Partners for Climate Protection

Municipal Resources for Adapting to Climate Change

ICLEI Local Governments for Sustainability

FCM | Green Municipal Fund / Fonds municipal vert

Ce document est aussi disponible sous le titre
Ressources municipales servant à s'adapter au changement climatique.

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Introduction

The Partners for Climate Protection (PCP) program is a partnership between the Federation of Canadian Municipalities and ICLEI — Local Governments for Sustainability. PCP is the Canadian component of ICLEI's Cities for Climate Protection™ (CPP) Campaign, which involves more than 900 communities internationally. In Canada, over 180 municipal governments are involved in the PCP program, which uses a five-milestone framework to guide communities in assessing and reducing greenhouse gas emissions.

Municipal officials have expressed a need for more information, resources and tools on climate change adaptation. To address this need, PCP asked ICLEI Canada and the Clean Air Partnership (CAP) to do the following research.

The purpose of this resource is to provide information to PCP members and other municipal officials about municipal adaptation initiatives and to provide resources for municipal officials who wish to undertake adaptation planning.

CAP has worked closely with the City of Toronto in the development of Toronto's climate change adaptation plan. CAP is also the convener for the Alliance for Resilient Cities, a network of municipal governments and other organizations that meet via bimonthly webinars to discuss climate change impacts of significance to Canadian municipalities, climate change risk assessment, adaptation planning and specific adaptation strategies. CAP has published four research reports related to climate change impacts and adaptation:

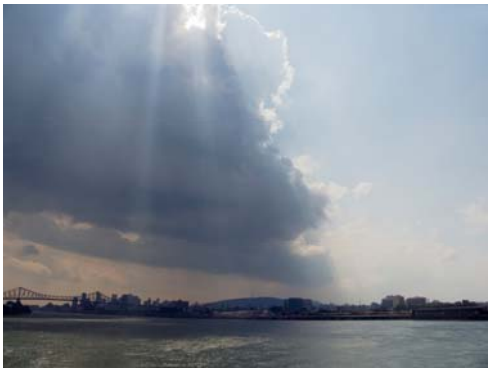
- A Scan of Climate Change Impacts on Toronto
  www.cleanairpartnership.org/pdf/climate_change_scan.pdf
- Cities Preparing for Climate Change
  www.cleanairpartnership.org/pdf/cities_climate_change.pdf
- Time to Tackle Toronto's Warming
  www.cleanairpartnership.org/pdf/time_to_tackle_toronto_warming.pdf
- Climate Change Adaptation Options for Toronto's Urban Forest
  www.cleanairpartnership.org/pdf/climate_change_adaptation.pdf

Two more reports are in progress.

ICLEI Canada has a long history of working on climate change mitigation. Reflecting members' needs and interests, it has expanded its climate lens in recent years to include adaptation. As FCM's partner in the PCP program, ICLEI provides technical support on greenhouse gas (GHG) mitigation to PCP members working through PCP's five-milestone process. ICLEI's technical support includes inventory and emission tracking methodologies, target-setting strategies, and processes for designing and implementing local action plans.

Impacts of climate change on Canadian municipalities

Canada is vulnerable to a range of impacts associated with climate change, including rising temperatures, more frequent, intense storms and rising sea levels. These changes are already being felt in towns and cities across the country. Some of the effects are arriving gradually — thawing permafrost in the North, for example, and the expanding range of disease vectors and insect pests as winters warm. Weather-related emergencies such as heat waves, smog days, floods, droughts and forest fires are on the rise. Municipal services and infrastructure are increasingly affected by these events. Though municipalities have focused their climate change efforts mainly on mitigation, it is not too soon to begin assessing their vulnerability to the changes that are already underway and to develop responses that protect their citizens, local environments and economies.



A huge cloud formation sweeps over a sunny day in Montréal, as seen from the St. Lawrence River. Extreme weather events are expected to increase as a result of climate change.

A residential street after an ice storm in Ottawa. An ice storm can devastate a community by bringing down power lines and harming vegetation.

