GREATER PETERBOROUGH AREA
CLIMATE CHANGE SCOPING DOCUMENT

Lynda Langford
July, 2013

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PREPARED FOR

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CLIMATE CHANGE WORKING GROUP

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EXECUTIVE SUMMARY

Climate change will impact the natural environment as well as human welfare by affecting economies, human health, infrastructure, intergovernmental relations and geopolitical linkages. The Greater Peterborough Area (GPA) Community Sustainability Plan calls for climate change protection which involves both climate mitigation and climate adaptation efforts.

Climate change modeling for Ontario predicts general increases in temperature and precipitation over the coming years. Local modeling for Peterborough projects gradual increases in mean air temperatures and precipitation over the coming decades. For example, the annual mean air temperature for Peterborough is 6.6 degrees Celsius. By 2020 this is expected to increase to 8.0 degrees Celsius and by 2050 9.4 degrees Celsius. Precipitation is expected to show some increases but will be more variable with extreme weather events becoming more common.

Municipalities will have to respond to climate change impacts in order to reduce environmental, economic and social risks. Rising temperatures, variable rainfall and extreme weather events have the potential to damage municipal infrastructure, disrupt municipal programs and services, impact agricultural productivity, stress local ecosystems and wildlife, threaten human health and weaken the local economy. Although there may be opportunities or benefits from climate change, it is anticipated that most impacts will alter existing situations in a negative or unplanned manner.

The Community Sustainability Plan lays out several key actions for climate change protection: public awareness, mitigation, adaptation and the incorporation of climate change adaptation into existing policies and programs wherever possible. These provide a starting point for climate change planning and management for the GPA.

Implementation of these actions is underway but still in the preliminary stages. Public awareness continues to be a challenge. For example, few municipalities in the GPA have any specific mention of climate change on their websites. At the time of writing, Sustainable Peterborough is taking the lead to secure funding to begin mitigation planning. This discussion and scoping document is intended to provide regionally relevant information in support of future climate change adaptation and planning efforts.

A preliminary sensitivity analysis (to climate change) completed for the City of Peterborough points to six key program areas that are potentially significant in terms of adaptation planning: emergency and risk management, sustainability, financial services, engineering and construction, environmental protection (waste water treatment), and public works (storm and sanitary sewers, bridges, culverts, etc.). Although more analysis is required, these program areas should likely be the focus of initial adaptation planning.

Existing management approaches and programs can also be used to promote adaptation: emergency management, infrastructure risk assessment, sustainable asset management, land use planning, municipal corporate planning, transportation planning and flood reduction strategies. Although these initiatives do not, in their current form, specifically address threats from climate change, there are opportunities to incorporate climate change adaptation into existing policies and program content.

Fundamental roadblocks to climate change protection include funding, competing priorities, information and expertise, uncertainty and governance. The upfront costs of mitigation and adaptation for municipalities are a frequently cited barrier to climate change action. Municipal staff, rarely have, climate expertise and the capacity of local municipal offices to handle and integrate regionally specific, climate related information and data is variable. Information is also required in a form that is understandable by municipal staff and the general public. The complexities of climate science and the unpredictability of weather events also discourage action due to uncertainty. Finally, climate change issues affect all levels of government and cut across all departments making it difficult to determine who is ultimately responsible and accountable.

Key requirements include enhanced adaptation research, updated engineering standards to address future conditions, risk assessment protocols addressing climate risks, strengthened emergency preparedness and response systems, simplified adaptation planning approaches, improved information collection and management and stronger leadership and financial support from Ontario Municipal Affairs and Housing,

A set of specific recommendations for the GPA should include such items as: common statements and policies in all official plans, unified planning and development requirements in zoning bylaws, specific strategies and action items to be incorporated into all applicable management plans (e.g. asset management, flood reduction, transportation plan), an infrastructure database for the GPA for emergency planning, the identification of “safe refuge sites” in the area such as arenas, schools or community centres, the integration of emergency plans to cover community and region-wide issues and finally, specific budget planning for disaster management and long-term climate change protection.

It is imperative that governments at all levels assume a leadership role and ensure that adaptation is occurring at a pace and scope that will safeguard our environmental, economic and social heritage.

FORWARD

The average person could be forgiven for not knowing what climate change will mean, particularly at a local, Peterborough, scale. This is complex and uncertain stuff. This document attempts to make sense of the vagaries of climate change in the real life context of local Peterborough government.

In an ideal world, the risks of climate change would be articulated to us by climate scientists and then acted upon by politicians, policy makers and citizens. In reality, we have been collectively ignoring scientists' call to action for at least two decades, if not longer. We always seem to find legitimate reasons for this: a lagging economy, a job crisis, competing policy priorities and so on. But, at some point, the chickens will come home to roost. Our future climate reality – the one we've been warned about by scientists - will arrive leaving younger generations to deal with our shortcomings. Indeed, in some ways, the future is already here.

This report is an effort to stop our collective procrastinating. The Climate Change Working Group of Sustainable Peterborough hopes that this report will become a touchstone for continuing discussions and actions about how we in Peterborough are going to live in and adapt to a changing climate. What do we need to learn? What can we do now? Where can we find guidance and advice?

The working group is so very lucky to have had Lynda Langford lead us in this work. After a career in environmental policy making in government, Lynda returned to graduate school to take up this work. We are the lucky ones to have learned so much from her.

Stephen Hill, PhD, PEng
Chair, Climate Change Working Group
Sustainable Peterborough

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PREFACE

This document serves as a background and scoping document for the Sustainable Peterborough Climate Change Working Group as well as to serve as a Major Research Paper towards a Master of Arts (Canadian Studies and Indigenous Studies) at Trent University. The hope is that information provided here will advance work of the Sustainable Peterborough Climate Change Working Group as well as initiate action by regional municipalities to begin or enhance the task of climate change adaptation. Whether human induced or naturally occurring, climate change is happening now. Severe weather threatens lives and devastates communities and will only be exacerbated by climate change.

TORONTO STAR HEADLINE: JUNE 25, 2013

ALBERTA FLOOD: A Staggering Blow to the Province –
High waters claim lives, wrecked houses and shut down businesses.

Human impact……thousands of people have lost personal belongings and at least four people have died in the worst flooding southern Alberta has seen in decades or possibly ever….

Environmental impact…… flooding in southern Alberta has changed the Rockies and foothills forever….. overflowing waters have altered everything from how the landscape will handle future flooding to the animals that live in it….

Economic impact….. its estimated that the damage will be between $3 billion and $5 billion…. losses after insurance will be in the range of $2.25 billion and $3.75 billion…..

Climate change will increase the severity of storm events. According to projections by the Canadian climate model, a very heavy rain or snow storm which we would now normally expect once every 20 years, could occur once every 14 years by the 2050's and once every 7 years by 2100 (Environment Canada, 2005). The magnitude and frequency in increase in storm events will put pressure on our environment, our personal property, our infrastructure and our social fabric. Communities need to prepare now.

> *"Precautionary action on climate change is like buying insurance for your home. You don't buy because you are certain of a disaster, you buy because you can't afford the losses"*
>
> H. Auld, Environment Canada

ACKNOWLEDGEMENTS

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Final thanks need to go to the members of the Climate Change Working Group. This project has been possible because of their vision, hard work, and ingenuity.

1.0 INTRODUCTION

Climate change impact on the natural environment will affect human welfare by upsetting economies, human health, infrastructure, intergovernmental relations and geopolitical linkages (Dyer, 2008). Climate change action involves both climate mitigation and climate adaptation efforts. Climate change mitigation refers to human actions to reduce emissions from greenhouse gas sources or the enhancement of greenhouse gas sinks which serve to remove harmful gases from the atmosphere. Adaptation as defined by the Intergovernmental Panel on Climate Change (IPCC) is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. A key goal of climate change adaptation is to maintain resilience of natural and social systems. Resilience refers to the ability of a natural or social system to recover from disturbance (Holling, 1973).

The Ontario Expert Panel on Climate Change Adaptation confirms that increased action is required at the municipal level to address climate change. Peterborough County, the City of Peterborough and surrounding municipalities and First Nations have acknowledged this challenge in their 2012 *Greater Peterborough Area Community Sustainability Plan,* which calls for increased action on climate protection.

This scoping document is intended to inform and assist climate change adaptation planning for the Greater Peterborough Area (GPA). The report looks at the latest climate information for the Peterborough area, summarizes anticipated impacts of climate change, reviews relevant government policies and commitments, discusses progress to date on climate goals outlined in the Community Sustainability Plan and, finally, summarizes key barriers and challenges that may be limiting or preventing progress at the local level.

2.0 CLIMATE CHANGE IN PETERBOROUGH

Weather patterns in the Peterborough area are determined by general climate factors such as solar radiation. However Peterborough is further influenced by its position in the Great Lakes basin. The Great Lakes tend to moderate temperatures and increase winter precipitation at locations downwind of them. The Oak Ridges Moraine, running east and west along the north shore of Lake Ontario, further influences the weather by shielding the Peterborough area from lake influences of Lake Ontario. Peterborough does however receive downwind snowfall generated by Lake Huron.

The most significant characteristic of both weather and climate in Peterborough and the Kawarthas is variability (Adams and Taylor, 1992). While the mean annual temperature for Peterborough lies between 6 and 7 degrees C., monthly temperatures vary significantly. It is not uncommon to have above-freezing temperatures in January and below-freezing temperatures in spring or fall. It is this normal variability of weather that makes it difficult for citizens to know when climate and weather events are outside normal variability. For this, expert modeling is required.

The Canadian Centre for Climate Modeling and Analysis (CCCma) of Environment Canada has a climate change model for Canada that provides a foundation for regional climate models developed by the Canadian Climate Change Scenarios Network. Climate change modeling for Ontario predicts general increases in temperature and precipitation over the coming years (see Table 1). That temperatures will increase is considered relatively certain, however changes in precipitation are more variable, and thus, difficult to predict with certainty.

