Ontario Centre for Climate Impacts and Adaptation Resources

OCCIAR is a university-based, resource hub for researchers and stakeholders that provides information on climate change impacts and adaptation. The centre communicates the latest research on climate change impacts and adaptation, liaises with partners across Canada to encourage adaptation to climate change and aids in the development and application of tools to assist with municipal adaptation. The Centre is also a hub for climate change impacts and adaptation activities, events and resources. [http://www.climateontario.ca](http://www.climateontario.ca)

Regional Adaptation Collaborative

The Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is an Ontario partner in Natural Resources Canada’s Regional Adaptation Collaborative (RAC) Climate Change Program. It is a three year program to help Canadians reduce the risks and maximize the opportunities posed by climate change. The Program helps communities prepare for and adapt to local impacts posed by our changing climate, such as: decreasing fresh water supplies; increasing droughts, floods and coastal erosion; and changing forestry, fisheries and agricultural resources. **The goal of the Program is to catalyze coordinated and sustained adaptation planning, decision-making and action, across Canada’s diverse regions.** The RACs Program is a partnership between the federal government, provinces and territories, working with local governments and organizations. [http://adaptation.nrcan.gc.ca/collab/index_e.php](http://adaptation.nrcan.gc.ca/collab/index_e.php)

Acknowledgements

OCCIAR would like to acknowledge Natural Resources Canada for their support in this endeavour as part of the Ontario Regional Adaptation Collaborative. This Ontario Regional Adaptation Collaborative Capacity Building workshop was organized in conjunction with the Hamilton Conservation Authority.

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“This project has received funding support from the Government of Ontario and Natural Resources Canada. Such support does not indicate endorsement by the Government of Ontario or Natural Resources Canada.”
Climate Change Impacts and Adaptation in the Hamilton Conservation Authority Watersheds

A Climate Change Adaptation Workshop

Maplewood Hall
917 Artaban Road
Hamilton, Ontario

Thursday June 16, 2011
Executive Summary

The workshop captured a diverse array of attendees including academics, consultants, city staff and conservation authority staff. The appeal for information in the area of climate change adaptation indicates that there is an understanding of the need for adaptation and a desire to be part of a group who undertakes the development and implementation of a climate change adaptation strategy. Each of the workshop participants brought their own priorities and was able to make the connection to how they will be affected by climate change and potential solutions for their field. These solutions are often beneficial to other areas of study and other sectors thus providing multiple benefits. Discussions during the workshop indicated interest both from an ecosystems perspective as well as the impacts to built and human systems. This balance will be helpful when addressing environmental, social and economic aspects of climate risks in the watershed.

The workshop created a venue for Conservation Authority and City of Hamilton staff to talk about priorities, ongoing activities, and most importantly, partnerships and how to work together in adaptation. Efforts to undertake adaptation planning can be seen in other Ontario communities and watersheds. These efforts can provide valuable insight for the Hamilton Conservation Authority and for the City of Hamilton. The City of Toronto is one such example. Although there are benefits in reducing Greenhouse Gas emissions and conserving energy, adaptation creates a valuable response to the current and future impacts of climate change.

There is inherent uncertainty in climate models and their ability to project climate change at reduced spatial scales is limited. However, adaptation requires planners and other stakeholders to gather and make use of the most up to date information and advance climate-cognizant decision-making. Managing adaptively through the Precautionary Principle will help reduce climate risks and will also build local resilience. Workshop participants identified a number of support pieces that would facilitate adaptation planning in the Hamilton Watershed including:

- Enhanced communication and education of CA staff, City staff and the general public
- Enhanced watershed monitoring; human, financial and educational resources
- Mainstreaming of climate change into existing policies and decision-making frameworks
- Developing tools in order to assess and manage climate risks
- Taking stock of and building upon current, ongoing initiatives
- Leveraging partnerships with all stakeholders

Some adaptation measures provide multiple benefits. Protection and
enhancement of green spaces provides both parkways for people and movement corridors for different animals.

Workshop attendees also commented on the benefits of having a business case that accompanies the plans for adaptation. In some cases, managers need to provide some indication of adaptation costs and a clear picture of the benefits they provide.

Finally, the local academic community can provide vast research support for local adaptation planning. Information such as weather and water data, ecosystem sensitivity/vulnerability research and adaptive capacity building techniques all inform adaptation planning.
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## Workshop Agenda

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<td>8:30 am to 8:50 am</td>
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| 8:50 am to 9:00 am | Welcome and Introduction  
Steve Miazga, Chief Administrative Officer, Hamilton Conservation Authority |
| 9:00 am to 9:30 am | Climate Change Adaptation – the Context  
Al Douglas, OCCIAR |
| 9:30 am to 10:00 am | Beyond the Storm: Toronto’s Climate Change Adaptation Program - It’s about Risk and Cost Management,  
David MacLeod, Toronto Environment Office, City of Toronto |
| 10:00 am to 10:30 am | Hamilton - Climate Change and City Actions  
Brian Montgomery, Air Quality and Climate Change Coordinator, City of Hamilton |
| 10:30 am to 10:45 am | BREAK (light refreshments)                                             |
| 10:45 am to 12:00 pm | Components of Adaptation Planning - Al Douglas, OCCIAR                |
| 12:00 pm to 1:00 pm | LUNCH (provided)                                                      |
| 1:00 pm to 1:30 pm | Overview of Adaptation Frameworks and Tools: Risk Management - Al Douglas, OCCIAR |
| 1:30 pm to 2:00 pm | Watershed Resilience and Climate Change: McMaster Centre for Climate Change Research - Mike Waddington, McMaster University |
| 2:00 pm to 2:30 pm | Building Resilience and Managing Change in our Watersheds, Hazel Breton, Hamilton Conservation Authority |
| 2:30 pm to 3:00 pm | Summary of Conservation Authority Regional Adaptation Workshop  
Jane Lewington, Conservation Ontario |
| 3:00 pm to 3:15 pm | BREAK (light refreshments)                                             |
| 3:15 pm to 3:45 pm | Group Discussion:  
What role do you think the Hamilton Conservation Authority should play in adapting to climate change? |
| 3:45 pm to 4:00 pm | Groups Report Back                                                     |
| 4:00 pm to 4:30 pm | General Question and Answer Period (questions for all of the speakers) |
| 4:30 pm       | Meeting Adjourned                                                     |
Overview

In collaboration with the Hamilton Conservation Authority, the Ontario Centre for Climate Impacts and Adaptation Resources held a one-day workshop in Hamilton to help the Hamilton Conservation Authority, the City of Hamilton and local environmental groups address the challenges of climate change.

