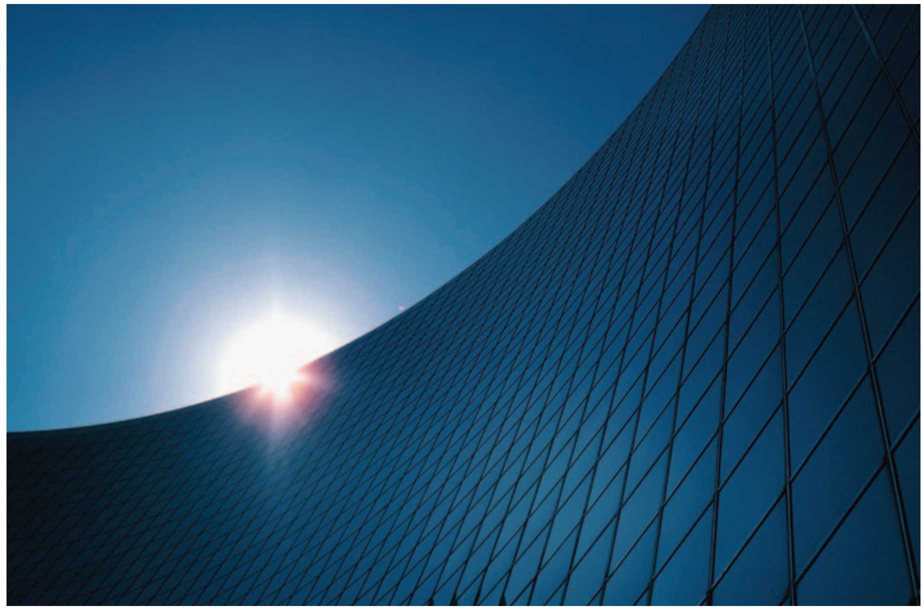
3

EXAMPLES: INTEGRATING CLIMATE CHANGE CONSIDERATIONS INTO MUNICIPAL DECISION- MAKING

The examples presented here have been selected to demonstrate how Canadian communities are starting to address climate change adaptation. It is hoped that these examples will help raise awareness of climate change impacts in other communities and provide ideas as to how these challenges might be addressed.

Some examples (Toronto, Halifax, Sept-Îles, Iqaluit) were explicitly inspired by a desire to adapt to climate change. Others represent an effective response to reducing vulnerability to climate change even though this was not the main reason for implementing the initiatives. All exemplify how communities have worked through a decision-making process that directly or indirectly considered climate change adaptation and thereby contributed to improving community capacity for long-term adaptation planning and implementation.

The examples illustrate a range of potential climate change impacts and possible adaptations extracted from municipalities of varying sizes, from across Canada. While the situations presented do not apply to all jurisdictions, each example demonstrates an aspect of integrating adaptation that may prove useful to other municipalities as they assess their vulnerability and develop their own adaptation strategies. These profiles are not intended to serve as case studies, nor do they claim to represent best practices.



Toronto's Heat-Health Alert System

This example illustrates how an adaptation measure can be based on existing program models and successfully integrated with similar programs.

Toronto developed its heat alert system proactively— before being crippled by a major heat wave— largely based on past disastrous heat wave experiences in Chicago (1995) and in Philadelphia (1993), both of which killed hundreds of urban residents and hence, were an impetus for implementing the Toronto Heat-Health Alert.

The City of Toronto has developed and implemented two extreme weather alert plans: Extreme-Cold Weather Alerts (in 1996), and Heat-Health Alerts (in 2001). These plans are designed to protect the City's most vulnerable populations—the elderly, children, medically at-risk persons, and the homeless—from extremes of heat and cold.

TORONTO'S ELDERLY

The elderly population is the most vulnerable age group to extreme heat events. According to the latest census (2001), the City of Toronto has a total population of 2.5 million people. Seniors are the fastest-growing age group and represent 14 per cent of the population. The number of seniors in the City has nearly doubled in the past 30 years. It is expected that 16 per cent of the population, or 480, 000 people, will be over the age of 65 by the year 2031. By this time, seniors will outnumber children 0-14 years of age, who now represent 17 per cent of the population. The 75-plus age group is expected to grow by 50 per cent over the same time period.

Typical summer daytime temperatures in Toronto vary between 17 and 20°C, though temperatures often can exceed 26°C. Between May and September, Toronto experiences on average 9.5 days over 30°C (averaged from 1961-1990). However, between 1995 and 2005, Toronto experienced an average of 16.1 days per year above 30°C. Some global climate change models estimate that temperatures in the Toronto area will rise between 2 and 5°C in the next 100 years. This implies that Toronto will experience more frequent heat waves.

Before the Heat-Health Alert system was introduced, Heat Warnings were issued using one-day forecasts of a humidex of over 40°C. The City identified a need to improve on this system, and developed the Heat-Health Alert system in partnership with the Toronto Atmospheric Fund and the University of Delaware. Using 46 years of meteorological data provided by Environment Canada and 17 years of mortality data, researchers identified which meteorological conditions coincide with an increase in the number of excess deaths. The Heat-Health Alert system relies on computer modelling of various weather factors, including humidex, apparent temperature (a measure of human discomfort due to combined heat and humidity), cloud cover, wind direction and speed, and air mass. Simply described, this method looks at the relationship between different air masses and climate conditions, and health (in the form of mortality).