Although climate change creates many common challenges for communities (e.g. the effects of more intense storms on infrastructure or the increased number of smog days), there are major differences in the way it will unfold in diverse regions. Information about expected impacts has been summarized by Natural Resources Canada for six broad regions of Canada in *From Impacts to Adaptation: Canada in a Changing Climate 2007* (www.adaptation.nrcan.gc.ca/assess/2007/index_e.php). However, even within these regions, the impacts of climate change will be affected by local weather patterns, topography, nearby bodies of water, development patterns and other factors. For this reason, it will be important for municipalities to take some time to investigate the specific risks for their communities.

Linkages to climate mitigation programs

Though climate change mitigation and adaptation strategies are linked by a common concern about climate change and its impacts, the types of assessment and the preventive actions required for adaptation are for the most part significantly different than for mitigation. For example, the development of a mitigation strategy begins with an emissions inventory, which involves assessing electricity and fossil fuel use, transportation and waste disposal. The development of an adaptation strategy begins with an assessment of climate vulnerabilities — to heat, precipitation, extreme weather, wind speed, sea-level rise, melting permafrost, changes in climate zones that affect plant, animal and insect species, and other factors. Although both involve a type of inventory and both are linked to climate change, they require very different sets of knowledge and skills.

The purpose of a mitigation strategy is to find ways to reduce or eliminate energy and fossil fuel use and to manage waste differently. While there is always room for innovative new strategies in these areas, a great deal of work has been done on ways to reduce GHG emissions over several decades and an array of mitigation strategies is available to municipal governments. The same cannot be said for adaptation. Much less is known about the short- and medium-term impacts of unavoidable climate change, and the world is still in the early days of developing solutions. Protecting people, infrastructure and ecosystems from climate change appears to be inherently more complex, partly because of the increased variability and extremes in weather introduced by climate change and partly because of the breadth and uncertainty of possible impacts. It will take a number of years before Canada has a well-established suite of strategies to which communities can refer when developing comprehensive adaptation programs.

In spite of the differences, there appears to be value in linking climate change mitigation and adaptation programs. Many actions support both mitigation and adaptation. For example, expanding urban forests and green space cools urban environments, leading to reduced GHG emissions from air conditioning. The same measure also reduces the potential climate change impacts of heat, air pollution and flooding. Similarly, increasing building insulation decreases GHG emissions from heating and cooling, and also increases comfort for inhabitants during extreme heat events. Such combined programs could also be more cost efficient for municipalities interested in both issues. There are many other examples of synergistic solutions that are more likely to be integrated into community planning if synergies are actively sought by both mitigation and adaptation planners.

Adapting to climate change in Canada and abroad

Listed in the table below are a number of Canadian and international communities that have begun work on assessing their vulnerability to climate change, on adaptation planning, or both. Some of these communities are at a very early stage in climate change risk assessment or adaptation planning. Some are focused on just one or two climate change impacts that have already begun to manifest locally.

Communities undertaking adaptation activities	
Canadian communities	**International communities**
*Calgary, Alta.	Anchorage, Alaska
Capital Regional District, B.C.	Chicago, Illinois
Clyde River, Nunavut	Fort Collins, Colorado
Dawson City, Yukon	Heidelberg, Germany
*Delta, B.C.	Homer, Alaska
*Edmonton, Alta.	Keene, New Hampshire
*Halifax, N.S.	London, United Kingdom
*Iqaluit, Nunavut	Los Angeles, California
*London, Ont.	King County, Washington
*Metro Vancouver, B.C.	Melbourne, Australia
*Montréal, Que.	Miami–Dade, Florida
*Oakville, Ont.	Milwaukee, Minnesota
*Ottawa, Ont.	New York, New York
*Peel Region, Ont.	Phoenix, Arizona
*Pickering, Ont.	Rotterdam, the Netherlands
*Port Alberni, B.C.	San Francisco, California
*Prince George, B.C.	Växjö, Sweden
*Portage la Prairie, Man.	
*Richmond, B.C.	
*St. John's, N.L.	
*Sudbury, Ont.	
*Toronto, Ont.	
*Vancouver, B.C.	
*Yellowknife, N.W.T.	
*York Region, Ont.	