The goals of the workshop were to help participants:

- to learn about climate change impacts and adaptation;
- to learn about what others are doing to adapt;
- to review the known ways in which climate has changed in the Hamilton Conservation Authority Watersheds and understand how that has impacted natural, built and human systems;
- to review selected projections of climate and resulting potential impacts;
- to examine various tools (e.g. Risk Assessment/Management) available to help communities and watersheds identify and prioritize risks associated with climate change;
- and to discuss the role of the Hamilton Conservation Authorities in climate change adaptation.

Introduction

Steve Miazga, the Chief Administrative Officer for the Hamilton Conservation Authority began the day by welcoming and thanking delegates for participating in this important workshop. Mr. Miazga continued by saying the Hamilton Conservation Authority Board has accepted that climate change is an issue that needs to be addressed and it will be included in a strategic plan later this year. Hamilton has already experienced climate change with several extreme weather events this year. The Hamilton Conservation Authority understands it is happening and for the community (i.e. for the environment, people and safety) climate change needs to be addressed. He concluded by saying that the Hamilton Conservation Authority wants to hear what participants have to say at the workshop and hopes they can become a leader in climate change adaptation.
Presentations

The following are brief summaries of the presentations made at the workshop. The presentations are available for viewing on the www.climateontario.ca website.
Climate Change Adaptation: the Context
Al Douglas, Director, Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR)

Al Douglas began his presentation by giving a brief overview of the context of climate change adaptation. Fossil fuel emissions have continued to increase in the atmosphere, tracking in line with the ‘worst case’ scenarios developed by the International Panel on Climate Change (IPCC). Current and continued emissions commits the planet to further global climate change. The IPCC has also shown that climate models using both natural and anthropogenic forcings correlate well with observed temperature over the last 100 years. Furthermore, the number of climate-related disasters has increased dramatically over the last 50 years.

In Canada, very significant changes in temperature have occurred in the northwest since 1948 and in Ontario temperatures have changed between 0.4 and 0.6°C. As a result, Ontario has experienced impacts in the form of weather-related challenges (e.g. shortening of winter road season, increase in spruce budworm, less snow, dry conditions and drought, heat stress, vector born disease and flooding). These weather-related or extreme events, which will increase in intensity and frequency into the future, have and will continue to test systems.

Mr. Douglas continued by saying that it is understood that the climate is changing, along with becoming more variable, and that we are exposed. Often, adaptation occurs autonomously (i.e. we cope), but it is the residual impacts that determines our vulnerability. For those, we have to respond with planned adaptation. Climate change will present new challenges that test our critical threshold to cope making us more vulnerable. Adaptation will increase our resilience. Unlike coping which is short-term and motivated by crisis, adaptation is a longer term, continuous process that combines old and new strategies and knowledge. In conclusion, Mr. Douglas stated that increasing our adaptive capacity (e.g. access to information, knowledge and skills, etc) will help us and our systems deal with climate change.
Beyond the Storm: Toronto’s Climate Change Adaptation Program

It’s about Risk and Cost Management

David MacLeod, Toronto Environment Office, City of Toronto

Mr. David MacLeod began his presentation by saying that the City of Toronto, as well as the GTA, the province as well as the country need to be resilient, and can accomplish this through GHG mitigation and adaptation.

Anticipated climate change impacts on Toronto, including more extreme weather events (e.g. heavy rain, flash floods, etc) could result in damage to Toronto’s infrastructure (i.e. damage to buildings, water, sewer transportation infrastructure, electrical systems). More heat waves and smog could result in more heat stress, illness and death. It is an added stress on resources required for assisting local vulnerable populations with limited mobility (e.g. homeless, isolated seniors). Flooding is a massive problem in Toronto. The City determined that the root cause of the washout of Finch Avenue from the August 2005 storm was an undersized culvert; Toronto has over 154 large culverts and is now undertaking a climate change vulnerability assessment on three of these culverts. The storm also resulted in a loss of cultural and natural heritage features, disrupted businesses, damaged cars and flooded basements.

Toronto is looking at several way to build resilience by helping residents protect their property with lot grading and sewer back flow valves, through green roof incentive programs, sustainable parking lots, urban naturalization, sustainable sidewalks, road weather information systems and 3 in 1 salt trucks that allow for flexibility to variable road and weather conditions.

In 2008, the Climate Change Adaptation Strategy was approved by City Council. This strategy will help the City ensure the safety of both citizens and staff, enhance customer service, reduce and avoid costs associated with extreme weather and practice due diligence. There are many groups in the Toronto area working on climate change adaptation and Mr. MacLeod is working on developing the Toronto Region Action Group on Extreme Weather Resilience which would allow all of these groups to work together.

Mr. MacLeod concluded by sharing some of the major adaptation programs that are happening in the City of Toronto including Heat and Smog Alerts, Wet Weather Flow Master Plan, Basement Flooding Program and the Climate Change Adaptation Strategy, which includes a climate change risk assessment.
Hamilton - Climate Change and City Actions
Brian Montgomery, Air Quality and Climate Change Coordinator, City of Hamilton

Mr. Brian Montgomery began his presentation by sharing work done by the Federation of Canadian Municipalities (FCM) which determined that municipalities have control over approximately 45% of Canadian greenhouse gas emissions. Hamilton has been involved with climate change issues for several years beginning with their partnership with FCM. Involvement continued with Vision 2020, Regional Emissions Plan, Climate Vulnerability Study and individual community efforts such as Tonnes for Trees. Hamilton has also undertaken action on climate change with its Corporate Air Quality and Climate Change Strategic Plan (2006-2008). The action plan which included both mitigation and adaptation and an emissions inventory, set targets of a 10% reduction of 2005 emissions by 2012 and 20% emissions of 2005 levels by 2020. The emissions inventory looked at corporate operations and community emissions (e.g. steel, waste, transportation, agriculture (i.e. livestock)). The study concluded that the biggest emitter was the steel industry (regulated by provincial and federal government), but the energy use in the community was still large and could be dealt with locally through policies and directives.

In June of 2010, Hamilton released a discussion paper “Taking Stock” to inform residents about its greenhouse gas emissions and provide a forum for ideas and actions to reduce emissions. A Climate Change Town Hall took place in March of 2011 and topics discussed included buildings, water, local economy and business, and moving people. More information can be found at www.hamilton.ca/climatechange. As well, the Buildings Energy Density mapping looked at the consumption of energy in the City of Hamilton. Several buildings within the city have green roofs/walls and heat vulnerability mapping has helped identify where vulnerable populations exist. Along with the work of the city, many other groups in the community are talking about climate change and/or have climate change programs in place.