The model predicts when the probability of excess mortality due to certain oppressive air masses rises above expected thresholds. When the conditions are such that it could potentially rise above 65 per cent, the Toronto Medical Officer of Health issues a Heat Alert. When the probability rises above 90 per cent, an Extreme-Heat Alert is issued. The variables associated with the oppressive air masses are tracked by the Heat-Health System, which is able to predict a heat alert or extreme-heat alert up to 48 hours before the event is expected.The City of Montreal is implementing a similar extreme heat alert plan. Heat alerts are issued when the temperature rises to 33°C for three or more consecutive days, or when temperatures remain above 25°C for two consecutive nights. Alerts are issued through the media and various community agencies, and response measures undertaken are similar to Toronto's.

At the beginning of the summer, the City of Toronto issues information about hot-weather risks and vulnerable populations to its partners and the media. The City also posts fact sheets on its Web site and distributes pamphlets. When a Heat Alert is issued, there is a city-wide response. Measures taken include:

- Contacting local media to inform the public that a heat alert has been issued.
- Contacting community agencies (more than 800 are involved) to inform them of the alert and ask them to take appropriate action. For example, shelters are asked to ease their curfew rules to allow people to stay inside during the day.
- Distributing bottled water through the Red Cross to vulnerable people at the places where they are likely to gather.
- Distributing Toronto Transit Commission (TTC) tokens to the homeless so they can reach cooling centres through community agencies that have out-reach programs.
- Operating a 12-hour heat information line to answer heat-related questions from the public and requests to check on seniors. (This helpline is operated by the Red Cross.)
- Staffing a Toronto Emergency Medical Services vehicle with a specially trained Community Medicine Program Paramedic, and ensuring the vehicle has emergency medical and other equipment to provide in-home medical and environmental assessments for persons at risk of developing heat-related illness.

In the event of an Extreme-Heat Alert, the City opens designated cooling centres at various public locations, such as civic centres. Some centres are open 24 hours as long as the Extreme-Heat Alert is in effect. As indicated, many of these activities are carried out in partnership with community services and agencies. Even the Toronto Animal Services provides information on how to help animals cope with hot weather.

The main benefit of the program has been an increase in awareness of problems related to extreme heat, and the partnering of various departments of the City of Toronto and non-governmental organizations and other local groups.

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Greater Vancouver Regional District's Stormwater Management Program

This example illustrates how climate change can be effectively incorporated into existing or emerging planning efforts, avoiding the need to develop new policies and programs.

This approach is encouraging, as it does not require introducing a whole new set of criteria into regional planning.

The Greater Vancouver Regional District (GVRD), a partnership of 21 municipalities and one electoral area, is home to more than two-million people with significant growth expected in the future. Its mandate is to engage in regional planning and to co-ordinate and carry out the delivery of essential utility services. The District is in the early stages of addressing climate change. As a regional authority, the GVRD is well placed to play a pivotal role in promoting and facilitating the development of adaptation measures.

The GVRD encompasses the saltwater estuary of the Fraser River delta, bounded by forested mountains to the north and east, and the Canada-U.S. border to the south. The region has a coastal climate characterized by mild, wet winters and warm, dry summers. There are significant variations in the regional climate that occur in cycles ranging from a few years to multiple decades.❖ For the GVRD, and indeed for southwestern British Columbia in general, it is difficult to distinguish between "natural" climate variation and (at least partly) human-induced climate change. Temperature records indicate a clear warming trend in the region of between 0.5 to 0.8°C over the past century, and annual precipitation in the region has increased over the past 50 years. Whether this is a "natural" variation or part of a long-term shift, the implication for regional planning authorities, such as the GVRD, is that climate cannot be assumed to be constant and that conditions may change within a standard planning horizon of 20, 50, or 100 years.

❖ Climate variation in western North America and beyond is affected by cyclical fluctuations in Pacific Ocean currents and sea-surface temperatures. These changes in ocean conditions in the eastern Pacific include what have come to be known in popular vernacular as El Niño and La Niña, as well as the more recently detected and more scientifically named Pacific Decadal Oscillation (PDO).

THE STORMWATER INTERAGENCY LIAISON GROUP

The GVRD and its municipalities have responsibility under the federal Fisheries Act to protect fish and fish habitat from negative impacts associated with storm and rainwater discharges to the environment. Of concern are potential runoff quantity and water quality changes to the region's many urban and rural salmon and trout streams. The GVRD, its municipalities, and provincial and federal environmental agencies in 2002 formed the Stormwater Interagency Liaison Group (SILG) to facilitate the co-ordination and sharing of common research related to stormwater management (the legal framework used was the Provincial Waste Management Act, which includes the management of stormwater).

One of the primary results of this co-ordinated approach has been the creation of a template for Integrated Stormwater Management Plans (ISMPs), which are watershed-specific, flexible and adaptive strategies. These plans integrate water management issues including watershed health, land use planning, engineering, community values and climate change and variability. Although climate change is not the primary driver in the development of these plans (expanding urbanization and intensive agriculture are), climate change has been integrated into the ISMP process and other approaches directed at managing the health of streams in the region.

In developing the ISMP process the GVRD and its members created an inclusive and comprehensive tool for managing complex risk-management issues that improves the region's capacity to deal with environmental risk, including the potential risks of climate change and variation.