*Canadian municipalities marked with an asterisk are PCP members.

Listed in the table below are a number of organizations that have strong links to municipalities, are looking to serve municipalities or are working on climate change risk assessment or adaptation planning.

Organizations working with Canadian communities on adaptation planning	
Alliance for Resilient Cities www.cleanairpartnership.org	Institute for Catastrophic Loss Reduction www.iclr.org
Canadian Institute of Planners www.cip-icu.ca	Northern Climate Exchange www.taiga.net/nce
Clean Air Partnership www.cleanairpartnership.org	Ontario Centre for Climate Impacts and Adaptation Resources www.climateontario.ca
ClimAdapt (Atlantic Canada) www.climadapt.com	Ouranos (Québec) www.ouranos.ca
Climate Change Impacts and Adaptation Division, Natural Resources Canada www.adaptation.nrcan.gc.ca	Pacific Climate Impacts Consortium www.pacificclimate.org
Columbia Basin Trust (B.C.) www.cbt.org	PEI Coastal Impact Group
Dillon Consulting www.dillon.ca	Pembina Institute www.pembina.org
EarthCare Sudbury www.city.greatersudbury.on.ca/earthcare	Prairie Adaptation Research Collaborative www.parc.ca
Ecology North www.ecologynorth.ca	Public Infrastructure Engineering Vulnerability Committee (Engineers Canada) www.engineerscanada.ca
Environment Canada www.ec.gc.ca	The Sheltair Group www.sheltair.com
Grand River Conservation Authority www.grandriver.ca	Toronto and Region Conservation Authority www.trca.on.ca
ICLEI Canada www.iclei.org/canada	Urban Leaders Initiative www.ccap.org
Indian and Northern Affairs Canada www.ainc-inac.gc.ca	Walpole Island First Nation www.bkejwanong.com

Communities undertaking adaptation activities

Municipal government adaptation strategies are at an early stage. More and more municipalities are recognizing the importance of addressing climate change impacts and adaptation, but to date there is no consistent approach, nor are there extensive resources and tools to help municipalities assess their vulnerabilities to climate change. To date, only London (U.K.) and Halifax have published detailed investigations into the range of risks that climate change poses for their communities. Sudbury and Toronto are currently conducting research in this area. Delta and its research partners at the University of British Columbia have thoroughly investigated the critical risk of sea-level rise for the community, though more information may be needed about other climate risks.

London (U.K.) started adaptation planning earlier than any of the other municipalities, and has gone the furthest with its planning to date. London has initiated a community resilience effort, conducted a community resilience or vulnerability study and developed goals and a preparedness (or adaptation) plan. London has also formally incorporated climate change impacts and adaptation into its official plan, and has embarked on a number of pilot projects to test specific adaptation strategies.

Halifax is well along in planning for adaptation, having completed a climate change risk management strategy, Climate SMART, which includes adaptation planning (www.halifax.ca/Climate/index.html). The city has launched guides and voluntary programs as part of implementing its adaptation plan.

Toronto's effort is more recent, but the city has begun adaptation planning. Toronto has an interdepartmental adaptation team that meets regularly. Of all the Canadian communities surveyed, Toronto may have the strongest mandate to move forward with the adaptation process. For more information, see Toronto's Climate Change Adaptation Strategy (www.toronto.ca/legdocs/mmis/2008/pe/bgrd/backgroundfile-12950.pdf).

Delta also appears to have embraced adaptation planning, particularly around issues related to sea-level rise.

Resources used in impact assessment and adaptation planning

Although resources and tools are still underdeveloped, a few useful resources are available for municipalities. The following resources can help municipalities better understand the major climate changes that are beginning to occur and some of the expected impacts:

- *Impacts, Adaptation and Vulnerability* (Intergovernmental Panel on Climate Change, April 2007) (www.ipcc.ch/ipccreports/ar4-wg2.htm).
- *From Impacts to Adaptation: Canada in a Changing Climate 2007* (Natural Resources Canada, 2007) (www.adaptation.nrcan.gc.ca/assess/2007/index_e.php).