Mr. Montgomery concluded by sharing the City of Hamilton’s Climate Change Charter which was developed as a means to send a common message to council and the community to show that action is taking place. His group is approaching people to endorse the charter during the city’s Climate Change Action Week in October.
Components of Adaptation Planning
Al Douglas, Director, Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR)

Mr. Al Douglas began an interactive session on the components of adaptation planning by stating that a good starting point is looking at historical climate data. The data must be from a representative station, be continuous and cover a period of 30 years. Continuous temperature and precipitation data, from 1970 to present, was collected from Environment Canada for the Hamilton A weather station. Graphs of temperature show the change in average mean temperature for the area, over the period of record, was 0.9°C, with a larger increase in the winter (1.7°C) and less in the summer (0.3°C). The Average Maximum Temperature increased 1.3°C. Graphs of precipitation show an approximate 3% increase in annual precipitation over the period of record.

Mr. Douglas continued by talking about vulnerability and posed a series of questions to the workshop participants.

1. Has your area experienced extreme weather events?
   Answer:
   - The area had recently experienced a few extreme weather events (i.e. wind, torrential rainfall) that resulted in electrical outages and fallen trees.

2. Have your operations been challenged by weather events?
   Answers:
   - Extreme weather events are a public safety issue. One participant found planning events for children challenging and has had to cancel events due to extreme weather;
   - High flows in rivers have prevented access to data resulting in projects delays;
   - Warmer weather has provided opportunities to parks, but they have also experienced negative impacts;
   - Over the last 6 years, each extreme weather event has been different (e.g. high intensity to long events). Each has posed operational challenges;
   - Reservoirs are impacted when a melt event occurs and the snowpack is lost early in the year.

3. Have you experienced losses due to weather events?
   Answers:
• Some businesses have experienced extreme financial losses from weather events (i.e. damage from high wind, sewer backup, flooding) as they were unable to deliver products to customers;
• In Hamilton, the ski hill and wave pool are highly sensitive to weather and it is hard to plan for the year.

Vulnerability is a function of current exposure to climate variability and change, sensitivity and adaptive capacity or the ability to implement adaptation. How has the community coped in the past and at present? If changes in the natural system occur, will the community still be able to cope? This needs to be examined in the context of the current situation and includes influences outside of climate change (e.g. population growth).

Climate models are used to look into the future. Each year the climate models improve and they project how temperature and precipitation may change. In Canada, the Canadian Climate Change Scenarios Network (CCCSN) at Environment Canada, OURANOS in Quebec and Pacific Climate Impacts Consortium (PCIC) provide climate modelling. It is important to remember that some events cannot be determined as they occur at too final a spatial and temporal scale. Statistical downscaling can help with these events, but it requires expertise not available to everyone. This should not be a reason for making sound ‘no-regrets’ decisions. The CCCSN has created ensemble projections, using 24 global models, for temperature and precipitation (cccsn.ca). The ensemble shows a 9% increase in winter precipitation by the 2050s (relative to 1961-1990 and using a medium emission scenario).

According to the IPCC, southern Ontario can expect increased frequency of heavy precipitation events, reduced snowpack and more winter rain, earlier spring freshet and more frequent summer dry spells and heatwaves (among others). Levels in the Great Lakes are projected to change which has implications for hydropower and navigation. Climate change will have both positive and negative impacts on the tourism and agriculture industries and municipalities will have to know how their infrastructure will be vulnerable or at risk. Community managers need to be aware of how climate variability and change will manifest itself and how it will translate into impacts and risks for the community.

Mr. Douglas continued by posing a series of questions to the audience.

Questions:
1. Can you relate to the projected impacts that were just discussed?
2. In what ways have you coped with changed weather and its impacts?
3. Given the projections of change, will these coping strategies continue to be adequate?
4. What will you do differently?

Answers:

- Public works industry has an infrastructure deficit; $150 million for natural deterioration alone and now climate change is affecting it. New infrastructure is being built on old standards and is supposed to be in service for 100 years.
- If municipal infrastructure, society, communication, power grids, railways, provincial roadways, and gas supply adapted, only half the job would be done. It is important to know how each area interacts with the others.
- Landowners are losing land due to storm events.
- Terrestrial ecologists to plant for what will be here in the future (planting selection).
- City of Toronto is planting Carolinian species anticipating warmer temperatures.
- Messaging needs to change depending on who you are working with. In a meeting with climate experts and scientists, it was decided that communication is the greatest barrier to climate change. There is a need for different messages for different people.
- There are microclimate challenges due the geography of the lakeside and airport. Each can have very different temperatures and precipitation events. It could be raining everywhere else but not in Hamilton. It is also the intense precipitation events that politicians pay attention to.
- Education plays an important role and all levels need to be educated. It is no longer acceptable to shake our heads and say that we are not sure. We need to get to the stage where people understand that change is going to happen and that we have to cope.
- We are not sure what the future will be, we have to plan for the range as it is no longer stationary.
- Part of the difficulty is how information has been communicated in the past. We need to talk about frequency and duration, for example a change of 4°C might mean 3 more extreme events per year – the degree may not be as important to people as 3 more events that flood basements. It’s not only global climate change – it impacts at a local and individual level.
- The message needs to be tailored to the audience and we have to begin targeting key audiences such as the public and council.
Mr. Douglas began his presentation saying that there are a series of assessment methods that can help guide adaptation planning. Information needs to be framed to make sense to those who are tasked to deal with climate change. For example, businesses and municipalities need to think about disruptions and downtimes; banking and lending sectors will want to know if companies are paying attention to weather related events; and the insurance sector is beginning to develop tools to define risk. Insurance risk can be quite significant (e.g. storm in GTA in 2005 $500M total and $247M in sewer backup payouts). It is also important to consider if due diligence been exercised in recognizing climate and weather-related risks.

The IPCC (2007) has defined four different assessment approaches. The Impact Assessment is scenario driven, uses expert input, includes a good range of futures and is good at identifying key issues, but sometimes uncertainty can lead to inaction. Risk Assessment deals with likelihoods and consequences. Municipalities understand the concept of risk and there are risk assessment tools very specific to Ontario that helps identify priorities and acceptability of risk. It is not always about eliminating risk but reducing it to an acceptable level. Vulnerability Assessments determine to what degree a system is susceptible to or unable to cope with the effects of climate change and adaptation options are often what is already being done (e.g. best practices). Policy Assessments determine how effective policy, programs and projects are given a changing climate. Integrated Assessments combines knowledge from diverse disciplines and recognizes the complexity of the issue. There are also more specific methods that can be used for different sectors such as the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol.

Once identified, strategies need to be put in place to reduce the vulnerabilities and increase coping capacities. There are a range of possible responses when considering adaptation options, these include: no regrets, profit/opportunity, win-win, low-regret, avoiding sustainable investments and averting catastrophic risk.