INTEGRATED STORMWATER MANAGEMENT PLAN (ISMP)
The ISMP goal is to develop effective stormwater plans that will result in no net loss to environmental quality and protect communities from localized flooding. The process actively seeks and uses input from various stakeholder groups within each watershed, and brings together planning, engineering, ecology, and flood and erosion protection within an adaptive management methodology. ISMPs will be developed throughout the GVRD in the order of watershed priority.

Within each ISMP process, an advisory group, including representatives from the development, agricultural, and environmental sectors, contributes historical knowledge of the watershed and helps to assess the benefits of the ISMP over time. The general public is involved in evaluating alternative management scenarios and reviewing the plan's success. This roundtable approach relies on a combination of knowledge on land use, water resources, and engineering from governments, local residents and key experts. A widely supported set of final adaptive management rules will allow landowners and developers to make long-term investment decisions with confidence, provide government agencies with regulatory certainty, and ensure that the investments of municipal governments lead to continuous improvements in stormwater management.

Member municipalities have agreed to implement ISMPs in all urban watersheds by 2014. When fully implemented, the adaptive management approach of the ISMPs are intended to address potential drainage, erosion, and flooding concerns, protect riparian and aquatic habitat, and remediate existing excess stormwater runoff. ISMPs will be regularly reviewed and updated.

The ISMP process is progressing well, with several ISMPs completed, underway or planned. While not driven by concern about the impacts of climate change, these planning and risk-management strategies have helped the GVRD to improve its capacity to deal with such changes should they occur.

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CREDIT TO BE DETERMINED

7 STEPS TO DESIGN AND IMPLEMENT AN ISMP

1	2	3	4	5	6	7
Secure political interest and support	Identify water-shed problems and opportunities	Develop objectives and alternative scenarios	Collect meaningful data and refine scenarios	Evaluate alternatives and develop component plans	Develop an implementation program	Refine the plan through adaptive management

Halifax Regional Municipality's the ClimateSMART Initiative

This example illustrates the importance of collaborative partnerships between multiple orders of government and the private sector.

ClimateSMART (Sustainable Mitigation & Adaptation Risk Toolkit) is an innovative new project officially launched in March 2004 and developed to help mainstream climate change mitigation and adaptation into municipal planning and decision-making.

Halifax Regional Municipality (HRM), the capital of Nova Scotia, is Atlantic Canada's largest city. The Municipality covers more than 5000 km^2 and has a population of more than 350,000. It offers an international seaport and airport, as well as commercial, educational, research and technology centres for the region.

In recent years, Halifax has experienced a number of extreme climate events, including several storms that have been described as "once-in-a-century" events. Damages and costs associated with these events have also increased. Most notable was Hurricane Juan in September 2003. The Class 2 Hurricane made landfall just outside Halifax and tracked across central Nova Scotia, causing extensive damage to property, infrastructure and the environment, which was estimated at more than $100 million. A few months later, in February 2004, the severe winter blizzard that became known as "White Juan", dumped almost 90 cm of snow on Halifax in one day. The result was $5 million in unbudgeted snow-removal costs and repairs to utility infrastructure. Such events have cost Halifax and its businesses and citizens millions of dollars, significant inconvenience, and disruption of services and lives. As a result, these events have triggered increased concern about the potential impacts of climate change.

ClimateSMART (Sustainable Mitigation & Adaptation Risk Toolkit) is an innovative new project officially launched in March 2004 and developed to help mainstream climate change mitigation and adaptation into municipal planning and decision-making. It is a collaboration between the public and private sectors. Partners include: the Federation of Canadian Municipalities' Green Municipal Funds;

Natural Resources Canada (Climate Change Impacts and Adaptation Program); Environment Canada; Nova Scotia Department of Energy; Nova Scotia Department of Environment and Labour; Nova Scotia Environmental Industries Association; select members of ClimAdapt; several community groups and local businesses, and HRM.

Prior to ClimateSMART, the municipality did not have climate change planning strategies in place. Recognizing its vulnerability to impacts from recent storms, and the increased risk to infrastructure, property and citizens, Halifax began looking for a mechanism to plan and implement effective strategies. When approached with the idea of ClimateSMART, HRM agreed to be a project partner and act as the prototype municipality.

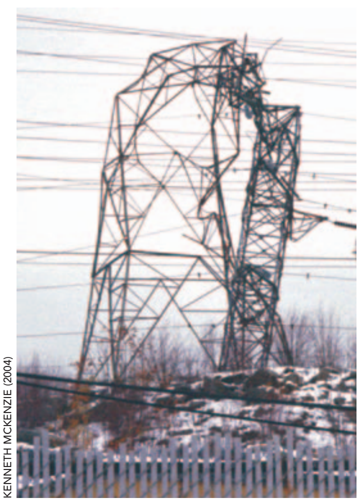
Principal tasks of the Halifax ClimateSMART project include:

1. Vulnerability assessments and sustainability analyses
2. Cost-benefit assessments
3. Emissions management and mitigation tool
4. Climate change risk management plan
5. An emissions management and adaptation methodology, including methodologies for each sector of the community
6. Communications and outreach

While still in its early stages, the project's future plans include defining and conducting risk and vulnerability assessments, and developing the adaptation management tools that will enable HRM to mainstream climate change into everyday municipal planning and decision-making.