TABLE 1: CLIMATE SCENARIOS FOR ONTARIO – CANADIAN CLIMATE MODEL (CRCM.2)

GENERAL PREDICTIONS

- *General increases in temperature, (e.g., mean annual, minimum and maximum temperatures, mean temperature of the warmest and coldest months and quarters)*
- *An increase in most precipitation indicators, except for the mean precipitation of summer, where the spatial pattern shows large variability*
- *A decrease in the length of the snow period*
- *An increase in future rainfall extremes and other extreme weather (e.g., drought)*

Scientists report that between 1948 and 2008, the average annual temperature in Ontario increased by 1.4 degrees Celsius. The year 2010 was the hottest on record, with northern Ontario experiencing 20 percent drier conditions than normal. Going forward, Ontario's average annual temperature is predicted to increase by 2.5 to 3.7 degrees Celsius by 2050.

The Canadian Climate Change Scenarios Network also provides summary reports on climate change projections for many locations across the country. A customized report for Peterborough projects gradual increases in mean air temperatures and precipitation over the coming decades (see Table 2).

TABLE 2: PROJECTED SCENARIOS FOR TEMPERATURE AND PRECIPITATION IN PETERBOROUGH

(Model) SR-A1B	(Model) SR-A1B
Changes in annual mean air temperature	Changes in total precipitation
Baseline (1971-2000) 6.6 degrees C	Baseline (1971-2000) – 862.1 mm
Projected increases:	Projected changes
2020s – 8.0 (plus/minus 0.4) 2050s – 9.4 (plus/minus 0.8) 2080s – 10.5 (plus/minus 1.0)	2020s – 883.7 mm (plus/minus 27.2) 2050s – 914.3 mm (plus/minus 42.1) 2080s – 944.6 mm (plus/minus 69.7)

Hazardous weather is of particular concern for many people in the Peterborough area because of recent flooding and severe rainfall events. The Ontario Ministry of Environment (2011), reports that the effects of climate change are already being felt and will increase in coming years. Eastern Canada has experienced more frequent and intense severe weather events. Extreme weather events like the Quebec ice storm of 1998 or the 2001 and 2004 flooding events in Peterborough are recent examples of the impacts of severe weather.

The Canadian climate model predicts that a once-in-twenty-year storm event, could occur once every 14 years by the 2050's and once every 7 years by 2100 (Environment Canada, 2005). Extreme heat will also become more common and the growing season in southern Ontario could be 4-7 weeks longer. In summer, Ontario may see drier soils and perhaps more droughts. These changes will dramatically affect how the climate is perceived by residents. By the end of the century, an Ontario summer may be like the hot and humid current-day summers of northern Virginia in the US (CCCma website, 2012).

3.0 POTENTIAL IMPACTS FROM CLIMATE CHANGE

To judge the seriousness of climate change, impact assessments are completed for natural and social systems (e.g., ecosystems, forestry, fisheries, water resources, human settlements, food production and human health). Impact assessments estimate future climate circumstances and forecast the implications for systems of interest. Studies can identify potential impacts with particular vulnerabilities relating to water supplies, heat waves, droughts and pests.

3.1 MUNICIPAL SERVICES AND INFRASTRUCTURE

Municipalities will be impacted by climate change. Municipalities manage over half (53 percent) of the public infrastructure – roads, bridges, buildings, sewers, transit, and water - in Canada (Federation of Canadian Municipalities, 2013) and this is susceptible to damage from extreme weather events and other climate impacts. Municipalities are also key players in the delivery of other multi-level government policies like climate change mitigation or energy conservation.

Impacts of weather on buildings and infrastructure will, for example, range from mundane issues such as asphalt softening during summer heat waves and cracking of concrete during freeze-thaw cycles, to major flooding, ice storms and extensive windstorm damage. The frequency and intensity of these small and large-scale effects is increasing, and this places increased stresses on infrastructure of all kinds beyond that which it was designed (Ministry of Environment, 2011). Potential impacts present a significant threat to municipal infrastructure and services (see Table 3).

3.2 BIODIVERSITY AND ECOSYSTEMS

Aquatic and terrestrial ecosystems provide benefits such as food, transportation, timber, flood control, water supplies, recreation and biodiversity. Human activities are already creating stresses on these ecosystems and this will only be compounded by climate change. Ecosystem boundaries are expected to shift and some species and biodiversity will be lost through habitat degradation. The Boreal forest is particularly vulnerable to climate change and so local forests (of the Boreal Shield Ecoregion) may be vulnerable. A combination of changing growth patterns, increased forest fire outbreaks and new pest outbreaks are expected to impact forest age, biomass and carbon storage. Like other natural ecosystems, the Boreal forest is expected to shift northward but not rapidly enough to accommodate adaptation. A northward shift in the range of 160-640 km over the next 100 years is expected while the historical migration rates for many species are in the range of 4-200km per century (Canadian Institute for Climate Studies, 1998). This will result in a significant shrinking of the Boreal forest. Other potential impacts are outlined in Table 4.

TABLE 3: POTENTIAL CLIMATE CHANGE IMPACTS – MUNICIPAL SERVICES AND INFRASTRUCTURCE

EMERGENCY SERVICES

- Greater incidents of personal safety emergencies e.g. tornadoes, floods
- Demand for emergency shelters and support during extreme weather or extended periods of power outage, blocked transportation routes, etc.
- Potential for increased incidents of wildfire

FACILITIES MANAGEMENT

- Additional costs may be incurred to maintain ice rinks and other winter recreation facilities/opportunities
- Municipal offices may incur additional summer cooling costs
- Generators and backup power supplies may be required for municipal offices, pumping stations, etc.

PUBLIC INFRASTRUCTURE

- Accelerated deterioration of asphalt and cement structures
- Road and bridge washouts from heavy rainfall events or runoff
- Increased damage to or blow down of trees and service poles
- More disruptions to power leading to problems with streetlights, traffic lights, water pumping stations, etc.
- Excessive storm water drainage and flooding leading to potential threats to water treatment and sewage systems
- Alterations of traditional approaches to landscaping and soil stabilization

PLANNING AND ZONING

- Existing floodplain setbacks from water courses used by Conservation Authorities may require further expansion
- Official plans may need to increase flood setbacks as well as enforce hazard area designations to protect source water areas e.g. ensure wetlands are maintained
- Building codes may require upgrading to increase energy efficiency or to enhance structural resistance to extreme weather
- More public information for homebuilders may be required to promote climate sensitive site selection, site planning, development planning, etc.

PRIVATE PROPERTY

- Enhanced property damage due to extreme weather events e.g. high winds/tornadoes that damage homes, farm buildings, trees and landscape, etc.
- Sewer backups and flooding that destroy property as well as present health threats
- Added pressure on heating and cooling systems resulting in increased utility costs
- Extended power outages may result in health threats, security issues, food spoilage, etc.
- Insurance coverage may become more expensive or not available for certain events
- Impacts to private property and homeowners may ultimately affect the collection of property taxes, utility bills, etc.

TABLE 4: POTENTIAL CLIMATE CHANGE IMPACTS – BIODIVERSITY AND ECOSYSTEMS	
BIODIVERSITY **Invasive species** – new species will take advantage of changing conditions and move into new areas **Changes in structure and composition of natural ecosystems**– new types, numbers and combinations of species **Loss of habitat, breeding sites and food resources for migratory birds** – as a result of changing lake levels and ecosystems **Species loss/extinction** – boundaries of ecosystems will move faster than species can migrate - some species will not be able to move or adapt **New plant/animal diseases** – disease species and pests that have previously been unable to overwinter in the area may soon survive winter temperatures and pose new threats. **AIR QUALITY** **Increases in ground level ozone (smog) –** caused from increased temperature resulting in higher incidences of asthma or in some cases crop damage	**SURFACE WATER** **Flooding** - locally, intense storms may result in increased flooding **Lower water levels –** increasing temperatures, decline in ice cover and higher evaporation will lead to a decline in water levels for inland lakes and the Great Lakes. Higher costs for shipping and maintenance of harbours, channels, docks, water intake pipes, etc. **Fluctuating water levels** – rapid or drastic fluctuations can be detrimental to fish at critical times e.g. spawning, winter survival **Loss of flood absorbing wetlands and floodplains** – combined pressures of development and climate change are likely to degrade the ability of wetlands and floodplains to absorb excessive runoff **Diminished groundwater recharge** – reduced summer water levels are likely to diminish the recharge of groundwater and thereby cause small streams to dry up and reduce the area of wetlands **Increase in management disputes** – water shortages may lead to pressure for water withdrawals from lakes and rivers, irrigation, etc.

3.3 HUMAN HEALTH AND SAFETY

In high latitude countries such as Canada, there is increased exposure to very hot weather events and weather hazards such as droughts, floods, wildfires and severe storms. Climate models project a doubling of the number of hot days (above 32 degrees C) in the Toronto-Niagara region by the 2030s and an increase in extreme heat days (above 36 degrees C) (Union of Concerned Scientists, 2003). These types of trends are likely for Peterborough as well. Hot weather can lead to heat stroke and other ailments (see Table 5). Warming temperatures can lead to an increase in the range of vector-

borne infectious diseases, e.g. West Nile virus, Lyme disease, or Malaria. Damage to water and sewer systems may lead to outbreaks of water borne diseases.

TABLE 5: POTENTIAL CLIMATE CHANGE IMPACTS – PUBLIC HEALTH AND SAFETY	
Spread of existing and new vector-borne infectious diseases - warmer temperatures have already begun to allow the spread of mosquito and tick-borne diseases e.g. Lyme disease and West Nile Virus. There is also the potential for the spread of Malaria **Increase in heat related morbidity or mortality** – increases in heat strokes, cardio-vascular problems, respiratory illnesses and stress related ailments are anticipated. **Decrease in cold-related morbidity or mortality –** cold related health risks are likely to decline	**Transmission of water-borne diseases** - overwhelmed or damaged water and sewer systems may result in more frequent or widespread outbreaks of water borne diseases such as cryptosporidiosis or giardiasis **Increases in respiratory diseases–** higher temperatures and more electricity generation for air conditioning increases the formation of ground-level ozone and smog which is likely to exacerbate asthma and other respiratory diseases **Increased molds and mildews** – ailments reported as a result of flooded and damp basements

3.4 ECONOMIC SECTORS

Climate change will impact national and local economies, particularly those reliant on natural resources, agriculture or tourism. Because key economic sectors depend on natural resources, both positive and negative impacts may occur. New opportunities for agriculture may be created as temperatures warm, although these benefits may also be limited by increased variation in precipitation. Agricultural crop ranges could expand northward which could lead to conflicts with existing land uses or primary economic sectors such as forestry and outdoor recreation. Fluctuating water levels may discourage cottagers and recreationalists as well as impact the market value of recreational properties and tourism businesses. The Greater Peterborough Area Economic Development Corporation reports that the economic impact of tourism for Peterborough and the Kawarthas totals over $300 million annually showing just how important sustaining tourism and recreational opportunities in the Peterborough area will be as climate impacts become more pronounced. Table 6 summarizes potential impacts to key economic sectors in the Peterborough area.