A number of guides have been produced in recent years to help local governments assess climate change vulnerabilities and risks, and plan and implement adaptation strategies:

- *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* (King County, Climate Impacts Group and ICLEI USA, 2007). Four communities — Delta, St. John's, Sudbury and Keene, New Hampshire — served as pilot communities where some of the tools in this guide were tested (http://cses.washington.edu/db/pdf/snoveretalgb574.pdf).
- *Climate adaptation: Risk, uncertainty and decision-making* (U.K. Climate Impacts Programme (UKCIP, 2003) (www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf).
- *Preparing for climate change: A guide for local government in New Zealand* (New Zealand Climate Change Office, 2004) (www.mfe.govt.nz/publications/climate/preparing-for-climate-change-guide-for-local-govt/index.html).
- *Climate Change Impacts & Risk Management: A Guide for Business and Government* (Australian Government, 2006) (www.climatechange.gov.au/impacts/publications/risk-management.html).

Municipalities using the King County/ICLEI USA guidebook and the UKCIP guide listed above have described them as useful but lengthy and targeted to larger municipalities. Resources tailored to smaller municipalities still need to be developed.

In addition to these guides, several other resources have been useful to municipalities undertaking climate change vulnerability or risk assessments and adaptation planning:

- *Climate Change Impacts and Adaptation: A Canadian Perspective* (Natural Resources Canada, 2004) suggests a "vulnerability approach" for assessing climate risks and provides suggested adaptation responses for a number of sectors (www.adaptation.nrcan.gc.ca/perspective/index_e.php#toc).
- *Adapting to Climate Change: A Risk-based Guide for Ontario Municipalities* (Bruce, Egener and Noble, 2006) provides a detailed methodology for assessing the risks of climate change and undertaking climate change adaptation planning for municipalities (www.adaptation.nrcan.gc.ca/projdb/pdf/176a_e.pdf).
- *Cities Preparing for Climate Change: A Study of Six Urban Regions* (Clean Air Partnership, 2007) proposes a framework for urban adaptation processes, based on a review of leading cities and urban regions (www.cleanairpartnership.org/pdf/cities_climate_change.pdf). *The Planning Response to Climate Change: Advice on Better Practice* (Office of the Deputy Prime Minister, London, 2004) focuses on incorporating climate concerns and adaptation into local government planning (www.communities.gov.uk/documents/planningandbuilding/pdf/147597.pdf).
- *Adapting to Climate Change: An Introduction for Canadian Municipalities* (Climate Change Impacts and Adaptation Research Network, 2006) provides an introduction to climate impacts, including case studies (www.c-ciarn.ca/adapting_e.html). This resource is targeted to elected officials.
- The City of Toronto's Climate Change Adaptation Reference Collection, developed with the help of the Institute for Catastrophic Loss Reduction, may be useful to other communities (www.toronto.ca/teo/climate_change_adaptation/index.htm).

Most of the above resources provide a detailed step-by-step approach to climate change impact assessment and adaptation planning. There is considerable overlap in their approaches.

Risk assessment tools

Halifax has gone through a formal, comprehensive risk assessment process to evaluate climate change risks. Halifax was motivated to begin developing an adaptation strategy following Hurricane Juan, which did considerable damage to the city in 2003. With the help of ClimAdapt, (a consortium of eight Atlantic Canadian private sector environmental firms and two non-governmental organizations), Halifax was able to secure funds from the federal government to support research and risk assessment related to climate change impacts and strategy development. The city developed a climate change risk assessment tool, drawing on a guide produced by the Canadian Standards Association entitled *Risk Management: Guideline for Decision Makers (CSA-Q850-97 (R2007))* (www.shopcsa.ca/onlinestore/GetCatalogItemDetails.asp?mat=2005912). This risk assessment tool is described in Halifax's *Climate Change Risk Management Strategy* (2007) (www.halifax.ca/climate/documents/ClimateChangeRiskManagementStrategyforHRMDecember2007.pdf*).*

The Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol produced by Engineers Canada is another risk assessment tool being used to assess the vulnerability of individual facilities or types of infrastructure (www.pievc.ca). The types of infrastructure considered include buildings; roads, bridges and other transportation infrastructure; stormwater and wastewater systems; and water resources. Engineers Canada selected Sudbury to use the protocol to assess the vulnerability of its roads to climate change. Yellowknife used the PIEVC Protocol to assess the threat of thawing permafrost to local buildings.