ClimateSMART has enabled Halifax to move from no climate change planning toward developing a comprehensive and integrated approach to climate change decision-making. Halifax is the prototype municipality for ClimateSMART. Information gathered and lessons learned from this project will be used to develop a municipal climate change planning and management toolkit that can be customized for use in other communities. Once completed, the toolkit will include information on greenhouse gas reduction plans, tools for assessing vulnerability and risk management, a climate change adaptation planning and management options guide, and a tool to assist municipalities in conducting cost-benefit adaptation assessments.

For HRM, the most significant lesson learned to date, and the greatest success indicator of the initiative, has been the partnership between all three orders of government and the private sector. Project partners have been able to effectively focus and co-ordinate efforts, expertise and resources toward developing a comprehensive, integrated approach to incorporate climate change mitigation and adaptation into municipal planning.


KENNETH MCKENZIE (2004)

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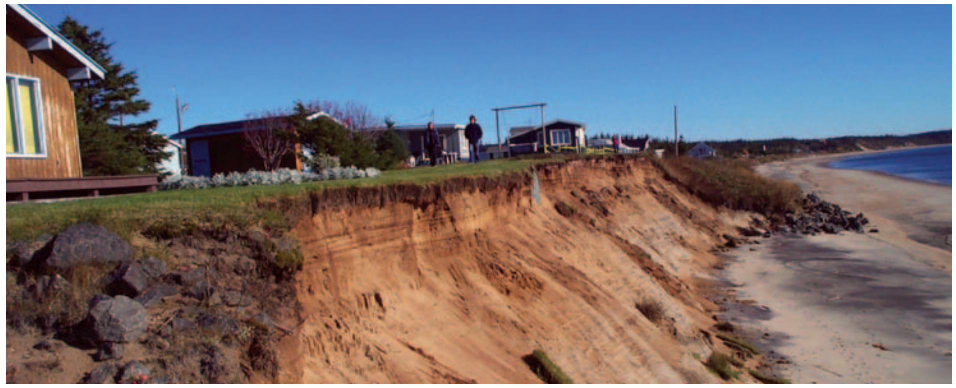


Coping with Shoreline Erosion in Sept-Îles

This example illustrates the collaboration between government decision-makers and researchers in defining adaptation strategies to reduce the impacts of climate change.

Along the shoreline, some owners are experiencing land loss of up to 8 m per year.

In Quebec, shoreline erosion primarily affects the estuarine regions and the Gulf of St-Lawrence that extends from Québec city to the Magdalen Islands. Shoreline erosion has particularly significant impacts along the coast of the city of Sept-Îles (population over 28 000), where 80% of the shoreline is comprised of unconsolidated sediment that is very vulnerable to marine erosion. Several community areas built on the Sept-Îles shoreline, in the low-lying coastal plains, are experiencing losses of land of up to 8 m per year. Since these communities are faced with the constant threat of storms, they have put protective structures (such as rock protections) in place as an emergency response. However, several of the structures have exacerbated erosion rates in the adjacent sectors and, as a result, new protective measures are now required.

In order to evaluate the risks and vulnerability of coastal populations exposed to these problems, certain provincial Ministries (*Ministère des Affaires municipales et des Régions*, the *Ministère du Développement durable, de l'Environnement et des Parcs*, the *Ministère de la Sécurité publique*, the *Ministère des Transports*, and the *Ministère des Ressources naturelles et de la Faune*), in collaboration with the *Conférence régionale des élus de la Côte-Nord* (Regional Conference for the North Shore), signed a specific agreement in March 2000. The agreement's purpose was to analyse the status of the shoreline erosion and to design a preliminary integrated management plan for the coast.

From 2000 to 2004, a study of the entire North Shore Region was conducted based predominantly on a time-dependent analysis of aerial photographs that dated back 70 years. This approach allowed researchers to determine that average erosion rates during that period were not at all comparable to current rates measured over the last decade, which are much higher. Most coastal dynamic researchers agree that the current climate is altering the historical erosion rates. Sea level rise, the reduction of sea-ice cover coupled with the shorter sea-ice period, and increases in cyclonic activity (storms), as well as several other climate-related factors are thought to be contributing to a probable increase in the erosion rates for the entire Gulf of St-Lawrence. Nevertheless, the increase in erosion will not be the same everywhere, and is expected to vary according to the type of coastal shoreline and its vulnerability to climate processes.

Consequently, efficient management of shoreline areas will depend, to a large extent, on our capacity to evaluate the impacts of climate change on coastal regions.

In order to validate these hypotheses, a group of experts from the Ouranos Consortium was asked to explore different adaptation measures with regard to climate change impacts on the occurrence of shoreline erosion. With the technical support of Ouranos experts, several committees of coastal area stakeholders and user groups from three study areas in the Gulf (including Sept-Îles) were formed to evaluate possible adaptation strategies for the region. This evaluation is currently being conducted on the basis of erosion scenarios considered optimistic (S1), moderate (S2) or pessimistic (S3), which in turn are based on projections of the historically observed rates of erosion. Over the course of the project, the climate and oceanographic analysis as well as coastal dynamic studies will allow researchers to identify which of the scenarios studied are the most probable in a future climate, and to support the corresponding preferred adaptation measures.