TABLE 6: POTENTIAL CLIMATE CHANGE IMPACTS – ECONOMIC SECTORS

AGRICULTURE

Loss of crops due to drought or variable rainfall – crop yields are always impacted by variations in weather but extreme variability may lead to more crop failures, serious reductions in yield or a need for new species

New crop diseases and pests - warmer temperatures may allow the spread of new crop diseases and pests that threaten production e.g. (soy) bean leaf beetle, European corn borer

Crop damage from pollution - anticipated increases in ground level ozone as a result of increased temperatures may result in crop damage

Stress to livestock - warmer summer temperatures suppress appetite and decrease weight gain in livestock

Poor quantity and quality of spring forage - warmer winters and less snow cover may impact the overwintering of forage crops

Increased yields of some crops - increased atmosphere CO2 and nitrogen as well as a longer growing season may boost yields of some crops such as corn, soybeans and wheat

TOURISM AND RECREATION

Damage of recreational equipment and facilities – flooding and other impacts can damage or destroy property

Alterations of aesthetics - low lake levels and exposed boating docks alter aesthetics and the cottage experience

Changes in quality of outdoor experience – increased aquatic plant growth may impact recreational boating and sport fishing

Changes in sport fish species - Warm water species like carp and pan fish may thrive while more desirable game fish such as lake trout may not

Changes in game species - some wildlife species may expand northward while new species invade from other areas

TOURISM AND RECREATION

Degradation of winter recreation - **shorter season, thinner ice, more thaw/rain events**

FORESTRY

Reduction and/or changes to forest ecosystems - it is anticipated that over time the boreal forest will shrink and other forest species will move northward

Alteration of forest composition and productivity - as trees adjust to changing conditions, commercially desirable species may be replaced with less desirable species e.g. hardwood species replaced by softwood species.

Increased incidents of wildfire - as temperatures warm the occurrence of wildfire will increase

Spread of new pests and diseases - warmer winter temperatures will allow for the spread of existing pests like the Gypsy Moth or Mountain Pine Beetle or the invasion of new threats

Stress or damage from severe weather - local forests and woodlots may be impacted by damage from severe storms or stress due to drought.

Higher levels of ground level ozone - may cause damage to forests

REAL ESTATE

Decreases in market value of recreational properties – as a result of lower water levels

Failure of tourism/recreation businesses – recreation opportunities may be lost

POWER GENERATION

Reduction in hydropower generation in the Great Lakes region – reduced water flow and dropping water levels could reduce hydro power generation (15 percent) – hydro power provides one quarter of the overall electrical supply in Ontario (Union of Concerned Scientists, 2009)

4.0 POTENTIAL OPPORTUNITIES FROM CLIMATE CHANGE

Climate change will create some potential benefits and new opportunities. For example, an extended summer season will allow tourism operators to stay open longer or to create new opportunities to enjoy outdoor recreation during shoulder seasons. Home heating costs may be reduced (however savings may be offset by higher summer cooling costs). There may also be opportunities for new agricultural crops or products as a result of an extended growing season (e.g., new strains of corn or soybeans). Some farmers are already experimenting with new species and farming methods (Expert Panel on Climate Adaptation, 2009). Warmer temperatures may benefit some resident mammals such as raccoons, skunks and white-tailed deer or allow a broader range of species to survive (e.g., species of flowers or birds that inhabit warmer regions).

Actions that we take to reduce greenhouse gas emissions can have immediate local benefits such as reducing air pollution, traffic congestion, and reducing energy costs. Studies in Europe and North America suggest that these benefits can offset at least 30 percent of mitigation costs (Canadian Institute for Climate Studies (1998). Energy efficiency measures implemented for municipal operations can drive substantial operational cost savings by reducing energy requirements for housing, buildings and transportation.

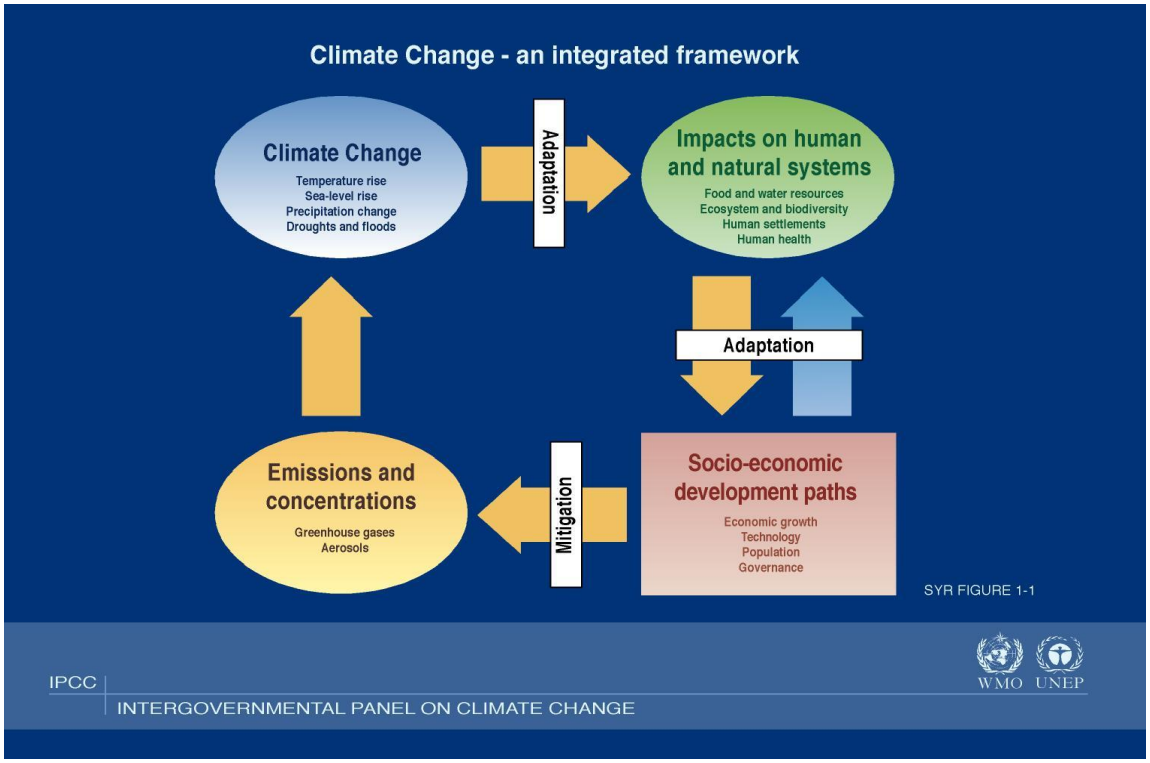
Adaptations in building and infrastructure design, water and energy conservation, renewable energy generation and diversification of economies are win-win strategies that provide useful starting points for communities to increase their adaptive capacity (Burton, 2008).

5.0 CLIMATE CHANGE GOVERNANCE

At the global level, Canada and most other countries signed the United Nations Framework Convention on Climate Change (UNFCCC) in the early 1990s. Broadly, the convention requires developed countries to implement national programmes and measures to control greenhouse gas emissions that cause global warming (i.e., mitigation) and to develop initiatives that will help countries adapt to the impacts of climate change (i.e., adaptation).

The Intergovernmental Panel on Climate Change (IPCC) is the leading body for the scientific assessment of climate change. It provides policy relevant scientific information on the current state of knowledge regarding climate change. The IPCC has developed the framework below (Figure 1) which illustrates the integrated relationship of mitigation and adaptation.

FIGURE 1: ILLUSTRATION OF CLIMATE CHANGE MANAGEMENT (Source: IPPC)



5.1 MITIGATION

The most recent targets adopted by the Canadian federal government as part of the 2009 UN Copenhagen Accord specify a 17 percent reduction in greenhouse gas emissions below 2005 levels by 2020. The Copenhagen Accord also included pledges by the signatories to ensure that the rise in global average temperature does not exceed 2 degrees Celsius. This 2 degrees Celsius rise is considered a "tipping point", beyond which the risks of severe climate destabilization becomes too great. While there is some debate, the 2 degree threshold corresponds to carbon dioxide (CO_2) levels between 425 – 450 parts per million (ppm) of CO_2.

Recent measurements show that in 2010, global CO_2 levels were measured at 390 ppm. In May 2013, the Mauna Loa Observation Centre in Hawaii recorded a daily average level of 400 ppm of CO2. CO2 levels are still on the rise globally. Although agencies are making some progress on mitigation, much more remains to be done.

Climate change is a broad, all-encompassing issue and there are many other sectors of government involved. An internet search for "climate change" on the Government of Canada website lists fifteen departments, plus other major government units including Parliament, Treasury Board, the Privy Council, the Prime Minister's office and the Governor General, and a number of other lesser agencies that have an interest in climate change policy and programs.

The Canadian government is developing regulations to reduce emissions on a sector-by-sector basis using intensity-based targets (i.e., tonnes of CO2 per tonne of product produced). The first of these regulations covers emissions from coal-fired electricity generation and was finalized in 2012. Work continues to address other emissions intensive industries including the oil and gas, fertilizer manufacturing, steel, cement, chemical, and pulp and paper sectors.