Scientific resources

A variety of scientific resources exist to help municipalities learn about climate change, prepare analyses of expected local impacts and, in some cases, begin evaluating adaptation solutions. Some of these resources include:

- The regional offices of Environment Canada, as well as its Adaptation and Impacts Research Group (www.msc-smc.ec.gc.ca/airg/index_e.cfm).
- The Earth Sciences Sector of Natural Resources Canada (http://ess.nrcan.gc.ca/index_e.php).
- The Canadian Hydrographic Service in the Department of Fisheries and Oceans (www.charts.gc.ca/pub/en/).
- The Pacific Climate Impacts Consortium (http://pacificclimate.org/resources/climateimpacts/).
- Data from the Atlas of Canada (http://atlas.nrcan.gc.ca/sites/english/maps/climatechange) and Natural Resources Canada's CoastWeb (http://gsc.nrcan.gc.ca/coast/index_e.php).
- Projections from the Canadian Centre for Climate Modelling and Analysis (www.cccma.bc.ec.gc.ca/) and from the Canadian Climate Change Scenarios Network (www.cccsn.ca).
- Individual scientists such as Norm Catto at Memorial University and David Pearson at Laurentian University.
- Researchers doing presentations on Alliance for Resilient Cities (www.cleanairpartnership.org/arc) and FCM's Green Municipal Fund™ webinars (www.fcm.ca/gmf).

It is important to note that although Canada has an array of research and scientific resources on climate change, cities are not yet drawing on many of these resources. One reason for this is limited staff time and resources.

Networks

Few communities are well connected to existing climate change research networks or to academic programs studying climate change impacts and adaptation. Municipalities can overcome this problem by joining the FCM–ICLEI Partners for Climate Protection (PCP) program (www.sustainablecommunities.ca/Partners-for-Climate-Protection). PCP is a leading network of Canadian municipal governments that have committed to reducing GHGs and acting on climate change. Through PCP, municipalities can access and share resources on climate change.

The guide produced by King County, the Climate Impacts Group and ICLEI USA, *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments,* provides municipal practitioners with a climate change impacts science primer, U.S. National Assessment regional

summaries, and many sources of information on climate change science, impacts and adaptation (http://cses.washington.edu/db/pdf/snoveretalgb574.pdf). However, this information is largely U.S.-focused.

Networks to support municipalities are also emerging through a number of other routes:

- The Alliance for Resilient Cities established by the Clean Air Partnership (www.cleanairpartnership.org).
- FCM's Green Municipal Fund capacity-building webinars, which include information on adaptation (www.fcm.ca/gmf).
- The new climate change adaptation tools and resources developed by Engineers Canada (www.engineerscanada.ca).
- The Canadian Institute of Planners (www.cip-icu.ca).

The Regional Adaptation Collaboratives program (www.adaptation.nrcan.gc.ca), a cross-Canada program funded by Natural Resources Canada, may also create a stronger connection between climate and adaptation scientists and municipal decision-makers.

In addition to drawing on external networks for discussion of climate change impacts and adaptation, some communities have also consulted internally with previously established internal committees. St. John's involved its Integrated Sustainability Community Planning Committee in work on climate change adaptation; Delta engaged its Interdepartmental Climate Change Working Group; and Yellowknife worked with its Community Energy Plan Implementation Advisory Committee.

London (U.K.) created its own adaptation network of local government and other stakeholders, the London Climate Change Partnership, including a representative from the United Kingdom Climate Impacts Program. London also participates in a regional network, the Three Regions Climate Change Group (www.london.gov.uk/trccg), along with the adjacent East of England and South East England regions. These regional groups pool resources to produce studies and guidebooks that are useful for all.