While experts are working on improving the scientific knowledge of the evolution of the maritime climate and its impacts on the coast, the city of Sept-Îles - already in the clutches of a growing problem - had to take action. Three main initiatives were undertaken (or are currently being undertaken) by the municipality in order to adapt to the challenges posed by the erosion:

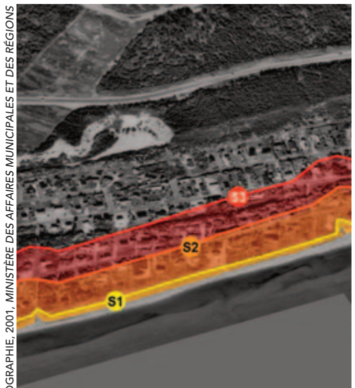
1 In September 2004, following the presentation by government experts of the risk analysis, the city set about informing its population of the trend. Four public sessions, attended by 400 citizens, were held in order to explain the phenomenon of the erosion, as well as to release the results of the shoreline erosion study.

2 In the spring of 2005, the regional county municipality of Sept-Rivières used erosion maps to determine "areas at risk", which were established for a 25-year future time horizon. These maps were used to implement a temporary control measure that provides guidelines for permitted and/or disallowed structures to be built in the protected areas (whose width varies between 20 and 135 meters depending on the area). Given the current knowledge of the risks involved, it is important to limit development and to prohibit all new construction in the erosion-affected areas. This approach was the first phase of an adaptation and risk management strategy At a future date, and based on the outcomes of the study undertaken by Ouranos researchers, the protected areas may be modified and either widened or narrowed.

3 A technical committee, comprised of representatives from the provincial government, the regional county municipality and the city, is working to establish a master plan for coastline intervention, in order to deal with erosion and coastal management problems over the short, medium and long terms. The plan consists of recommendations for each of the city's coastal areas, an intervention scenario that entails either the implementation of protective measures (riprap, beach development and nourishment, groins, reconstruction of adjacent dunes), or actions related to a gradual withdrawal and relocation of buildings and roads. This master plan, established with a 25-year time horizon, will be the subject of a cost-benefit analysis and will be based on climate change projections established by the work on coastal erosion completed by the Ouranos Consortium group.

Shoreline erosion is a complex problem that affects several sectors, which is why the contribution of all stakeholders is needed. The Sept-Îles community is being assisted by the technical support of government departments and climate change scientists. This dynamic combination will allow appropriate adaptation strategies for anticipated future impacts to be established. Until then, the municipality is advocating the precautionary principle by establishing temporary legislation.

ORTHOPHOTOGRAPHIE, 2001, MINISTÈRE DES AFFAIRES MUNICIPALES ET DES RÉGIONS



Projected scenarios of risk zones

S1 **Optimistic scenario** Average rate of erosion of the past 70 years

S2 **Moderate scenario** Maximum rate of erosion for a 10 year period

S3 **Pessimistic scenario** S3=2 S2-S1

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Iqaluit's Sustainable Subdivision

This example illustrates the benefits of collaboration between municipal governments and the scientific community.

Building Iqaluit's climate change resiliency will require careful evaluation of how the community currently deals with climate and environmental hazards, and whether these mechanisms will be adequate in the future.

Iqaluit is the capital city of Canada's newest territory, Nunavut. This Arctic city has a relatively low mean annual temperature of minus 10°C. Although the region has experienced changes in snow and sea ice conditions and weather variability in recent years, air temperatures have not yet changed appreciably. Climate models project that temperatures will be 1.5 - 4°C warmer by the 2050s, which will lead to even more significant changes to the land and the sea. In addition, it is projected that average annual precipitation may increase by up to 15 per cent.

A small city by Canadian standards, Iqaluit is developing fast. In 2001, the population was just over 5,000, a 24 per cent increase from 1996. By 2022, municipal planners estimate that 1,600 new housing units will be required to accommodate the growing population. In response, Iqaluit initiated planning in 2003 for a new subdivision to accommodate 370 new residential units on a large undeveloped plateau.

CLIMATE OBSERVATIONS BY THE INUIT

Inuit from Iqaluit have reported a range of changes in local climate and environmental conditions:

- Snowfall amounts and accumulation are declining, and changes in the characteristics of snow have been noted
- Permanent snow patches, an important source of drinking water for hunters and travellers, are disappearing
- Wind is increasingly variable and unpredictable
- Sea ice is thinner, forms later, and melts earlier and faster in spring

Collectively, these changes have significantly affected the productivity, timing, and safety of traditional hunting and other land-based activities, which are integral to Inuit identity, health and well-being.

The plateau subdivision was designed with specific targets for environmental sustainability (especially greenhouse gas reduction), and a focus on minimizing the environmental footprint of new buildings and services. Sustainability criteria included special consideration of the site's physical conditions and local microclimate to help design resilient, safe and energy-efficient structures. The City also considered new and creative measures to address potential impacts of current and future climate variability on the subdivision's infrastructure and services.

Planners are implementing innovative approaches in defining and reducing the new subdivision's exposure to wind. Wind conditions in Iqaluit are strongly affected by channelling effects and variability of the local topography. As a result, wind data from the local Environment Canada weather station (the only source of wind data for development planning) are not reflective of conditions at the site of the subdivision. To collect more accurate site-specific data, municipal planners collaborated with a local research institute, installed an automated weather station on-site, and collected wind-speed and wind-direction data. The information is being used to align roads and buildings in the direction of prevailing winds to minimize snowdrifts and help reduce a building's heat loss to wind. This adaptive strategy is in accordance with the energy-efficiency objectives of the development plan.