Provincially, Ontario has taken action to reduce greenhouse gas emissions from the electricity sector and plans are in place to phase out coal plants by the end of 2014 (Ministry of the Environment, 2013). The Ontario Greenhouse Gas Emissions Reporting regulation requires emission reductions and reporting of greenhouse gases that include carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons and perfluorocarbons.

Reducing greenhouse gas emissions requires coordinated action by all levels of government. The federal government provides incentives for municipal governments to reduce emissions by providing funding for inventories and planning through the Green Municipal Fund. The Green Municipal Fund is administered through the Partners for Climate Protection program which is a partnership between the Federation of Canadian Municipalities (FCM) and the International Council for Local Environmental Initiatives (ICLEI).

Municipal governments have direct or indirect control over approximately 44 per cent of national greenhouse gas emissions (Federation of Canadian Municipalities, 2009). Municipal governments are essential to achieving local, community-based emission reductions since they have responsibility over land-use planning and development, transportation, infrastructure, economic activity and consumption of energy resources.

The Federation of Canadian Municipalities (FCM) consists of cities and communities from across Canada and currently has over 2000 members. The FCM argues

Municipal governments currently have direct or indirect control over approximately 44 per cent of national greenhouse gas emissions.

that local governments play key roles in reducing emissions as well as preparing and positioning their communities for adaptation. The FCM, in partnership with ICLEI, offers assistance to municipalities for climate change planning and adaptation through programs such as Cities for Climate Protection (CCP) and Partners for Climate Protection (PCP). Through the Municipal Green Fund, FCM also provides financial assistance and knowledge to municipal governments and partners for municipal environmental projects. The Green Municipal Fund provides grants of up to 50 percent of costs to a maximum of $350,000 toward the completion of emissions inventories, the establishment of reduction targets and the development of local action plans to achieve emission reduction targets.

Greenhouse gases are gases that absorb and emit thermal infrared radiation; it is this physical property that causes the greenhouse effect that results in global warming and climate change.

In Ontario, the transportation, electricity, industrial and residential sectors account for approximately 85% of greenhouse gas emissions. The remaining 15% is generated from agricultural, commercial, waste and other sectors

5.2 ADAPTATION

The Bali Action Plan was adopted in 2007 by member nations of the United Nations Framework Convention. The Bali plan identified adaptation as a key building block of a global response to climate change. At the Cancun Climate Change Conference in December 2010, the parties adopted the Cancun Adaptation Framework. The objective of the Framework is to enhance action on adaptation, reduce vulnerability, and build resilience, particularly in developing countries. The Framework acknowledges that the most appropriate scale for adaptation planning is at the municipal level as this is where climate impacts will be most directly felt.

Domestically, the federal government renewed climate change adaptation funding in 2011 with a $148.8

million contribution over five years. These funds were shared between 10 different federal departments.

At the provincial level the Ontario Ministry of the Environment is the lead agency although many other departments provide a supporting or ancillary role. The report *Adapting to Climate Change in Ontario* identifies key areas of concern including economics, public health, infrastructure reliability (roads/ bridges/ water and sewer/ telecommunications and energy), building safety, and wildlife habitat. The Province of Ontario has a well-developed policy and program base in climate change. There is a specific *Plan for a Cleaner, more Sustainable Future* report, a specific *Adaptation Strategy and Action Plan 2011-2014*, an overall action plan entitled *Adapting to Change, Protecting Our Future*, as well as many related materials to aid in understanding, planning and preparing for climate change. These plans and reports can be downloaded from (www.ene.gov.on.ca).

The Government of Ontario also plays a special role in coordinating efforts between the federal and municipal governments. To do this they have created the Ontario Regional Adaptation Collaborative with the assistance of the federal government. One of the goals of this partnership is to support local and regional groups in developing climate change action plans. Beyond this coordinating mechanism, Ontario has a specific website, www.climateontario.ca, and has developed a Community Adaptation Initiative for a two year period to help Ontario communities adapt to climate change. It also helps to support the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR), which is a university-based resource hub for researchers and stakeholders searching for information on climate change impacts and adaptation.

The Ontario Ministry of Municipal Affairs and Housing administers the Municipal Act which provides for the structure of local municipalities and counties and sets out their basic powers including the ability to regulate and license, provide services, manage finances and maintain infrastructure. There is a Provincial Policy Statement concerning land use planning implemented through the Planning Act. New proposed policy for managing and directing land use planning states that activities should promote development and land use patterns that maintain biodiversity and resilience to climate change (Ministry of Municipal Affairs and Housing, 2012). The Ministry is also looking at changes to the building code to enhance the resilience of buildings as well as improve energy conservation.

Similar to their role in mitigation, the Federation of Canadian Municipalities acknowledge that local governments play key roles in preparing and positioning their communities in order to build resilience and to establish the right conditions for adaptation. Key concepts of managing climate change are outlined by ICLEI and FCM in publications such as *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments* (2007), *Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation (*no date*)* and *Partners for Climate*

Protection: Municipal Resources for Adapting to Climate Change (2009). These publications and other program information are available through the FCM website (www.fcm.ca). A list of supporting documents is provided in Appendix 2.

Locally, the City of Peterborough and Selwyn Township are members of the FCM and the City of Peterborough is a participating partner in the Partners for Climate Protection program. Additional involvement of lower tier municipalities will be required to take advantage of existing FCM programs to assist in mitigation planning.

6.0 GREATER PETERBOROUGH AREA - CLIMATE CHANGE ADAPTATION

The Greater Peterborough Area is comprised of 2 upper tier municipal governments, 8 lower tier governments and 2 First Nations Reserves. Upper tier levels include the City of Peterborough and the County of Peterborough. Lower tier municipalities include the Municipality of Trent Lakes, Selwyn Township, the Township of Asphodel-Norwood, Township of Cavan Monaghan, Township of Douro Dummer, Township of Havelock-Belmont-Methuen, Township of North Kawartha, and the Township of Otonabee-South Monaghan. First Nations in the area include the Hiawatha First Nation and the Curve Lake First Nation. Municipal governments and First Nations provide a range of services and programs including policy and program development, financial management and taxation, public utilities, transportation, policing, firefighting, emergency management, licensing and regulation, land use and urban planning, parks and recreation and others.

Climate protection measures are required to not only help prevent further climate change by reducing greenhouse gas emissions but also to protect the public interest in terms of government assets, community services, public health and safety, emergency management, and economic stability. Local residents look to municipal governments for leadership in times of crisis, and innovation and vision in preparing for the future.

6.1 GOALS AND KEY ACTIONS

The upper and lower tier municipalities and First Nations of the Greater Peterborough Area (GPA) have collectively developed *The Greater Peterborough Area Community Sustainability Plan* which was released in 2012. The Plan identifies Climate Change as a priority area (see Table 7). Efforts are now underway by the Sustainable Peterborough Coordinating Committee to advance climate change initiatives through the Climate Change Working Group.

TABLE 7: GREATER PETERBOROUGH AREA COMMUNITY SUSTAINABILITY PLAN – CLIMATE CHANGE THEME

GOAL - *OUR GOAL IS TO REDUCE OUR CONTRIBUTION TO CLIMATE CHANGE WHILE INCREASING OUR ABILITY TO ADAPT TO CLIMATE CHANGE CONDITIONS*

KEY ACTIONS

1. Prepare to respond and adapt to changing conditions associated with climate change.
2. Develop broad public acceptance of efforts to mitigate climate change.
3. Reduce and offset greenhouse gas emissions produced within our community.
4. Prioritize actions that contribute to both mitigation and adaptation.
5. Incorporate climate change adaptation into existing policies and programs wherever possible.

6.2 PROGRESS TO DATE

Following from the proposed actions in the Sustainability Plan, the progress to date has been reviewed according to four areas: public acceptance, the utilization of existing programs to achieve goals, the reduction and offset of greenhouse gas emissions (mitigation), and adaption strategies and actions.

6.21 Public Awareness and Acceptance

A survey conducted for Natural Resources Canada in 2009 by Environics interviewed 503 senior respondents in businesses, municipal governments (174 respondents) and provincial governments. The survey found that the majority of respondents were aware of what climate change is, could identify potential impacts on their region over the next 20 years, and felt that climate change was happening now (Horton and Richardson, 2009). However, the concept of planned climate change adaptation and the nature of risks to and opportunities for organizations over the long-term was generally not well understood. The survey concluded the climate change adaptation remains outside of everyday decision-making and planning in their organizations.

While plenty of information is available about climate change on the internet and on federal and provincial government sites, few municipalities in the Greater Peterborough Area include any specific mention of climate change on their websites. As part of a broader communication effort, municipal websites should be updated to include more information on regional climate change trends and local area impacts. This could provide local residents with information about climate change preparedness and safety (e.g., flood warnings, flood protection, emergency measures, local emergency shelters, home security, food and water safety and supplies, etc.)

There are also challenges with messaging and framing climate communications. For example, information regarding average temperature increases of 2 or 3 degrees Celsius does not necessarily convey urgency regarding long term climate risks and outcomes. Key messages should be developed that provide tangible scenarios and outcomes for residents. This might, for example, include information about the total damage costs from the 2004 flooding event in Peterborough. Other indirect costs or impacts such as increased insurance costs or long-term health impacts from molds and mildews should be reported to portray the risks of severe weather events.

6.22 Utilization of Existing Programs and Approaches

A review of municipal programs in the Greater Peterborough Area indicates that existing programs and policies do not yet specifically address climate change. Nonetheless, some programs indirectly support climate adaptation planning. For example, proper management of facilities increases their adaptive capacity and thereby supports climate adaptation. For the most part, though, planning and decision making is based on

traditional approaches and does not yet incorporate more detailed analysis of climate related sensitivity, adaptive capacity or vulnerability. These assessments help to more accurately reflect the vulnerability of municipal facilities and programs to climate change and can prioritize issues. A review of key programs indicates that there are opportunities to incorporate climate change concerns into ongoing activities. Examples include the following:

Emergency Management Plans/Disaster Management - Municipalities and ministries are required by legislation to develop, implement and maintain emergency management programs that focus on emergency preparedness and response activities. Requirements include the designation of an emergency management coordinator, the writing of an emergency response plan and the formation of a program committee. There is also an Ontario Disaster Relief Assistance Program that is designed to help municipalities, individuals, farmers, small business and non-profit organizations get back on their feet after a natural disaster.