Adaptive management is a structured, iterative process of optimal decision-making in the face of uncertainty, aiming to reduce uncertainty through system monitoring. Even though the future is uncertain, strategies need to be flexible in case the right decision was not made. Continued monitoring and evaluate will allow incorporation of new science and information to make adjustments.
Building Resilience and Managing Change in our Watersheds
Hazel Breton, Hamilton Conservation Authority

The Hamilton Conservation Authority focus on a number of areas including water management, natural areas and built heritage, outdoor recreation, education and awareness and corporate sustainability. In terms of its core mandate, regulatory responsibilities for hazard management for flooding and erosion focus on prevention, protection and response; and legal agreements and memorandums of understanding with various agencies are help with ecosystem protection. The Hamilton Conservation Authority endorses adaptive environmental management, information-based decision-making, a precautionary approach and collaboration.

A recent wind storm resulted in fallen trees; rain storms have caused flooding in basements; and low flow conditions have affected riparian flora and fauna in streams. The Hamilton Conservation Authority, along with other groups, will have to take into account projected changes and impacts in their watersheds.

Adaptive strategies already being considered by Conservation Authorities include implementing riparian buffers; enhancing and restoring wetlands, reforesting, putting more storage on the landscape, raising awareness of the impact of northward migration of flora, fauna and disease; reviewing and if needed adjusting dam operations; implementing good risk management policies; maintaining a current watershed plan; and building demonstration projects. The Hamilton Conservation Authority needs to consider and encourage changes within its programs (e.g. water management needs to take climate change into account). Understanding the science is first in reaching the desired endpoints (i.e. climate adaptation and mitigation, weather ready state, resilient communities, healthy watersheds).

The Hamilton Conservation Authority and its partners will need to continue to manage watersheds in the face of ongoing and future issues; contributions of loading to Cootes Paradise and Hamilton Harbour; future issues including growth, redevelopment, aging infrastructure, deterioration in water quality, flooding and changing climate; within the context of Integrated Watershed Management to address these issues in a proactive manner; and programs with climate change as an additional but integrated consideration.

Next steps are to continue the dialogue with staff, board, foundation and partners to work towards a strategy by December; increase understanding of how climate is changing and the associated impacts and apply this understanding to plans and operations with ‘no-regrets’ strategies; access the need for policy and guidelines; and periodically review and update the above.
Summary of Conservation Authority Regional Adaptation Workshops

Jane Lewington, Conservation Ontario

Conservation Ontario represents 36 Conservation Authorities in Ontario. Conservation Authorities will play a key role in building resilience of local watershed to climate change, a role that has been recognized in the Expert Panel Report. Some have already begun to assess what climate change means to their business, as a component of their business plan and informally at the program level. Some Conservation Authorities have begun mitigation efforts within their own operations (e.g. green buildings, fleet vehicles) while others are developing science and monitoring to track the impacts of climate change.

Through collaboration between Conservation Ontario and OCCIAR, three workshops were held this year to help Ontario’s Conservation Authorities address the challenges associated with climate change. The objectives of the workshops were to raise awareness of climate change and its implications to Conservation Authority business; provide an update on provincial perspective and initiatives; provide opportunity for Conservation Authorities to share current climate change initiatives and discuss challenges and approaches for incorporating adaptation and mitigation into their programs. Results from the workshops provided important insights and will inform and support further adaptation planning and action.

Outcomes

Key Themes:
Conservation Authorities require:

- *Enhanced communication and education* to share information, knowledge and approaches
- *Enhanced monitoring of climate and weather and modeling of the interactions of climate and ecosystem components* as data provides the science for informed watershed management decisions
- *Human, financial and educational resources* in order to keep pace with growing watershed management responsibilities
- *Local support* for climate change initiatives (continue to build)
- *Mainstreaming of climate change* into existing Conservation Authority programs and policies
- *Educating the public* about their role in adapting to climate change impacts
- *Venue* for Conservation Authorities to share successes and challenges related to climate change
- *Tools to be developed* to help with adaptation planning. Conservation Authorities need resources such as
guidelines and tools to aid adaptation planning at the watershed level
• *Building upon what is already happening* – don’t need to completely re-invent the wheel
• *Leverage* Conservation Authorities’ resources & working groups by developing joint partnerships with governments and agencies

Specific short term priorities:
• Share Conservation Authority strategies, models and matrixes
• Develop a forum or venue to share information
• Develop climate change education and communication materials specific to Ontario watersheds and Conservation Authority programs
• Undertake local modelling, collect and compile local watershed climate data, and develop the story.
• Identify critical partners (Province, Municipalities, which Agencies?)
• Develop climate change white papers to garner support from senior management and Conservation Authority Boards
• Begin to develop individual Conservation Authority strategies and tools
• Assess how Conservation Authority operations can incorporate climate change considerations themselves

Long term priorities:
• Build the Science
• Enhance monitoring and tracking for climate change impacts
• Use common climate change data collection systems at watershed scale
• Evaluate current modelling to see if it is sufficient
• Address aging flood program
  • Work with province to improve flood plain mapping, IDF curves, flood forecasting and detection/communication
• Promote incorporation of climate change into provincial policy
• Identify budget implications for climate change adaptation and develop guidance
• Begin work on specific issues such as shorelines, water levels, stewardship planting, natural heritage studies, storm water management, regulations, etc.
• Assess how climate change adaptation is incorporated into Conservation Authority IWM plans
• Develop a risk management framework
• Identify and set up training modules for Conservation Authority staff
• Identify opportunities (e.g. tourism/outdoor)

Conservation Ontario’s Role:
• Advocacy – link climate change and Integrated Watershed Management and contribute to definition of climate change responsibilities
• Central hub for Information – Conservation Ontario to facilitate information sharing
• Education and awareness
  o Among provincial/federal stakeholders
  o Provide communication support to Conservation Authorities (e.g. resources, presentations, etc.)
• Promote consistency among Conservation Authorities
• Partnership development – identify and facilitate new partnerships around climate change
• Identify areas where Conservation Authorities can leverage resources
• Facilitate training/workshops for Conservation Authority staff
• Keep Conservation Authorities informed on developments around climate change initiatives
• Facilitate development of guidance documents
• Solicit and provide input to climate change initiatives on behalf of Conservation Authorities
Appendix 1: Group Discussion
Group Discussion

What role do you think the Hamilton Conservation Authority should play in adapting to climate change?