Potential future impacts of climate change on terrain stability were also considered in deciding whether the sewer and water lines servicing the subdivision would be placed above ground or below. City officials acknowledged that average surface and ground temperatures in Iqaluit will likely increase in future, which could increase the depth of the permafrost active layer. Buried water and sewer lines in ice-rich clay soils would then become more susceptible to buckling. It was determined that the known benefits of burying the sewer and water pipelines outweighed the unknown potential risks associated with future climate change impacts. Burying the lines would protect them from large inter-annual temperature fluctuations above ground, while minimizing wear and tear.

Further, municipal officials acknowledged the need for more in-depth information on how local climate conditions are changing at present and what changes are expected in the future. This will help define how and to what extent the community may be vulnerable. For example, city engineers are interested in obtaining active-layer monitoring data from a local ground-temperature station to determine how permafrost conditions are changing relative to surface air temperature.

Building Iqaluit's climate change resiliency will require careful evaluation of how the community currently deals with climate and environmental hazards, and whether these mechanisms will be adequate in the future. Tools to incorporate future climate scenarios in engineering design and municipal development planning processes are especially important. It is also important to acknowledge that climate-related hazards represent one piece in a puzzle of many stresses: socio-economic, demographic, climate and other environmental stressors. The challenge will be in effectively integrating climate change adaptation needs in a range of development initiatives, many of which may not seem to pertain directly to climate or the environment.

City officials look forward to continuing their collaboration with the scientific community in assessing Iqaluit's adaptive capacity and to deal with climate-related hazards, today and in the future.

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BELBIN AND CLYBURN, 1998

Annapolis Royal's Tidal Surge Project

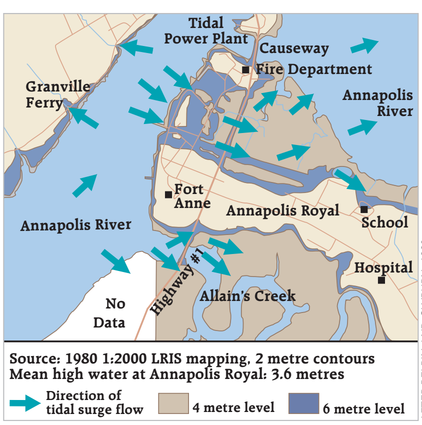
This example illustrates the kind of practical steps that even small communities with limited capacity can take to reduce their vulnerability to climate change.

CARP discovered that a tidal surge during a severe storm was a rare but real threat to coastal zones in their region.

Annapolis Royal, Nova Scotia, is a small coastal community located on the southern shore of the Bay of Fundy. It is vulnerable to flooding because much of the region is below sea level as a result of Acadian settlers using dykes to reclaim land from the sea during the 17th century, and the fact that land has been naturally sinking for thousands of years.

It is anticipated that climate change will cause coastal communities to experience a rise in sea level and an increase in the frequency and intensity of storm surges and coastal erosion. Annapolis Royal residents wanted to know whether the risk of flooding would increase in the future and what infrastructure, such as roads, bridges and buildings, would be vulnerable.

To fill these knowledge gaps, the Tidal Surge Project (the coastal flooding component of the Annapolis Climate Change Outreach Project) was undertaken in 1998. With minimal resources, a citizens-based group, Clean Annapolis River Project (CARP), conducted an assessment of the town's vulnerability to storm surges. The primary goal was to identify and gather information on potential threats, including floods during times of extreme tides and storm surges, so the community could put appropriate emergency-response plans and procedures in place.



AFTER BELBIN AND CLYBURN, 1998

CARP discovered that a tidal surge during a severe storm was a rare but real threat to coastal zones in their region, particularly if it occurred concurrently with an unusually high tide (the latter happens several times each year). Using future climate change scenarios and resulting sea level rise predictions, storm surge floods were mapped at four and six metres above mean sea level (see map). With the information gathered, CARP was able to identify wide potential risk zones for tidal surge flooding and some possible implications for people living in the region.

In response, adaptive planning measures have been taken. For example, the detailed maps outlining potential flood zones effectively demonstrated the need for proper dyke maintenance, and the need to raise these structures has been acknowledged by the provincial government. The maps also enabled Annapolis Royal to identify areas of particular concern and to take measures to reduce potential economic loss and human harm. The mapping process revealed that the Fire Department was situated on a small rise, which would prevent it from being flooded during extreme weather. However, it would also become an island, isolated from the rest of the community. The Fire Department's emergency response plans have since been modified, including rehousing much of the rescue equipment (previously stored solely at the station) to deal more effectively with areas that could become isolated during a flood. The Fire Department has also acquired a boat.

THE CHALLENGE OF FINDING CRITICAL DATA

The Clean Annapolis River Project (CARP) searched records from museums, newspapers, and historical societies to discover the types of events that had occurred in the past and to estimate changes in climatic and tidal factors. This information was compiled into a 10-page list of major storms, which was further narrowed down to those that had a storm surge component. The Saxby Gale of October 4-5, 1869, the most severe, was used as a model for flood predictions.

Finding precise elevation data was also crucial to the project. Digital mapping was rejected as a source of elevation data because of inaccuracies and lack of detail. The standard contour interval in the 1:10 000 digital map packages is five metres, which can legally be anywhere between 2.5 and 7.5 metres. This is significant when a few centimetres can be the difference between a disastrous flood and a non-event. Instead, CARP obtained 20-year-old, 1:2000 scale paper maps with 2 m contours and 1/10 m spot elevations. With this more detailed information, they were able to determine the locations at most risk from tidal surge flows and the areas most in danger of flooding.