All municipalities in the GPA have emergency response plans. Emergency Management Ontario monitors compliance and the province works with municipalities to ensure that municipalities meet the standards required. However, emergency management/response plans are not intended to anticipate and prevent climate change risks but rather to prepare for emergencies and implement emergency management. UNESCO suggests that for every $100 spent by the international community on risks and disasters, $96 go to emergency relief and reconstruction and only $4 on prevention (Sperling and Szekely, 2005). Emergency managers should begin to think about potential situations that may require new or additional emergency measures (e.g., extended power outages during severe winter storms particularly for isolated residents).

UNESCO suggests that for every $100 spent by the international community on risks and disasters, $96 go to emergency relief and reconstruction and only $4 to prevention.

Infrastructure Risk Assessment - Risk assessments are used to inform decision making in areas such as emergency management, strategic planning, facilities management, security, etc. There are standardized approaches to risk assessment (e.g., ISO 31000, Canadian standard: CAN/CSA –Q850-01, etc.) however the FCM has developed a national guide (written by Black, Bruce and Egener, 2010) to help municipalities specifically analyze the risks of climate change. The risk assessment process requires the identification of climate-related hazards and the potential risks that may cause harm in terms of injuries or deaths, health losses due to illness, property damage and losses, other

economic losses, cultural impacts and environmental or ecosystem losses or impairment. The FCM, in partnership with the Canadian Standards Association, has developed an e-learning course for municipal staff and service providers to learn about adapting critical infrastructure to severe weather. Engineers Canada has begun to develop protocols for public infrastructure risk assessments that use climate trends and projections information to assess future climate risks (PIEVC Engineering Protocol).

There is no evidence from local municipal websites of municipalities in the GPA undertaking risk assessments that consider climate change risks. Municipalities should be encouraged to include climate information in risk assessments (if not already doing so) or adopt protocols and standards being developed by others that address climate change risks.

Sustainable Asset Management Plans - Because municipalities are responsible for almost half of public infrastructure, it is important for them to manage assets strategically. To do this, they develop sustainable asset management plans which can address roads, bridges, water and sewer, social housing or other community assets. Asset planning involves facility planning, asset life cycle management, long-term capital planning, risk management, corporate policy and other asset related issues. Ontario municipalities are required to develop detailed asset management plans to accompany any request for provincial infrastructure funding.

Green infrastructure *refers to natural or engineered systems that mitigate potential impacts of existing and future development. Examples include: grassy swales and rain gardens to promote infiltration; roadside curb cuts to direct runoff to grassy swales and rain gardens; permeable pavement and green roofs to reduce runoff; rock pits, catch basins and detention ponds to reduce peak runoff flows; and water and energy conserving infrastructure. (Ministry of Municipal Affairs and Housing, 2009)*

The asset management process provides an opportunity to incorporate climate change risks when generating the life cycle investment profile for each asset component. Currently, most municipalities in the Greater Peterborough Area have completed or are developing an asset management plan however climate change is not mentioned specifically in the Sustainable Asset Management guidebook developed by FCM. This guidebook could be updated to incorporate climate change considerations.

Land Use Plans and Municipal Corporate Plans - Land use planning helps guide where to locate homes, businesses, factories, parks and schools and where to

place roads, sewers and other essential services. The Ontario Planning Act sets out the rules for land use planning in the province and describes how land uses may be controlled (e.g., zoning bylaws) and who may control them (planning boards, etc.). An Official Plan is the document that sets out general planning goals and policies at the local level within the context of provincial policy directions. All upper and lower tier municipalities in the Greater Peterborough Area have official plans. However, climate change does not receive special recognition as a major risk factor in planning to date. Corporate Plans are updated every 5 years and guidelines should be developed to ensure that climate risks are incorporated into future updates throughout the GPA.

City of Peterborough - Flood Reduction Master Plan - Because Peterborough was hit with a severe rainfall event in 2004 that caused significant damage (flood damage reportedly in excess of $100 million in direct physical damages to private and public property), the City developed a Flood Reduction Master Plan to investigate the causes of flooding and to determine remedial measures to reduce risks. The report describes the urban drainage systems, identifies causes of the flood damage and provides a tool box of solutions that could be used to reduce risk. The City has aggressively been pursuing the implementation of recommendations to reduce the City's vulnerability to flooding. Although the Study does not address climate change specifically, it enables the City to improve the adaptive capacity of the urban drainage system, which is important for adaptation.

Transportation Master Plans - The City of Peterborough has recently updated its Comprehensive Transportation Plan and an updated County of Peterborough Transportation Plan has also been approved. These plans are intended to guide decision making related to transportation for the next 20 years. These Plans address infrastructure improvements and enhancements, safety updates and new policy and standards requirements however do not specifically address potential climate change risks. Recommendations in these reports to support active transportation could be considered a strategy to reduce greenhouse gas emissions although neither document specifically outlines strategies to address future impacts of climate change e.g. flood prone areas, drainage, potential for increased snowfall, etc.

Community Sustainability Plan - The GPA Community Sustainability Plan recommends the incorporation of climate change adaptation into existing policies and programs wherever possible. There are various opportunities available where this could happen as noted above.

6.23 Mitigation Initiatives

Within the context of the Greater Peterborough Area Community Sustainability Plan, the Sustainable Peterborough Partnership is leading climate change mitigation efforts for the community. At the time of writing, Council approvals are being sought by the Sustainable Peterborough Coordinating Committee for funding to initiate a mitigation planning effort, possibly utilizing the FCM Partners for Climate Protection Program for partial funding as well as a planning template. The Climate Change Working Group will oversee the development of the Community (non-municipal) emission inventory and local plan development. A Municipal Sector Sub Committee will be established to oversee the development of the Corporate (municipal operations) inventory and local action plan.

The FCM planning process uses a five-milestone framework for reducing greenhouse gas emissions. The five steps or milestones are as follows:

Milestone One: Creation of a GHG emissions inventory and forecast - the inventory will include two components; a community inventory and a corporate inventory. The Community inventory will record data from the institutional, commercial, industrial (ICI), transportation and residential waste sectors. The Corporate inventory records data from municipal government facilities and operations, including buildings, street lighting, water and wastewater treatment, the municipal fleet and corporate solid wastes. Data gathered will be used to establish future projections and assist in the development of emission reduction targets.

Milestone Two: Establishment of emission reduction targets - emission targets specify how much the community will strive to reduce harmful emissions. FCM recommends a 20 percent reduction in GHG emissions below baseline levels for municipal operations within 10 years and a 6 percent reduction in GHG emissions below baseline levels for the community within 10 years. Reduction targets will be established through a public consultation process and approved by local Councils.

Milestone Three: *Development of local action plans* - Plans include a summary of baseline emissions forecasts and targets, a set of existing and proposed emissions reduction actions and implementation strategies including the resources involved to achieve reduction targets. Two separate local action plans (corporate and community) can be developed or they can be combined. Opportunities for public consultation will be provided and plans will require approval from council, municipal staff, stakeholders and the community.

Milestone Four: *Implementation of plans or a set of activities* - Plan implementation will be led by the municipality but will also involve non-government organizations and the private sector. Implementation will depend on funding and therefore is likely to be incremental as funds become available. A key funding source is the

FCM's Green Municipal Fund. In some cases, implementation can be achieved through performance requirements.

Milestone Five: *Monitoring and Reporting* - monitoring is needed to determine if reduction measures are being achieved. Processes and procedures for data management and data sharing will be developed where necessary. Findings will be reported to stakeholders and the Federation of Canadian Municipalities.

The Sustainable Peterborough Coordinating Committee has agreed to apply to the FCM Partners for Climate Protection Program for funding to proceed with completion of Milestones 1-3. Upon approval by local Councils, an application will be made to FCM to acquire funding from the Green Municipal Fund (for inventory and development of plans). The average total cost of completing corporate and community sector local (mitigation) action plans is estimated as $110,000 by FCM. FCM will fund up to 50% of costs for completion of Milestones 1-3. External funders, municipalities and their partners will have to raise the remaining funds. External matching funding is also being sought by the Climate Working Group.

While funds are available to assist in the development of local action plans, a key concern is the ultimate cost of implementing, monitoring and reporting on the plans recommendations. While some costs can be offset by savings in energy conservation and other efficiencies, upfront funding for climate protection remains a key barrier to progress and this will be discussed in more detail later in this document.

6.24 Adaptation Planning and Assessment

The benchmark survey completed by Natural Resources Canada (2009) suggests that 73% of municipalities felt that they were taking some form of action to adapt to climate change. These high numbers likely stem from a broad definition that municipalities are applying to adaptation. For example, adaptation can refer to any consideration of climate change in decision making, long term planning and policy development, design of infrastructure, current operational decisions or risk management planning. Also mitigation (reduction or offset of GHGs) is generally considered a form of climate change adaptation by municipal government. As previously mentioned, the IPCC defines adaptation as *any* adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities.

On the other hand, planned adaptation is the result of a *deliberate* policy decision based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain or achieve a desired state. While many municipalities may be taking actions they consider to be adaptation, very few are completing planned adaptation as defined by IPCC.

Planned adaptation for municipalities normally involves a review of anticipated regional climate impacts, an assessment of the sensitivity of municipal facilities and programs to anticipated impacts, an assessment of the adaptive capacity of these facilities and programs to absorb negative impacts, a summary of facilities and programs that are considered vulnerable to climate impacts, an assessment of risks for vulnerable facilities and programs and, finally, the development of adaptation options. Adaptation involves team approaches for assessments and planning as well as stakeholder and public consultation into goal setting and priority setting. Existing adaptation plans or case studies demonstrate a variety of approaches to adaptation ranging from specific detailed vulnerability assessments (e.g., surface water, culverts, community housing) or risk assessments (e.g., public infrastructure) to more general adaptation plans which combine mitigation and adaptation initiatives. Larger, upper tier municipalities have completed most of the deliberate adaptation planning to date.