Summaries of adaptation activities in selected communities

Corporation of Delta, British Columbia

Delta is a low-lying community bordered by the Fraser River to the north and the Strait of Georgia to the west. The community is aware of its vulnerability to climate change. Sea-level rise is of primary concern, considering the fact that the municipality maintains 60 kilometres of dikes. Availability of water for drinking and irrigation is also a concern.

Delta is concerned about the following effects of climate change:

- Increased precipitation.
- More extreme weather events.
- Increased vulnerability to flooding.
- Overall loss of biodiversity as invasive plants and animals replace native species.
- Threats to Delta's dike system and salinization of valuable farm land as a result of rising sea levels.

In 2007, the Delta Council approved Delta's Climate Change Initiative, which has two main goals: to reduce GHG emissions from municipal buildings, fleet vehicles and operations; and to adapt municipal infrastructure and emergency plans to ensure that the community is well-prepared for and protected against climate change impacts.

Some of the specific adaptation activities contained within the initiative include:

- Upgrading dykes to provide extra protection against floods and storm surges.
- Monitoring changes in temperature, nutrients, contamination and biodiversity in creeks and streams that flow from land to sea.
- Tree planting.

For more detailed information, please visit the Corporation of Delta's Climate Adaptation Project website (www.corp.delta.bc.ca/EN/main/residents/771/50845/59147/iclei.html).

Halifax Regional Municipality, Nova Scotia

In its Climate Change Risk Management Strategy, completed in December 2007 and released in April 2008, the Halifax Regional Municipality (HRM) identified a wide range of climate change vulnerabilities and prioritized them based on the probability of their occurrence and the severity of the likely impact (www.halifax.ca/climate/documents/ClimateChangeRiskManagementStrategyforHRMDecember2007.pdf).

High-priority impacts include:

- Coastal zone impacts from sea-level rise and storm surges, causing damage to coastal ecosystems and increased erosion.
- Flooding and damage to buildings and infrastructure from sea-level rise, storm surges and extreme weather events.
- Impacts on port operations.
- Increases in insurance costs and in economic and social costs associated with adaptation.
- Increased risk of forest fire in the urban–rural fringe.
- Increased variability in the quality and quantity of water for agriculture from surface water sources.
- Salt water intrusion into groundwater supplies.
- Spread of vector-borne diseases such as Lyme Disease and West Nile virus.
- Tree blowdown from extreme weather events.
- Storm, hail or drought damage to crops (in rural parts of the municipality).
- Impacts on terrestrial and aquatic biodiversity resulting from temperature and flow changes.

Halifax has been working formally on climate change adaptation since 2004, spurred on by the experience of Hurricane Juan in 2003, followed by the blizzard "White Juan" in 2004.

The formation in 2001 of ClimAdapt (a network of eight Atlantic Canadian private sector environmental firms and two non-governmental organizations interested in climate change adaptation (www.climadapt.com)) was an important precursor to Halifax's work on adaptation. ClimAdapt helped bring together funds and partners for an intensive program of research and development of tools for climate change adaptation decision-making. The resulting Halifax Climate SMART program involves both mitigation and adaptation.

For more detailed information, please visit the Climate SMART website (www.halifax.ca/Climate/index.html).

City of Keene, New Hampshire

The Keene community could be vulnerable to the following climate change impacts:

- Floods from heavy rainstorms (which submerged a third of the city in 2005), affecting buildings, roads, culverts and bridges.
- More frequent freezing rain, leading to road icing, safety hazards and increased costs for road maintenance.
- Buckling of roadways from increased freeze–thaw events.
- Damage to the wastewater treatment plant from increased stormwater flows.
- Power outages from severe storms and from excess demand due to extreme heat.
- Communication system breakdowns during severe storms or power outages.
- Damage to parks and green spaces due to flooding, wind damage, erosion and quick fluctuations in temperature.
- Damage to wetlands from floods and droughts.
- Dying off of native plant species such as the sugar maple, which cannot adapt to a warmer climate.
- Expansion of invasive pests formerly controlled by cold winters.
- Damage to trees and other plants from ice storms and erratic freeze–thaw patterns.
- Regional food insecurity resulting from climate change impacts on agriculture.
- Decrease in tourism due to reduction in maple syrup production, loss of fall colours and a shorter ski season.