The results of the project were presented to citizens in a series of public forums. The mock disaster scenario that followed engaged the town's fire, medical, and emergency response teams. The public was also involved, allowing citizens to observe the potential effects that a flood might have on their lives and enabling them to explore how to minimize property damage and harm during a real disaster. As a result of this public-outreach effort, one homeowner particularly at risk decided to renovate and raise his home by more than half a metre.

BELBIN AND CLYBURN, 1998

This project led to a number of spinoffs, including further research to produce more precise elevation data. The Centre of Geographic Sciences (COGS) in nearby Lawrencetown has worked with LIDAR and Sidescan radar to gain a more accurate picture of the shoreline. Most significantly, the provincial Emergency Measures Organization (EMO) has begun to closely monitor the patterns and heights of the tides throughout Nova Scotia.

CARP's Tidal Surge Project demonstrated that even with limited resources, communities can reduce the uncertainty of climate change effects and find ways to adapt. Because Annapolis Royal is sinking and storm surges have been known to cause floods in the past, the adaptations recommended by this vulnerability assessment (raising the dykes, relocating emergency equipment, revising and practicing emergency response plans, etc.) will provide benefits regardless of impacts brought on by climate change.

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MOVING FORWARD WITH PLANNED ADAPTATION

It is important for all orders of government to address their preparedness for anticipated climate change impacts by assessing the vulnerability of the infrastructures for which they are responsible. A proactive approach that accounts for climate change impacts in policy and program development, and in planning processes, may avoid the significantly higher costs associated with reactive measures. A proactive approach also enables effective adaptation strategies through no- or low-regrets options.

Adaptation to climate change is essential for municipal governments to protect the well-being of citizens and to manage public resources effectively. Successful adaptation measures require planning and appropriately resourced strategies. Often, the expertise exists within municipalities to assess its vulnerability to climate change. Furthermore, existing programs and policies can be used to address climate change issues.

Whether a municipality is just starting to think about adaptation, ready to take the next step and carry out a vulnerability assessment, or preparing to plan and implement a comprehensive climate change adaptation strategy, there are information resources to help. As a start, Appendix B includes a selection of Web sites and resources on climate change impacts and adaptation, ranging from material created for a general audience to resources intended for the scientific community. General information is readily accessible, and regionally specific resources are constantly evolving as more information becomes available.

For more information on vulnerability assessments or other steps to integrate climate change considerations into municipal decision-making, contact the nearest regional office of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN). The regional offices are listed on C-CIARN's Web site at www.c-ciarn.ca.

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APPENDIX A: CLIMATE MODELS

Climate models and scenarios: tools to glimpse the future

The scientific understanding and prediction of anticipated changes in our future climate (and its associated variability) is an evolving research field with much work still to be done. However, a clear picture of the expected global climate is emerging, with an increasing degree of confidence in the prediction of climate trends at the regional level. Climate models are the primary tools used to assess future climate.

Climate models are computer programs that simulate the climate system's behaviour based on the fundamental laws of physics. They are the best available representation of our planet but remain a simplified version of climate control processes. There are two types of models: Global Climate Models (GCMs), which simulate coarse planet climate dynamics with a horizontal spatial resolution in the order of 400 x 400 km, and Regional Climate Models (RCMs), which cover a limited area with a finer resolution of roughly 50 x 50 km.

Simulations from the Canadian Global Coupled Circulation Model (CGCM2) are used to provide the boundary conditions for two versions of the Canadian Regional Climate Model (CRCM) in Figures 1 and 2.These show the differences in mean temperature and precipitation patterns of the future period (2041-2063) compared to the historical period (1961-1990).

The CRCM results stem from an ensemble of 3 pairs of simulations (consisting of past and future). One pair assumes a medium-level of global socio-economic growth and no change in the relative consumption of renewable versus non-renewable energy resources (IS92a scenario, IPCC 1992). The two other pairs are generated with two different CRCM versions from a scenario of slow economic growth and few technological developments (SRES A2, IPCC 2000).

Figures 1 and 2 represent a possible future Canadian climate. Simulations from other RCMs, which may use different nesting data (GCM), different periods or different greenhouse gas (GHG) emission scenarios, may produce results not identical to those shown here. Moreover, each climate model contains inherent uncertainties related to the hypotheses and the simplifications of the reality on which it is based. Consequently, municipal governments would be wise to ensure that several climate models and scenarios are used to evaluate and compare different climate change outcomes for their specific region. It should be noted that changes in average seasonal rainfall are insufficient to assess changes in drought or flood conditions for a specific area. These events require a detailed analysis of daily local precipitation distribution.

Climate models and climate scenarios are part of a suite of tools that can be used to determine likely climate changes for a given region. Climate models provide the virtual meteorological data that feeds into the construction of climate scenarios.

TO FIND OUT MORE...

Canada is among the world's leaders in the development of climate models and climate scenarios. These resources provide information on our current understanding of future climate change, the work now underway, and future research directions.