- Leadership role in communication to the public.
- Conservation Authority and municipality should work together to include climate change in subwatershed plans. Internally, Conservation Authority could work on policy development and regulations to include climate change. Some issues are out of Conservation Authority control and must be addressed by the province.
- Develop a comprehensive map of hazards.
- The Hamilton Conservation Authority should play a role in the discussions with the city on urban boundaries. What the city decides to do on the boundaries may have a bigger impact than climate change. These changes, combined with extreme events will make the event more hazardous.
- The insurance industry, through the Insurance Bureau of Canada is highly motivated to understand. They are testing a risk assessment tool and Hamilton was one of the first communities to provide data.
- Instead of dealing with hazards - how do we protect ourselves and what have we done to insulate ourselves by integrating it into our assessments. Can we turn hazards into enhancements?
- Valuing lands in different ways e.g. wetlands – apply new methods to evaluate the services of the Conservation Authority.
- Targeted acquisition of land to connect existing parcels – a natural heritage system approach.
- Making tools available to - and teaching landowners on how to manage their land.
- Protecting the watershed can do more to improve Hamilton Harbour than is currently being done. Maintaining rain barrels to reduce the amount of water going into the sewer (education program). Also, if the land is sensitive it should cost higher to develop.
- The city is not mandating green roofs, but if anyone is interested they will not stop it. There are some demonstration sites. One rain barrel program this summer and is at grass roots level.
- Storm water master plan showed areas that need to be fixed – last 12 pages was looking at swales and council did not even pick up on it. We need to move this type of thinking forward, not as an afterthought.
- Departments need to support each other in areas that can benefit both.
• Hamilton Conservation Authority could map the tree canopy in the watershed (adaptation and mitigation)
• Communication – the general public will not want to spend money on green infrastructure unless they know what the benefits will be – the message needs to get out to the public and the people who will be investing in it.
• Communication – visiting neighbourhoods and partners with the knowledge to teach them about climate change. Show the community we all agree and need their help to move forward.
• Town hall discussions with testimonials.
• Involve people who have already been impacted by recent storms – bring the issue to the forefront so it is not forgotten.
• Need for greater communication between the City and the Conservation Authority.
• The Conservation Authority’s main purpose was flood control, now they are doing much more (e.g. reforestation, drinking water, etc) with less resources which is very difficult.
• Need practical, cost effective approaches (funding) to get the public involved with green initiatives.
• Demonstration projects.
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Ontario Centre for Climate Impacts and Adaptation Resources

The Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is a university-based resource hub for researchers and stakeholders searching for information on climate change impacts and adaptation. The Centre communicates the latest research on climate change impacts and adaptation, develops tools and frameworks to assist with municipal adaptation and liaises with partners across Ontario and Canada to encourage and support adaptation to climate change.

The mandate of the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is to communicate the science of climate change including its current and future impacts; encourage the development and implementation of adaptation strategies in order to reduce climate vulnerability and increase resiliency; and create and foster partnerships with stakeholder groups within Ontario and Canada in order to advance adaptation action. The Centre is also a hub for climate change impacts and adaptation activities, events and resources.

The objectives of today's workshop are:

- to learn about climate change impacts and adaptation;
- to learn about what others are doing to adapt;
- to review the known ways in which climate has changed in the Hamilton Conservation Authority Watersheds and understand how that has impacted natural, built and human systems;
- to review selected projections of climate and resulting potential impacts;
- to examine various tools (e.g. Risk Assessment/Management) available to help communities and watersheds identify and prioritize risks associated with climate change;
- and to discuss the role of the Hamilton Conservation Authorities in climate change adaptation.
## Workshop Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 am to 8:50 am</td>
<td>Registration (and light breakfast)</td>
</tr>
<tr>
<td>8:50 am to 9:00 am</td>
<td><strong>Welcome and Introduction</strong>&lt;br&gt;Steve Miazga, Chief Administrative Officer, Hamilton Conservation Authority</td>
</tr>
<tr>
<td>9:00 am to 9:30 am</td>
<td><strong>Climate Change Adaptation – the Context</strong>&lt;br&gt;Al Douglas, OCCIAR</td>
</tr>
<tr>
<td>9:30 am to 10:00 am</td>
<td><strong>Climate Change Adaptation in the City of Toronto</strong>&lt;br&gt;David McLeod</td>
</tr>
<tr>
<td>10:00 am to 10:30 am</td>
<td><strong>Climate Change Adaptation and the City of Hamilton</strong>&lt;br&gt;Brian Montgomery</td>
</tr>
<tr>
<td>10:30 am to 10:45 am</td>
<td>BREAK (light refreshments)</td>
</tr>
<tr>
<td>10:45 am to 12:00 pm</td>
<td><strong>Components of Adaptation Planning</strong>&lt;br&gt;Al Douglas, OCCIAR</td>
</tr>
<tr>
<td>12:00 pm to 1:00 pm</td>
<td>LUNCH (provided)</td>
</tr>
<tr>
<td>1:00 pm to 1:30 pm</td>
<td><strong>Overview of Adaptation Frameworks and Tools: Risk Management</strong>&lt;br&gt;Al Douglas, OCCIAR</td>
</tr>
<tr>
<td>1:30 pm to 2:00 pm</td>
<td><strong>Watershed Resilience and Climate Change: McMaster Centre for Climate Change Research</strong>&lt;br&gt;Mike Waddington, McMaster University</td>
</tr>
<tr>
<td>2:00 pm to 2:30 pm</td>
<td><strong>Hamilton Conservation Authority</strong>&lt;br&gt;Hazel Breton</td>
</tr>
<tr>
<td>2:30 pm to 3:00 pm</td>
<td><strong>Summary of Conservation Authority Regional Adaptation Workshop</strong>&lt;br&gt;Jane Lewington, Conservation Ontario</td>
</tr>
<tr>
<td>3:00 pm to 3:15 pm</td>
<td>BREAK (light refreshments)</td>
</tr>
<tr>
<td>3:15 pm to 3:45 pm</td>
<td><strong>Group Discussion:</strong>&lt;br&gt;What role do you think the Hamilton Conservation Authority should play in adapting to climate change?</td>
</tr>
<tr>
<td>3:45 pm to 4:00 pm</td>
<td><strong>Groups Report Back</strong></td>
</tr>
<tr>
<td>4:00 pm to 4:30 pm</td>
<td><strong>General Question and Answer Period</strong>&lt;br&gt;(questions for all of the speakers)</td>
</tr>
<tr>
<td>4:30 pm</td>
<td><strong>Meeting Adjourned</strong></td>
</tr>
</tbody>
</table>
Background

*Climate Change*

Climate is naturally variable and has changed significantly over the history of the Earth. Over the past two million years, the Earth's climate has alternated between ice ages and warm interglacial periods. There are a number of climate variability drivers, from changes in the Earth's orbit, changes in solar output, sunspot cycles, volcanic eruptions, to fluctuations in greenhouse gases and aerosol concentrations. When considered together, they effectively explain most of the climate variability over the past several thousand years. These natural drivers alone, however, cannot account for the increase in temperature and accompanying suite of climatic changes observed over the 20th century.