The City of Keene signed onto the Cities for Climate Protection Campaign (CCP) in 2000 and has since developed a Local Action Climate Plan to reduce GHG emissions to 10 per cent below 1995 levels by 2015.

The Keene community is already experiencing the impacts associated with a changing climate. To address these changes, the City of Keene has committed to expanding its climate protection efforts to include climate change adaptation.

Keene is working with ICLEI USA in a pilot project to implement a milestone process similar to the CCP program. The pilot project will assess the community's vulnerability to climate impacts and establish a methodology to enhance its resilience.

Keene's Climate Resilient Communities (CRC) committee used scientific information from three main sources to identify changes in climate that could affect the town. The committee combined this information with local knowledge of existing vulnerabilities to identify specific ways in which the city could be affected by climate change.

For more detailed information, please visit the City of Keene's climate change website (www.ci.keene.nh.us/planning/climatekeene.htm).

Greater London Authority, United Kingdom

London's vulnerabilities were described in a detailed assessment, *London's Warming*, released in 2002 (www.london.gov.uk/gla/publications/environment/londons_warming_tech_rpt_all.pdf). Some of the potential vulnerabilities include the following:

- Higher average temperatures and more heat waves (600 people died in the 2003 heat wave).
- Increased electricity demand for air conditioning.
- Flooding both from extreme precipitation (especially in winter) on the Thames floodplain and from sea level rise and storm surges.
- Water shortages in summer, coupled with increased demand.
- Impacts on the financial sector from domestic and global extreme weather events.
- Worsened air quality from temperature inversions, increased ozone concentrations and higher pollen counts.
- Degradation and loss of habitat in London ecosystems.
- Building and road subsidence and heave (shifting of foundations) resulting from the drying out of clay soils.
- Disruption of transportation as a result of flooding and extreme weather.
- Increased damage from stronger windstorms.

Led by the Greater London Authority, the London Climate Change Partnership (LCCP) was created in 2001 (www.london.gov.uk/climatechangepartnership). LCCP includes representatives of local governments, utilities, transportation, water and health agencies, business associations and environmental NGOs. In addition to the vulnerability assessment mentioned above, LCCP has undertaken sectoral studies of climate change impacts and adaptation options and published several guides to adaptation. Its publications are all publicly available at Greater London Authority's LCCP website.

For more detailed information, please visit the City of London's climate change website (www.cityoflondon.gov.uk/Corporation/LGNL_Services/Environment_and_planning/Sustainability/Climate_change).

City of St. John's, Newfoundland and Labrador

The Atlantic Chapter of *From Impacts to Adaptation: Canada in a Changing Climate 2007* (www.adaptation.nrcan.gc.ca/assess/2007/at/index_e.php) outlines the climate changes expected in the region, including:

- longer, hotter and drier summers
- thunderstorm and lightning activity
- increased storm activity
- more winter and spring precipitation
- stronger winds
- variable snow cover
- decreased fog

St. John's is very concerned about flooding. The city has experienced major floods from extreme weather events in the past, such as Hurricane Gabriel and other storms that normally occur once every 100 or 150 years. Flooding has already done major damage to the city's storm sewage system and this is a primary vulnerability concern.

The city's first formal participation in climate adaptation planning was via ICLEI Canada's Climate Adaptation Pilot Project in 2007, which tested the usefulness of the King County and ICLEI USA publication, *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments*, in the Canadian context. The project involved three workshops with city staff. Staff discussed the guidebook's strategies for conducting a climate impacts and resilience study, identifying priority planning areas for action, setting preparedness goals and developing a preparedness plan.

Although this pilot project has concluded, the city will continue its climate adaptation activities through its Integrated Sustainability Community Planning (ISCP).

For more detailed information, please visit the City of St John's climate change website (www.stjohns.ca/cityservices/environment/climatechange.jsp).