ICLEI has developed an approach to assist municipalities undertake adaptation planning. Their guide provides a step by step approach to completing a Climate Change Preparedness Plan. The guidebook outlines an enhanced planning process where comprehensive sensitivity, adaptive capacity, vulnerability assessments and risk

TABLE 8: ASSESSMENT FRAMEWORK BASED ON ICLEI WORKBOOK

SENSITIVITY ANALYSIS	ADAPTIVE CAPACITY	VULNERABILITY
Sensitivity refers to the degree to which a built, natural or human system is directly or indirectly affected by changes in climate conditions.	Adaptive capacity refers to the ability of built, natural and human systems to accommodate changes in climate with minimum disruption or additional cost	Vulnerability refers to the susceptibility of a system to harm from climate change impacts
ASSESSMENT QUESTIONS • How exposed is the service area to the impacts of climate change? • Is the service area subject to existing stresses? • Will climate change cause the demand for a resource or service exceed its supply or current abilities? • Does the service area have limiting factors that may be affected by climate change? • Are there measures that are presently in place that are able to provide a buffer against expected future changes? • Is there a plant and animal species of concern that is currently located near the limits of its range?	ASSESSMENT QUESTIONS • Are the systems associated with this planning area already able to accommodate changes in climate? • Are there barriers to a system's ability to accommodate change in climate? • Are the systems already stressed in ways that limit their ability to accommodate changes in climate? • Is the rate of projected climate change likely to be faster than the adaptability of the systems? • Are there efforts already underway to address impacts of climate change related to systems in the planning area?	ASSESSMENT METHOD • Combine findings of sensitive analysis and adaptive capacity analysis to determine how and where your community is vulnerable to climate change

assessments are used to identify potential problem areas or risks to be addressed by the preparedness plan. These assessments are completed by answering a series of questions regarding systems/components in the planning area (see Table 8).

Once vulnerabilities are identified, system components are categorized as having high, medium or low vulnerabilities. A risk assessment process is then applied to system components (based on factors of consequence and probability) and rated as high, medium or low risk. Vulnerability and risk assessment findings are then compared using a matrix format to identify priority system components that should be address by the adaptation or preparedness plan.

To test the ICLEI approach, I completed a sensitivity analysis for the City of Peterborough using the questions above and the sample table format in the workbook. (The results of the sensitivity analysis are included in Appendix 3.) Results show six high sensitivity (to climate) program areas for the City: emergency and risk management, sustainability (safe, sufficient supply of water, air, energy, natural resources and renewable energy), financial services, engineering and construction (storm and sanitary sewers, bridges, culverts, etc.), environmental protection (waste water treatment) and public works. These results appear reasonable however instructions in the workbook call for completion of the analysis by a team of staff and experts. Results by an interdisciplinary team would no doubt alter these findings. The completion of adaptive capacity and vulnerability assessments were not attempted for high sensitivity programs (as directed in the workbook) mainly due to the requirement for more technical expertise.

Despite the fact that a range of expertise is required to complete the assessment framework, the test sensitivity analysis did point to some issues regarding the process. Some general observations include the following:

- The analysis is complicated and very time consuming.
- The relationship of questions to sample templates is not always clear.
- The approach assumes the same parameters for assessment can be used for both social and ecological system components e.g. limiting factors, buffering capacity, natural range.
- Social assessment parameters require more definition.
- The survey approach in the form of questions is poorly designed to accommodate comparative analysis between system components (e.g. yes/no answers).
- Social/environmental systems are assumed to hold equal importance – environmental performance demonstrates that they are not – some weighting of results may be required.
- Approaches to prioritization/rating do not necessarily recognize how decisions are made at a municipal level.

My effort to test this approach to the City of Peterborough exposed the ICLEI model as being complicated, subjective, and requiring a broad range of information and data as well as extensive expertise on a broad range of topics. This may present challenges to municipalities who lack the staff to lead or perform such tasks or the funds to hire a consultant to undertake the analysis. It is unlikely that municipalities, particularly lower tier municipalities, will be able to complete this type of planned adaptation. Rather, it is likely that municipalities will continue to develop adaptation plans that include a combination of approaches such as the continuation of existing planning processes and programs with added attention paid to potential climate impacts, enhanced risk assessments for infrastructure decision making, mitigation actions and isolated detailed vulnerability assessments for essential services, etc. Perhaps more thought should be given by FCM or ICLEI to the identification of the best combination of approaches rather than the development of a particular overall approach.

Signs of the Times #992

Ontario, Quebec clean up after flood disaster [Jul 15] http://www.cbc.ca/story/canada/national/2004/07/15/

'Peterborough Mayor Sylvia Sutherland said those living downstream who rely on well water should boil their water before consumption. Streets have been washed out and most were impassable, with the water almost one-metre deep and lapping at car windows. Earlier in the morning, the current of water was moving so fast down the roads, people would not have been able to stand in it. Hundreds of basements have been flooded. Residents were told not to pump the water out of their basements because they would be removing clean water with raw sewage. Further heavy rains were expected across much of Ontario, with specific warnings for Belleville, Haliburton, Algonquin, Pembroke, Smiths Falls and Lanark.'

7.0 BARRIERS AND CHALLENGES

While climate change protection is acknowledged as a priority in the Community Sustainability Plan, for the most part, climate related actions in the GPA remain very much in the preliminary stages. Progress is slowed by a number of barriers and challenges which have been organized according to reoccurring themes.

Funding – The climate adaptation survey by Horton and Richardson (2009) for Natural Resources Canada indicates that for municipalities the cost of adaptation was the most frequently cited barrier to adaptation (90% of responses). Responses were unclear whether this referred to total costs of adaptation in general or the costs of implementing adaptation plans and actions. For example, the FCM through the Green Municipal Fund will partially fund the establishment of emission reduction targets and the development of climate mitigation plans but does not support the implementation and monitoring of the plans. Funding is also dependent on matching funds and partnerships. Natural Resource Canada will provide funding for some types of research however applications also require matching funds or in-kind contributions which require resources from municipalities. The ability of municipalities to pay for new climate change mitigation and adaptation initiatives is limited particularly for small lower tier governments. The ability to pay is variable across municipalities depending largely on the population base (and tax revenues). Larger cities are demonstrating more progress on climate related initiatives while smaller, local governments are less able to initiate new actions. This is also complicated by the fact that potential impacts of climate change may be disproportionate across municipalities. Potentially hardest hit areas may be the least able to pay for climate change protection.

Competing Priorities - Much of Canada's municipal infrastructure is already old and reaching the end of its service life. The value of municipal infrastructure is estimated to be in the billions of dollars. Municipalities have also been the recipients of government programs and services that have been downloaded from upper levels of government e.g. provincial highways. Residential development is steadily increasing which places growing pressure on local governments for more access roads, better road maintenance and more services. The FCM has already identified an infrastructure deficit for Canada of $60 billion and warns that added risks from climate change will only exacerbate the problem. The FCM calls for funding action from the federal government to eliminate the municipal infrastructure deficit and better position municipalities to handle current and future climate conditions.

Information and Expertise - The Natural Resources Survey indicated that there is a high level of awareness and understanding of climate change by municipalities. Eight in ten respondents had a view that climate change is happening now and could identify potential impacts on their region in the next 20 years. Also 75% of municipal

respondents identified lack of information as a barrier to climate change action. Although extensive scientific research has been done on climate and climate modeling, more information and research is required on regional or local impacts, vulnerabilities and approaches to adaptation. Although there is much information and data available from government sources, the capacity of local municipal offices to handle and integrate information and data is variable. Information is also required in a form that is understandable by municipal staff and the general public. Currently the benefits of climate adaptation are not well understood. Climate adaptation also requires the development of expertise at the local level because climate impacts and adaptation needs can vary from one area to another.

As mentioned, the Natural Resources Canada survey also points out that approximately 73% of municipal respondents indicated that they are taking some form of action to adapt to climate change. Some municipalities include both mitigation and adaptation in their definition of adaptation while others include any ongoing activity that may support or promote adaptation in the future (e.g., maintenance of facilities). This flexible or broad definition may in fact distract from the need to focus on specific targets or high risk situations.

Uncertainty - The unpredictability and variability of weather, the dynamics of global climate change, the regional differentiation of impacts, the scope of natural and social vulnerabilities and the uncertainty of adaptation solutions all contribute to making climate change adaptation a highly complex issue. Academic theories are still developing and interdisciplinary studies are limited. The variety of impacts, risks factors and management approaches can boggle the mind and confuse the decision makers. Even if sufficient funding was available, uncertainty and confusion are likely to slow progress on climate adaptation.

In addition, the scope and complexity of climate change also requires team approaches and collaboration efforts which are not only time consuming but required leadership and facilitation skills. The capacity of municipal staff to champion climate adaptation is in many cases limited.

Governance - Climate change issues affect all levels of government and cut across all departments. It is of interest to many First Nations, non-government organizations and industry. Climate change is an emerging and evolving issue and roles and responsibilities of government sectors and others are not clearly defined. Municipalities have been identified as the leaders in the management of infrastructure and local services and as such are expected to cope with the variability and uncertainty of regional impacts. Municipalities in Ontario have been subject to previous amalgamations and program downloading which are still requiring adjustments. For the most part, municipalities look to other levels of government or organizations to “act first”. Municipal governments tend to deal with local issues while upper levels of government deal with higher order problems. Climate change is viewed as a global

issue regardless of whether impacts may be regionally and locally specific. Small local municipalities in particular are not likely to jump out in front of climate mitigation and adaptation unless more direction and support is available from other levels and forms of government, e.g. Ontario Municipal Affairs and Housing.

Toronto Star: Aug 1, 2013

Headline: **Miami among 316 U.S. cities doomed by rising sea level, study finds**

Interesting Quotes:

Benjamin Strauss (scientist at Climate Central, a non-profit research group based in Princeton, N. J.) states "Prior greenhouse gas emissions have already locked in four feet of future sea-level rise that will submerge parts of 316 municipalities"

Anders Levermann (Potsdam Institute for Climate Impact Research) found that each degree Fahrenheit of global warming translates to 4.2 feet (1.3 metres) of sea level rise in the long run.