Climate change may manifest itself as a shift in mean conditions or as changes in the variance and frequency of extremes of climatic variables. Global average surface and lower-troposphere temperatures during the last three decades have been progressively warmer than all earlier decades, and the 2000s (2000–09) was the warmest decade in the instrumental record (NOAA, 2010). Arndt et al., (NOAA, 2010) compared temperature data for the last 6 decades in Canada and concluded that the 2000s was the warmest decade out of the six that are available for its national study, with an average temperature of 1.1°C above normal. In order, from warmest to coolest, the remaining decades are: 1990s (+0.7°C); 1980s (+0.4°C); 1950s (+0.1°C); 1960s (0.0°C); and 1970s (-0.2°C) (Arndt et al., (NOAA), 2010).

There is growing recognition that these changes may pose challenging problems for sectors and watersheds as well as all levels of government. There is confidence in the ability of climate simulation models to provide managers with useful projections of future climate scenarios to support planning and management across a range of space and time scales.

Globally, two broad policy responses to address climate change have been identified. The first is mitigation, which is aimed at slowing down and lessening the potential future impacts of climate change by emitting less greenhouse gases in the atmosphere or capturing it through various sequestration methods. The second is adaptation, which is aimed at reducing the negative impacts of climate change through actions other than the reduction of GHG emissions, and also making the best of the positive effects of climate change. The primary focus of this workshop is on adaptation.
Impacts and Adaptation

There is consensus among international scientists that climate change is occurring, that the impacts are already being felt in regions all around the world and that they will only get worse. “Impacts due to altered frequencies and intensities of extreme weather, climate and sea-level events are very likely to change” (IPCC, 2007).

Even after implementing measures to reduce greenhouse gas emissions, some degree of climate change is inevitable and is already having economic, social and environmental impacts on communities. Adaptation limits the negative impacts of climate change and takes advantage of new opportunities. It is not an alternative to reducing greenhouse gas emissions in addressing climate change, but rather a necessary complement. “Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions” (IPCC, 2007). Reducing greenhouse gas emissions decreases both the rate and overall magnitude of climate change, which increases the likelihood of successful adaptation and decreases associated costs. Adaptation is not a new concept as many approaches have already allowed us to deal with our extremely variable climate. The nature and rate of future climate change, however, poses some new challenges.

Ontario is relatively well adapted to present climatic conditions; however, it may not be ready for the impacts resulting from changes in average and extreme climatic conditions. Recently, Ontario has experienced climatic events such as such as drought, flooding, heat waves and warmer winters. These have resulted in a wide range of impacts including water shortages, lower Great Lakes water levels, declines in
agricultural production, power outages and outbreaks of water-borne diseases.

Developing an effective strategy for adaptation requires an understanding of our vulnerability to climate change. “Future vulnerability depends not only on climate change but also on development pathway” (IPCC, 2007). Vulnerability is determined by three factors: the nature of climate change, the climatic sensitivity of the system or region being considered, and our capacity to adapt to the resulting changes. The tremendous geographic, ecological and economic diversity of Canada means that the 3 factors mentioned above, and hence vulnerabilities, vary significantly across the country. In many cases, adaptation will involve enhancing the resiliency and adaptive capacity of a system to increase its ability to deal with stress.

Adaptation responses include biological, technical, institutional, economic, behavioural and other adjustments that reduce vulnerability to the adverse impacts, or take advantage of positive effects, from climate change. Effective responses to climate change require an integrated portfolio of responses that include both mitigation and adaptation.

Ontario is generally well equipped to adapt to climate change, but this adaptive capacity is not uniformly distributed across the province. Ontario has noted differences in adaptive capacity between urban and rural communities (Table 1). Indicators such as: economic resources; availability of, and access to, technology, information and skills; and the degree of preparedness of its infrastructure and institutions (Smit, et al., 2001) are all necessary in developing and acting on a climate change adaptation strategy (Figure 2).

It is imperative that decision-makers understand current vulnerabilities and the extent of future change to make well-informed adaptation planning decisions. Without this, insufficient actions or actions that inadvertently increase vulnerabilities could be made.

Table 1: General differences in adaptive capacity, which affect vulnerability to climate change, between urban and rural communities (Atlantic Canada, Quebec, Ontario and Prairies) (Lemmen et al., 2008).
<table>
<thead>
<tr>
<th>URBAN CENTRES</th>
<th>RURAL COMMUNITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td><strong>Strengths</strong></td>
</tr>
<tr>
<td>Greater access to financial resources</td>
<td>Strong social capital</td>
</tr>
<tr>
<td>Diversified economies</td>
<td>Strong social networks</td>
</tr>
<tr>
<td>Greater access to services (e.g. health care, social services, education)</td>
<td>Strong attachments to community</td>
</tr>
<tr>
<td>Higher education levels</td>
<td>Strong traditional and local knowledge</td>
</tr>
<tr>
<td>Well-developed emergency response capacity</td>
<td>High rates of volunteerism</td>
</tr>
<tr>
<td>Highly developed institutions</td>
<td></td>
</tr>
<tr>
<td><strong>Limitations</strong></td>
<td><strong>Limitations</strong></td>
</tr>
<tr>
<td>Higher costs of living</td>
<td>Limited economic resources</td>
</tr>
<tr>
<td>More air quality and heat stress issues</td>
<td>Less diversified economies</td>
</tr>
<tr>
<td>Lack of knowledge of climate change impacts and adaptation issues</td>
<td>Higher reliance on natural resource sectors</td>
</tr>
<tr>
<td>High dependence on critical, but aging infrastructure</td>
<td>Isolation from services and limited access</td>
</tr>
<tr>
<td>Issues of overlapping jurisdictions that complicate decision-making processes</td>
<td>Lower proportion of population with technical training</td>
</tr>
</tbody>
</table>

Figure 2: Determinants of adaptive capacity (adapted from Smit et al., 2003 as cited in Warren and Egginton, 2008)
Historic Climate and Climate Trends

The following is a compilation and summarization of weather and climate data for Hamilton, Ontario (Figure 3 – 7). These graphs provide insight into how much certain climate variables, in this case temperature and precipitation, have changed over the life of the weather station. In conducting a regional analysis of climate change, additional stations from multiple sources would provide a more substantive evaluation. The data below were obtained from Environment Canada.

Daily Weather

Daily climate data from the Hamilton A weather station (43°10'18.072" N, 79°56'03.036" W, John C Monro Hamilton International Airport), obtained from Environment Canada, was averaged to obtain monthly values for temperature and precipitation (Environment Canada, 2011). Seasonal climate values (i.e. winter DJF, spring MAM, summer JJA and fall SON) were calculated by averaging the monthly data. In the following section, temperature and precipitation data, for the years 1970 to 2010, are displayed annually and seasonally (winter, spring, summer and fall) with line charts (Figures 3 to 7) and includes: mean, maximum and minimum temperature and annual precipitation. Definitions of mean, maximum and minimum temperature and annual precipitation can be found in the Glossary.