City of Greater Sudbury, Ontario

The following climate changes are projected for Sudbury by 2050:

- average temperature increase of 2–3°C
- shorter snowfall season
- more frequent and intense extreme weather events
- 10–15 per cent increase in annual precipitation
- more rain and less snow
- more extreme heat days
- increased variability in wet and dry periods
- longer growing season

The City of Greater Sudbury has participated in several climate adaptation activities, including the following:

- The city is involved in a project to assess the impacts of climate change on roads and associated structures. This is part of a country-wide project by the Public Infrastructure Engineering Vulnerability Committee of Engineers Canada (www.pievc.ca/e/abo_overview_.cfm). In Sudbury, staff engineers are evaluating whether the city will need to change road pavement standards to cope with forecasted climate impacts.
- The city is working with the Sudbury District Health Unit on the development and implementation of the Hot Weather Response Plan to educate the public about extreme heat and ensure that public spaces with air conditioning are available during heat waves.
- The City of Greater Sudbury has been a participant in ICLEI Canada's Climate Adaptation Pilot Project, a series of workshops to introduce and evaluate the first three milestones in the *Preparing for Climate Change* guidebook.

For more detailed information, please visit the EarthCare Sudbury website (www.city.greatersudbury.on.ca/earthcare).

City of Toronto, Ontario

Toronto's vulnerabilities were first summarized in *A Scan of Climate Change Impacts on Toronto*, published by the Clean Air Partnership in 2006 (www.cleanairpartnership.org/pdf/climate_change_scan.pdf). A number of vulnerabilities were also discussed in *Ahead of the Storm*, a discussion paper prepared to help the city develop its adaptation strategy (www.toronto.ca/teo/pdf/ahead_of_the_storm.pdf).

These documents identified a number of potential impacts, including:

- More hot days and heat waves, with increases in related illness and deaths.
- Increased demand for electricity for air conditioning, and stress on electrical distribution systems.
- Poorer air quality and more smog, with impacts on health and mortality.
- Impacts on water quality from higher water temperatures, decline in lake levels and increased dredging.
- Flooding from intense rainstorms, with damage to buildings, road and utility infrastructure and streams.
- Increased incidence of droughts.
- Expansion of insect vectors that spread infectious disease, as well as pests that attack trees.
- Damage to roads from increased freeze–thaw cycles.

The City of Toronto has begun adaptation planning (see Toronto's Climate Change Adaptation Strategy (www.toronto.ca/legdocs/mmis/2008/pe/bgrd/backgroundfile-12950.pdf). The city has an interdepartmental adaptation team that meets regularly. Of all the Canadian communities surveyed, Toronto may have the strongest mandate to move forward with the adaptation process.

For more detailed information, please visit the City of Toronto climate adaptation website (www.toronto.ca/teo/adaptation.htm).

City of Yellowknife, Northwest Territories

Some of Yellowknife's vulnerabilities to climate change were outlined in an unpublished report prepared for the city by the Pembina Institute (http://communities.pembina.org/partners/yellowknife). These include:

- Freeze/thaw "heaving" of roads and other infrastructure.
- Increased erosion of river banks, depositing sediment into the water supply.
- Higher-intensity storms, which may result in localized flooding.
- More intense and frequent snowstorms and increased cost of road clearing.
- A reduced season for ice roads, which affects mines in the area.
- Greater weight of hoar frost on power lines, which increases the risk of power disruption and increases maintenance requirements.
- Vulnerability of hydroelectricity supply from changes in water levels.
- Changes in insect populations and resulting impacts on health, recreation and the food chain.

Thawing permafrost is also a problem in some areas of Yellowknife. For example, the airport runway required extensive restoration after permafrost began to thaw.

Several adaptation workshops and other events involving City of Yellowknife officials have taken place in the city in recent years, including a one-day workshop on municipal climate change adaptation organized by Ecology North, a local environmental NGO, in March 2006.

Later in 2006, the Pembina Institute approached the City of Yellowknife with an offer to help the city develop the tools, capacity and decision-making processes necessary to address climate change impacts in the community. Pembina secured $70,000 for the project from Indian and Northern Affairs Canada. The institute had previously worked with Yellowknife on the development of a community energy plan.

For more detailed information, please visit the City of Yellowknife's website (www.yellowknife.ca/City_Hall/Committees/Community_Energy_Planning_Committee.html).