……Jason Thistlethwaite, (Director of University of Waterloo's Climate Change Adaptation Project) comments "I was shocked by how much sealevel rise is already predicted to occur… and even if we do a good job fighting climate change and reducing greenhouse gas emissions, we are looking at seven to ten feet of sea-level rise by the end of century"

8.0 CONCLUSIONS

The FCM has called for help from the federal government and suggested that the federal government should take the lead on various activities to support climate change adaptation at the municipal level. Key proposed actions include the following:

- Strengthen science related to climate change impacts
- Work with engineering professionals and the insurance industry to determine if and how engineering standards should be adjusted to reflect future conditions
- Develop risk assessment protocols that will help decision-makers assess vulnerability to climate change
- Ensure local authorities have fully resourced emergency preparedness and response systems in place to respond to severe weather events

This list captures many of the reoccurring recommendations found in the academic literature, government documents and related reports and reflects the types of support required by municipalities that make up the Greater Peterborough Area.

Fundamental roadblocks to climate change protection include funding, expertise, capacity, uncertainty, and governance. There are several existing programs and approaches that can be used to address adaptation (i.e., risk assessment, asset management, flood reduction measures, etc. however current guidebooks and established protocols need to be updated to accommodate ongoing changes). The question is: who should do this and how should it be coordinated so that standards and consistencies are maintained. Can such approaches accommodate regional variations in potential impacts?

Models and approaches for sensitivity analysis, adaptive capacity assessment, vulnerability assessment and risk assessment tend to be complicated, time consuming and inconsistent. This situation has the potential to discourage municipal staff from undertaking initiatives on their own or require extensive support from consultants which is unaffordable. Uncertainty on the part of local staff regarding climate science and adaptation requirements makes it difficult for staff to even craft focused proposals and detailed study requirements.

There are extensive sources of information, guidance and support for municipalities particularly through FCM and ICLEI. For example, FCM has developed a Quick Action Guide: Municipal Action on Climate Protection which lays out 20 steps that can be taken immediately to curb greenhouse gas emissions.

The Community Sustainability Plan lays out the key actions for climate change protection: public awareness, mitigation, adaptation and the incorporation of climate change adaptation into existing policies and programs wherever possible. This provides an excellent starting point for climate change protection however the challenges of

implementing these actions are significant. Strategic preplanning will be required to advance on all fronts. A set of specific recommendations for the GPA should include such items as: common statements and policies in all official plans, unified planning and development requirements in zoning bylaws, specific strategies and action items to be incorporated into all applicable management plans (e.g. asset management, flood reduction, transportation plan), an infrastructure database for the GPA for emergency planning, the identification of area "safe refuge sites" such as arenas, schools or community centres, the integration of emergency plans to cover community and area wide issues and finally, specific budget planning for disaster management and long term climate change protection.

A key requirement is action on the part of Ontario Municipal Affairs and Housing. Adaptation should not be optional. Rather, Municipal Affairs and Housing should follow the lead of other provinces by requiring all municipalities to develop adaptation plans as part of their regular planning activities. Financial support should also be provided to ensure that no municipality falls behind. It is imperative that governments at all levels assume a leadership role and ensure that adaptation is occurring at a pace and scope that will safeguard our environmental, economic and social heritage.

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APPENDIX 1: GLOSSARY OF TERMS

CLIMATE CHANGE - Climate change refers to any change in climate over time whether it is generated by human actions or by natural variability. The *United Nations Framework Convention on Climate Change* defined climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

CLIMATE ADAPTATION - Adaptation to climate change refers to the process of moderating or offsetting the impacts of climate change through deliberate actions. The *Intergovernmental Panel on Climate Change (IPCC*) defines adaptation as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished however two general types of adaptation include reactive adaptation and anticipatory adaptation. Reactive adaptations are measures taken in response to climate change and anticipatory adaptations are measures taken in advance of climate change. In essence, climate mitigation could be considered a reactive adaptation while other efforts to promote preparedness are anticipatory adaptation.

CLIMATE MITIGATION - Mitigation refers to efforts to reduce or prevent the emission of greenhouse gases (GHG) which are a major contributor to global warming. Mitigation can involve the use of new technologies or changing management practices to reduce the amount of greenhouse gas generated or emitted. Mitigation efforts can also involve the protection of natural sinks like forests and oceans which help to remove carbon from the atmosphere as well as the creation of new sinks through forest silviculture (care and cultivation) practices or green agriculture.

GREENHOUSE GAS - A greenhouse gas is a gaseous constituent of the atmosphere which contributes to the enhanced warming of the earth's atmosphere (greenhouse effect). Greenhouse gases absorb and emit radiation that ultimately affects atmospheric temperatures. Carbon dioxide, nitrous oxide, methane and ozone are the primary greenhouse gases although others occur in lesser amounts. Mitigation efforts for the most part, focus on the reduction of carbon dioxide levels.

SENSITIVITY - Sensitivity refers to the degree to which a system is affected, either adversely or beneficially by climate variability or climate change. Sensitivity can be direct or indirect. Direct sensitivity can be illustrated by a farmer's crop. Crop yields change in response to the variability of precipitation and temperature and therefore crop yields are directly sensitive to climate change. Indirect sensitivity refers to system components that may not feel the direct impacts of climate change but are supported

by some factor that is. For example, changing water levels on the Great Lakes may impact shipping schedules which in turn impact the transport of grain to foreign markets and ultimately impacts if and when farmers can sell their grain to local grain terminals.

SINK - A natural sink is an area will sequesters or removes carbon from the atmosphere through natural processes. IPCC defines a sink as any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere.

RESILIENCE - Resilience refers to the ability of a natural or social system to recover from stress. Climate change will introduce stressors in the form of changing weather variables, extreme weather events and other secondary or indirect effects. The IPCC defined resilience as the ability of a social or ecological system to absorb disturbance while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Resilience is a concept which recognizes that systems are complex, non-linear, self-organizing and constantly changing. This represents a significant shift from traditional notions of controlled systems and sustainable yield in resource management to the recognition that systems whether social or ecological are complex, interconnected and subject to unpredictable change. Resilience then can serve as a measure of robustness and buffering capacity of a system to changing conditions.

Human response to climate change can include actions that restore a system to a desirable domain, allow the system to return to a desirable domain by itself or adapt to the changed system because changes are irreversible. Resilience may be restored or increased through management.

ADAPTATIVE CAPACITY - An important measure of resilience is the magnitude or scale of disturbance that can be absorbed before a system changes. The ability of the system to absorb disturbance is referred to as its' adaptive capacity. According to IPCC, adaptive capacity refers to the ability of a system to adjust to climate change (including climate variability and extremes) and moderate potential damages, to take advantage of opportunities or to cope with the consequences. Adaptive capacity is the property of a system to adjust its characteristics or behaviour in order to expand its ability to cope with climate variability or future climate conditions.

VULNERABILITY - The resilience of social-ecological systems is also affected by the system's vulnerability to environmental stresses. Vulnerability refers to the susceptibility of a system to harm or damages from stressors such as climate change impacts. Systems that are sensitive to climate change and less able to adapt to changes are generally considered to be more vulnerable. Vulnerability relates to the capacity of individuals and social groups to respond to, cope with, recover from or adapt to any external stress placed on their livelihoods and well-being as a result of changing climate.

Characteristics of vulnerability can be biophysical or social. The IPCC defines vulnerability as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed and its' climate sensitivity and its adaptive capacity.

APPENDIX 2: LIST OF GUIDEBOOKS AND RESOURCES FOR MUNICIPALITIES

There are a lot of resources available to assist municipalities with climate change planning:

Acting Locally: The Municipal Role in Fighting Climate Change – prepared by FCM – the report helps municipalities address the challenges of climate change through the reduction of GHG emissions

Adapting to Climate Change: An Introduction for Canadian Municipalities – prepared by Richardson (2010) for Natural Resource Canada – provides municipal decision-makers and staff with information to help them understand the need for climate change adaptation and how to put adaptation measures in place

Climate Change Adaptation Toolbox – prepared by Ontario Ministry of Natural Resources – an online toolbox which is designed to help interested parties access tools and techniques to support vulnerability assessments and adaptation action

Climate Change Adaptation Planning: Handbook for Small Canadian Communities - prepared by Canadian Institute of Planners – to help small Canadian communities prepare and implement a climate change adaptation plan

Changing Climate, Changing Communities: Guide for Municipal Climate Adaptation – prepared y ICLEI – provides a milestone framework that leads local government practitioners through a process of initiation, research, planning , implementation and monitoring for climate adaptation planning.

Canadian Communities' Guidebook for Adaptation to Climate Change: Including an approach to generate mitigation co-benefits in the context of sustainable development – *prep*ared by Bizikova, Neale and Burton 2008 for Environment Canada and University of British Columbia - provides leaders who aim to address local development issues in a sustainable way and are concerned about climate change

Five-Milestone Framework for Reducing Greenhouse Gas Emissions – prepared by FCM and ICLEI – to provide information to Partners for Climate Protection (PCP) members on a five-milestone framework that can help municipal government to take action to reduce GHG emissions from the community and municipal operations

Municipal Resources for Adapting to Climate Change – prepared by FCM and ICLEI – to provide information to Partners for Climate Protection (PCP) members and other

municipal officials about municipal adaptation initiatives to provide resources for municipal officials who wish to undertake adaptation planning

Preparing for Climate Change: A Guidebook for Local, Regional and State Governments – prepared by ICLEI – intended to help decision-makers in local, regional and state governments prepare for climate change by recommending a detailed, easy-to-understand process for climate change preparedness based on familiar resources and tools

Quick Action Guide: Municipal Action on Climate Protection – prepared by FCM and the Government of Canada – provides a listing of the top ten corporate and community activities implemented by municipalities in their efforts to reduce GHG emissions

APPENDIX 3: TEST SENSITIVITY ANALYSIS - CITY OF PETERBOROUGH

Using the ICLEI document, *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments*, a test sensitivity analysis was completed for Municipal programs and services for the City of Peterborough. The analysis was done using the six questions and sample template for sensitivity analysis provided in the ICLEI guide.