Maximum, minimum, and mean temperature data and precipitation data were missing from the Environment Canada dataset for January and February 1970. As a result, average annual mean temperature, average annual maximum temperature, average annual minimum temperature, average winter mean temperature, average winter maximum temperature, average winter minimum temperature, total annual precipitation and total winter precipitation could not be calculated for 1970.
Historical Climate Data for Hamilton

Annual Temperature and Precipitation

Figure 3: Average annual mean, maximum and minimum temperature (°C) and total annual precipitation (mm) from 1970 to 2010. Data from Hamilton A (Environment Canada, 2011) shows that average annual mean temperature has increased 0.9 °C, average annual maximum temperature has increased 1.3°C, average annual minimum temperature has increased 0.5°C and total annual precipitation increased 26 mm at this location over the 41 years of record.
Winter Temperature and Precipitation

Figure 4: Average winter mean, maximum and minimum temperature (°C) and total winter precipitation (mm) from 1970 to 2010. Data from Hamilton A (Environment Canada, 2011) shows that average winter mean temperature has increased 1.7 °C, average winter maximum temperature has increased 1.8°C, average winter minimum temperature has increased 1.4°C and total winter precipitation decreased 9 mm at this location over the 41 years of record.
Spring Temperature and Precipitation

Figure 5: Average spring mean, maximum and minimum temperature (°C) and total spring precipitation (mm) from 1970 to 2010. Data from Hamilton A (Environment Canada, 2011) shows that average spring mean temperature has increased 0.7 °C, average spring maximum temperature has increased 1.1°C, average spring minimum temperature has increased 0.2°C and total spring precipitation increased by only 4 mm at this location over the 41 years of record.
Summer Temperature and Precipitation

Figure 6: Average summer mean, maximum and minimum temperature (°C) and total summer precipitation (mm) from 1970 to 2010. Data from Hamilton A (Environment Canada, 2011) shows that average summer mean temperature has increased 0.3 °C, average summer maximum temperature has increased 0.4 °C, average summer minimum temperature has increased 0.3 °C and total summer precipitation increased 29 mm at this location over the 41 years of record.
Fall Temperature and Precipitation

Figure 7: Average fall mean, maximum and minimum temperature (°C) and total fall precipitation (mm) from 1970 to 2010. Data from Hamilton A (Environment Canada, 2011) shows that average fall mean temperature has increased \( 0.7 \) °C, average fall maximum temperature has increased \( 1.3 \) °C, average fall minimum temperature has increased \( 0.1 \) °C and total fall precipitation increased 16 mm at this location over the 41 years of record.

Future Climate - Climate Change Projections for Southwestern Ontario
The following maps (Figures 8 – 13) were created by the Canadian Climate Change Scenarios Network at Environment Canada (www.cccsn.ca). The temperature and precipitation maps are ensemble projections of 24 global climate models using a medium emissions scenario. According to the CCCSN (2011), the 'medium' projection represents the mean of the combination of low (B1) and high (A1B) projections, with the 'low' projection representing the all-model mean resulting from the least aggressive emission assumption (the result from the commonly referenced SRES-B1 scenario) and correspondingly, the 'high' projection results indicate projected changes with the most aggressive emission assumption. The maps show the mean change from 1961-1990 to 2040–2070 (or 2050s). The projections are summarized in Table 2.
Figure 8: Projected Change in Annual Air Temperature (CCCSN, 2011). Ensemble projection shows a change in mean annual air temperature from 1961–1990 to 2041–2070 or 2050s; medium emissions scenario. Approximate location for Hamilton is shown by the red star. Projection shows a 2.6°C increase by the 2050s.
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Climate Change Impacts and Adaptation in the Hamilton Conservation Authority Watersheds

Figure 12: Projected Change in Winter Precipitation (CCCSN, 2011). The ensemble projection shows the change in winter precipitation from 1961–1990 to 2041–2070 or 2050s; medium emissions scenario. Approximate location for Hamilton is shown by the red star. Projection shows a 9.34% increase by the 2050s.
Figure 13: Projected Change in Summer Precipitation (CCCSN, 2011). The ensemble projection shows the change in summer precipitation from 1961–1990 to 2041–2070 or 2050s; medium emissions scenario. Approximate location for Hamilton is shown by the red star. Projection shows a 0.11% decrease by the 2050s.
Table 2: Summary of the ensemble projections (CCCSN, 2011)

<table>
<thead>
<tr>
<th>Climate Change Projections for Southwestern Ontario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensemble projections show a mean change from 1961-1990 to 2041-2070 or 2050s, medium emission scenario</td>
</tr>
<tr>
<td>Annual Air Temperature</td>
</tr>
<tr>
<td>Winter Air Temperature</td>
</tr>
<tr>
<td>Summer Air Temperature</td>
</tr>
<tr>
<td>Annual Precipitation</td>
</tr>
<tr>
<td>Winter Precipitation</td>
</tr>
<tr>
<td>Summer Precipitation</td>
</tr>
</tbody>
</table>
Climate trends and projected values for Southern Ontario from 2010 to 2050

Observed climate trends and climate related factors, along with projections to the 2050s are summarized in (Table 3). These were created for the Institute of Catastrophic Loss Reduction by James Bruce (2011) and can be used for initial assessment of adaptation priorities. The author suggests that for more detail, the appropriate comprehensive reference should be consulted. Projections of values from 2010 to 2050 are based on outputs from climate models using the A2 scenario and extrapolation of observed trends since the 1960s (Bruce, 2011). Ranges in observed and projected values indicate differences over the region. A list of references and further instruction on how to interpret these tables can be found in the report – Climate change information for adaptation – Climate trends and projected values for Canada from 2010 to 2050.
http://www.iclr.org/climateextremesbruce.html

Table 3: Observed climate trend and climate related factors and projections to the 2050s.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max °C</strong></td>
<td><strong>Min. °C</strong></td>
<td></td>
</tr>
<tr>
<td>Annual</td>
<td>0 to 1</td>
<td>0.5 to 1.5</td>
</tr>
<tr>
<td>Winter</td>
<td>0.5 to 1</td>
<td>0.5 to 1.5</td>
</tr>
<tr>
<td>Spring</td>
<td>0.5 to 1.5</td>
<td>0.5 to 1.5</td>
</tr>
<tr>
<td>Summer</td>
<td>0.5 to 1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Autumn</td>
<td>-0.5 to -1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Extremes (1950 - 2007)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frost Free Days</td>
<td>0 to 30</td>
</tr>
<tr>
<td>Growing Days &gt; 5°C</td>
<td>10 to 30</td>
</tr>
<tr>
<td>Toronto T_max &gt; 30°C</td>
<td>~ 20 days average (2000-2010)</td>
</tr>
<tr>
<td>Double T_max 20</td>
<td>4°C</td>
</tr>
<tr>
<td>T_max 20 → T_max 10</td>
<td>(i.e. double frequency)</td>
</tr>
</tbody>
</table>
## Precipitation