The Canadian Centre for Climate Modelling and Analysis (CCCma) has developed numerous climate model versions of the Canadian global model, provides climate data for these models, and distributes data for the CRCM. **WWW.CCCMA.BC.EC.GC.CA/DATA/DATA.SHTML**

The Ouranos Consortium Climate Simulations team develops the Canadian Regional Climate Model (CRCM) and uses multiple climate models to provide regional climate projections. **WWW.OURANOS.CA**

The Canadian Climate Impacts Scenarios (CCIS) Web site distributes and provides guidance for using climate change scenarios. **WWW.CICS.UVIC.CA/SCENARIOS/**

The Climate Change Scenarios Network (CCSN) adds information on impacts and adaptation research from national and regional perspectives. **CCSN.CA**

APPENDIX B: INFORMATION AND RESOURCES

Useful Climate Change Web Sites

CLIMATE CHANGE

The following sites provide general information on climate change science, greenhouse gases and emissions, and taking action on climate change.

Government of Canada Climate Change: www.climatechange.gc.ca

Climate Change Impacts and Adaptation Program (CCIAP)
This site provides information about funding for research and activities that improve our knowledge of Canada's vulnerability to climate change. Summary information about projects funded under the program is also presented.
adaptation.nrcan.gc.ca

Environment Canada Climate Change: www.ec.gc.ca/climate/

CLIMATE CHANGE IMPACTS

The impacts of climate change on communities and lifestyles, by region, across Canada:
adaptation.nrcan.gc.ca/posters

Canadian Climate Impacts and Adaptation Research Network (C-CIARN)
This site provides information on the impacts of climate change and adaptations for Canada, by sector and region, and provides networking opportunities with researchers and stakeholders interested in adaptation. www.c-ciarn.ca

Canadian Institute for Climate Studies (CICS)
This site provides stakeholders with climate scenario information and scenario construction advice to impacts researchers in Canada.
www.cics.uvic.ca/scenarios/

Climate Change Scenarios Network (CCSN)
The CCSN is Environment Canada's vehicle for distributing climate change scenarios and adaptation research from national and regional perspectives. www.ccsn.ca

Climate Change Hub Gateway
This gateway provides links to provincial climate change information Web sites. The hubs have been established in most provinces and territories across Canada to reflect local needs. Their primary focus is on sharing information tools and best practices of climate change outreach activities and programs, and raising awareness of climate change, its impacts on communities and people's lives, and the actions that can be taken to adapt to climate change and to mitigate its impacts. nccp.ca/NCCP/cchg/index_e.html

Federation of Canadian Municipalities (FCM)
Under Sustainable Communities, look up national programs and funding initiatives for municipalities, such as the Partners for Climate Protection Program.
www.fcm.ca

Ouranos Consortium
Ouranos develops and adapts the necessary tools to provide decision-makers with detailed climate change scenarios on a regional scale. It also performs evaluations of expected sectoral impacts to optimize adaptation strategies. The Climate Simulations team at Ouranos develops and uses CRCM to provide regional climate data.
www.ouranos.ca

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APPENDIX C: CLIMATE CHANGE TERMINOLOGY

Adapted from IPCC 2001, with additions

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects that moderate harm or exploit beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptation benefits: The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures.

Adaptation costs: Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs.

Adaptive capacity: The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Climate scenario: A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information, such as the observed current climate. A "climate change scenario" is the difference between a climate scenario and the current climate.

Climate projection: A projection of the response of the climate system to emission or concentration scenarios of GHGs and aerosols, or radiative forcing scenarios, often based on simulations by climate models. Climate projections are distinguished from climate predictions to emphasise that climate projections depend on the emission/concentration/radiative forcing scenario used, which is based on assumptions about, for example, future socio-economic and technological developments that may or may not be realized and are therefore subject to uncertainty.

Climate variability (CV): Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Greenhouse gas (GHG): Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere.

Hazard: A field of certain threats or impacts, which exist regardless of the availability of object or element (i.e., recipient) exposed to the impact (compare with gravitational, electromagnetic or radiation fields).

Hazard identification: The process of recognizing that a hazard exists and defining its characteristics.

Mitigation: A human intervention to reduce the sources or enhance the sinks of GHGs

Precautionary principle: It absorbs notions of risk prevention, cost-effectiveness, ethical responsibilities toward maintaining the integrity of human and natural systems, and the fallibility of human understanding. The application of the precautionary principle or approach recognizes that the absence of full scientific certainty shall not be used to postpone decisions where there is a risk of serious or irreversible harm.



Residual risk: The risk that remains after all management options have been exhausted.

Resilience: The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Risk: A function of the probability and consequences (i.e., magnitude and severity) of an adverse event or hazard.

Risk communication: Any two-way communication between stakeholders about the existence, nature, form, severity, or acceptability of risks.

Risk control option: An action intended to reduce the frequency and/or severity of injury or loss, including a decision not to pursue the activity.

Risk information library: A collection of all information developed through a risk-management process. This includes information on the risks, decisions, stakeholder views, meetings and other information that may be of value.

Risk management: Decisions to accept exposure or to reduce vulnerabilities by either mitigating the risks or applying cost-effective controls.

Risk perception: The significance assigned to risks by stakeholders. An individual's or group's perception, or belief, that a particular event or hazard is a threat (usually to human health or property). Perceptions of risk are generally determined by one's values, attitudes, socio-economic class, gender, and other factors. In this sense, risk is often said to be "socially constructed".

Risk scenario: A defined sequence of events with an associated frequency and consequences.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.