Programs and Services considered include the following:

1. Emergency and Risk Management – preparation for high risk incidents e.g. floods
2. Fire Service
3. Community Services
    - Recreation and facilities - arenas, campgrounds, sport
    - Arts, culture and heritage - art gallery, library
    - Social and family services - child welfare, job search
4. Sustainability - safe, sufficient supply of water, air, energy, natural resources and renewable energy
5. Corporate Services
    - Financial services
    - Human resources
    - Property management
    - Legal services
6. Planning and Development Services
    - Planning – plans of subdivision, zoning, official plans
    - Building standards, codes and bylaws
    - Social housing
    - Business development - industrial park, airport
7. Utility Services
    - Engineering and construction
    - Sewers and sanitation
    - Water supply and water treatment
    - Solid waste management
    - Transportation - traffic, public transit, parking

The test sensitivity analysis points to six high sensitivity program areas for the City: emergency and risk management, sustainability, financial services, engineering and construction (storm and sanitary sewers, streets, culverts, etc.), environmental protection (waste water treatment), and public works.

Specific results are presented in the following table.

Result of Sensitivity Analysis

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
EMERGENCY & RISK MANAGEMENT	COMMUNITY EMERGENCY - spring floods, virus outbreak, bomb threat etc.	Temperature	Increased average temperatures, increased days over 30C Episodes of warmer temperatures in winter	Heat related threats to human health e.g. heat strokes, respiratory problems, etc.	High Sensitivity	Increased pressure on emergency preparedness and emergency services e.g. early warning systems, communications, emergency shelters, emergency power supplies, essential services such as clean drinking water, etc.
		Precipitation	Variable precipitation e.g. rainfall or snowfall extremes	Loss of public and personal property e.g. flooding from excessive rainfall or snow melt		
			Excessive dryness from lack of summer rainfall	Drought, increased potential for wildfire, threats to human safety		
		Extreme weather events e.g. tornadoes, hurricanes, extreme wind velocity, drought	Increase in extreme weather	Personal and municipal property damage and threats to human safety Power outages more common, of greater duration especially in time of extreme heat or cold		

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
FIRE SERVICE	FIRE SUPPRESSION AND RESCUE SERVICE	Temperature Precipitation	Summer heat waves Increased lightning storms	Increased wild/grass fires Increased building fires Increased support for emergency situations	Medium Sensitivity	Increased pressure for fire service primarily in summer months Fire services can be dependent on volunteers Fire Departments provide significant support to emergency medical services e.g. ambulance assist
COMMUNITY SERVICE	ARENAS - Memorial Centre - Evinrude Centre - Kinsmen Civic - Northcrest	Temperature	Warmer winter temperatures	Potential impacts to facility maintenance e.g. additional cooling costs for shoulder season ice formation	Low Sensitivity	These building serve as shelter and refuges during and after severe events
	ARTS, CULTURE AND HERITAGE - arts, culture -heritage activities and facilities	Extreme weather events	Increased occurrence of extreme weather events	Potential damages to heritage buildings and difficulties finding replacement materials Disruption of cultural events Increased insurance costs	Low Sensitivity	

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
	FACILITIES AND SPECIAL PROJECTS -marinas -parks -campgrounds	Temperature Precipitation Extreme weather e.g. floods, high winds	Warmer summer temperatures Rainfall events Increased occurrence of extreme weather events	Potential to encourage use Potential to discourage use Damage to facilities from extreme weather Damage/blow down of trees in campground and park	Medium sensitivity	Increase in warm weather may provide opportunities for new types of outdoor recreation or extended seasons Potential to impact Tourism Implications for capital projects i.e. increased standards
	RECREATION - sport fields - beaches - wading pools - day camps - swimming lessons	Temperature	More days of high temperatures e.g. over 30 degrees C	Increased use of facilities Contingency planning for heat strokes	Low Sensitivity	Potential for added pressure to supply outdoor summer recreation Public education for protection from extreme heat
	SOCIAL SERVICES -financial and employment assistance	Temperature Precipitation	Increases in temperatures Variable rainfall and snowfall	Low income residents less able to cope with negative impacts of climate change e.g. increased heating or cooling costs Weather can impact provision of seasonal employment opportunities	Low Sensitivity	

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
	SUSTAINABILITY - safe, sufficient supply of water, air, energy, natural resources and renewable energy	Temperature and precipitation Extreme weather events e.g. floods, wind damage, tornadoes, etc.	Temperature increases/ precipitation variability Increase in extreme weather events	Changing lake levels impacting tourism and fisheries, potential for water shortages, increased ground level ozone, threats to ecosystem stability, threats to human health e.g. new diseases, threats to economic stability e.g. crop loss or damages, etc.	High Sensitivity	Community Sustainability Plan in place – additional effort required to complete climate change mitigation and adaptation
CORPORATE SERVICES	FINANCIAL SERVICES -collection of property taxes -operating and capital budgets -tenders, proposals and payments	Temperature/ precipitation Extreme weather events	Temperature increases, variability in precipitation Increases in extreme weather events	Significant implications for budgets and financial management particularly for unforeseen extreme weather events	High Sensitivity	Costs to adapt to climate change will have implications for operating and capital budgets and are likely to impact tax rates
	HUMAN RESOURCES -administration -classification -recruitment -training	Temperature and precipitation Extreme Weather Events	Increased temperatures. More variability in precipitation Higher incidents of extreme weather	Impacts of climate change may require new management approaches, development standards etc. Staff will need to be informed and/or educated about climate change issues	Medium Sensitivity	A gradual upgrading of staff expertise should be planned for New positions should require some familiarity with climate change mitigation and adaptation requirements and approaches

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
	PROPERTY MANAGEMENT -management and maintenance of City owned property and buildings	Temperature and precipitation Extreme weather events	Increased temperature and precipitation variability Increased extreme weather events	Upgraded maintenance standards may be required e.g. amount of insulation Property damage may increase Replacement costs will impact capital budgets	Medium Sensitivity	Energy Conservation initiatives in place Insurance costs likely to increase
	LEGAL SERVICES - legal advice - real estate transactions - prosecutions	Precipitation Extreme weather events	Variable precipitation Increased extreme weather events	Increased enforcement of bylaws may be required i.e. retention or protection of wetland areas as storm-water storage areas Flooding can cause polluted water supplies which can lead to human illness. This may result in legal action against municipalities	Medium Sensitivity	

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
PLANNING AND DEVELOPMENT SERVICES	BUSINESS DEVELOPMENT -industrial park - business opportunities	Temperatures and Precipitation Extreme weather events	Variable precipitation Increased extreme weather events	Additional heating and/or cooling costs for industrial sites Planning of industrial park needs to take into consideration potential impacts of weather extremes i.e. flooding	Low Sensitivity	The attraction of industry may be impacted by the preparedness of municipalities for climate change
	HOUSING - social housing portfolio	Temperature Extreme weather	Higher temperatures Increases in extreme weather events	Higher energy costs for residents for cooling Damage to buildings	Low Sensitivity	
	PLANNING DIVISION - plans of subdivision - zoning - official plans - site plans	Extreme weather events	Increased extreme weather events	Land use planning will need to incorporate climate adaptation e.g. protection of sensitive areas, groundwater recharge areas, floodplains, etc. More stringent enforcement of bylaws may be required	Medium Sensitivity	Ongoing and regular updates to Official Plans and Zoning Bylaws to incorporate climate adaptation will be imperative

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
UTILITY SERVICES	ENGINEERING AND CONSTRUCTION -design and construction of all new storm and sanitary sewers	Temperature Precipitation Extreme weather events	Temperature increases, more variability Variability in precipitation Increased extreme weather events	Accelerated freeze/ thaw cycles leading to faster break down of concrete materials, shorter facility life cycle Added pressure to already deteriorating facilities	High sensitivity	Increased maintenance costs Updated approach to facility management will be required Potential changes in design standards Potential changes in building materials
	ENGINEERING AND CONSTRUCTION -construction of sidewalks, streets, bridges and culverts	Climate variability	Increased variability and increased extreme weather events	Same as above – implications for construction and maintenance	High sensitivity	Same above
	ENVIRONMENT PROTECTION -waste water treatment plant -pumping stations	Precipitation Extreme weather events i.e. wind storms, ice storms, excessive rainfall	Variability in precipitation, potential for excessive rainfall and runoff Increases in extreme weather	Flooding can overwhelm waste water treatment systems Some systems may not have separate sewer and surface runoff systems Power outages can impact pumping stations and reduce water pressure Washouts and pipe breaks can occur	High Sensitivity	Potential for serious impacts on human health and the environment Costs of backup power or power alternatives Costs of repairing or replacing pipes and/or facilities

Program Sector	Management Unit	Relevant Climate Factors	Projected Changes to Climate Factors	Potential Impacts of Changing Climate Factors	Relative Sensitivity to Climate Change	Comments or Notes
	PUBLIC WORKS -solid waste collection -sanitary and storm sewer systems -bridges, culverts and streets	Extreme weather events	Increases in extreme weather events	Excessive rainfall and runoff can overwhelm culverts and storm water drainage system as well as lead to washouts of streets and bridges Sewer backups in homes can present health hazards	High Sensitivity	
UTILITY SERVICES –	TRANSPORTATION TRAFFIC/ TRANSIT/ PARKING -bus service -parking and parking lots -traffic signals -transportation planning	Extreme weather events – precipitation, ice storms, wind storms	Increases in extreme weather events	Flooded streets and ponding water may disrupt transit services and transportation routes Power outages can impact traffic system	Low Sensitivity	Transportation plans should include contingency plans i.e. alternate routes Buses may be required for evacuation to shelters
	WASTE MANAGEMENT - solid waste collection and disposal - Bensford Road Landfill,			Waste collection may be cancelled or delayed leaving waste on streets	Low Sensitivity	