<table>
<thead>
<tr>
<th>Observed (Trends)</th>
<th>By 2050 (from 2010)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Precipitation (1950 - 2007)</strong> (compared to long term average)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual</td>
<td>10 to 20%: 1.5 to 5 mm/decade</td>
<td>5%</td>
</tr>
<tr>
<td>Winter</td>
<td>0 to 3 mm/decade most in lee of Great Lakes</td>
<td>5 to 20%</td>
</tr>
<tr>
<td>Spring</td>
<td>0 to 1.5 mm/decade</td>
<td>10 to 15%</td>
</tr>
<tr>
<td>Summer</td>
<td>0</td>
<td>0 to 10%</td>
</tr>
<tr>
<td>Autumn</td>
<td>1.5 to 3 mm/decade annual</td>
<td>0%</td>
</tr>
</tbody>
</table>

### Ratio of Snow to Total Precipitation (1950 - 2007)
- **Annual**: -1.5% / decade -5 to 10%

### Intense Precipitation (1959 - 2007)
- **P$_{20}$ = 50 to 75 mm: average (1981 - 2000)**
  - P$_{20}$ 10% increase severity
- **Severity of precipitation events (>99%)**: 31% (adjacent USA)
- **Frequency heavy rain amounts (>99%)**: 27% (adjacent USA)
- **Greatest % increase observed in Spring**: 7 to 15% per decade (May)

### Freezing precipitation (rain and drizzle)
- **Average (1961-1990)**
  - > 6 hr events
  - Precipitation: 50 hours
  - Rain: 10 to 25 hours

### Wind

<table>
<thead>
<tr>
<th>Observed (Trends)</th>
<th>By 2050 (from 2010)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intense Wind Storms</strong> (Central Pressure &lt;970hpa)</td>
<td></td>
<td>See Note 2</td>
</tr>
<tr>
<td>Over Northern Hemisphere (1950 - 2000)</td>
<td>8%</td>
<td>8 to 15%</td>
</tr>
</tbody>
</table>

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Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR)
## River Flow

<table>
<thead>
<tr>
<th>River Flow</th>
<th>Observed (Trends)</th>
<th>By 2050 (from 2010)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dates of Spring break-up (1948-2002)</strong></td>
<td>Earlier, not significant</td>
<td>15 days earlier</td>
<td></td>
</tr>
<tr>
<td><strong>Ice Cover (1975-2008)</strong></td>
<td>Great Lakes - average winter cover</td>
<td></td>
<td>See Note 3 See Note 5</td>
</tr>
<tr>
<td>Huron</td>
<td>30% to 15%</td>
<td>Great Lakes Winter Ice Cover Close to Zero</td>
<td></td>
</tr>
<tr>
<td>Erie</td>
<td>33% to 10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Streamflow (1967 - 2008)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual</td>
<td>10 to -20%</td>
<td>-10%</td>
<td></td>
</tr>
<tr>
<td>Minimum Daily</td>
<td>10 to -20%</td>
<td>-20%</td>
<td></td>
</tr>
<tr>
<td>Maximum Daily</td>
<td>-10 to -30%</td>
<td>-10 to 10%</td>
<td></td>
</tr>
</tbody>
</table>

### Notes

1. Ranges in observed and projected values indicate differences over the region.
2. Wind-disaster records of Public Safety Canada indicate for storms >100km/h national frequency rose 16% from 1970 to 1990 with most in coastal regions, except for tornadoes. Ontario recorded 29 tornadoes in 2006 and again in 2009 – long term average is 11.
3. Major floods and landslides (from PSC data base), where intense rains, or rain on snow, apparently increased 80% nationally between the 1970s and 1990s. However, 1970s event recording may have been less thorough than in 1990s. Data base extends only to 2005. (See Note 5)
4. Storm surges: Trends towards reduced ice cover and stronger winds over Great Lakes increase incidence of damaging storm surges. e.g. Average Wind Lake Superior increased 4.5 to 4.9m/sec from 1985 to 2007.
   **Record observed short duration rain intensities:**
   - Tobermory Cypress Lake: 60 min 112mm, two hour 118mm (2003)
   - Toronto North York: 15 min 66mm, 30 min 90mm, 2 hour 132mm (2005)
   - Upper Grand River basin: 1 day >200mm (2004)
   - Peterborough (Trent University), one day 240 mm (2004)
6. In some places near the Great Lakes little change or declines in number of hot days Tmax>30°C are due to cooler waters of the lakes in spring and summer.
Risk Assessment/Management Process

Risk assessment/management is one tool that can help stakeholders identify and prioritize current risks caused by climate-induced events and impacts, and develop and implement actions to reduce these risks to acceptable levels.

As climate related events continue and become more frequent and/or severe in the future, possibly resulting in a greater magnitude of loss or a higher likelihood of loss, then risk management can also be used in adapting to the future risks of climate change. The risk management process provides a systematic, information and science-based tool to help decision-makers analyze risks (and potential benefits), and select optimal courses of action. It uses a pragmatic approach that utilizes existing structures and functions within the community. It helps stakeholders identify and prioritize risks associated with climate (or weather) related events. Once the risks are identified and prioritized, adaptation actions or measures can be developed for risks with the greatest consequence and the greatest likelihood of occurring first, and risks with lower likelihood of occurrence and lower consequence later.

Risk assessment is but one step in the risk management process. Risk assessment is measuring two attributes that comprise risk: the magnitude of the consequences, and the likelihood that it will occur. The purpose of risk assessment in the context of climate change is to identify risks and events that may be induced or exacerbated by climate change and to evaluate the magnitude of their consequences and the likelihood that they will occur. It can be a useful tool in adapting to the negative aspects of climate change since it can be used to address a range of climate-related impacts with both a high or low likelihood of occurrence.

The completion of each step leads logically to the next or ends the process if the hazard/risk is resolved (Figure 14). The process is iterative and each step can be revisited if new information becomes available. The process assists in priority setting and balancing complex risk control strategies, their effectiveness and costs.
The risk assessment/risk management approach is based on a process that follows ISO and CSA standards that have been adapted to fit the context of climate change. More recently, an updated version of the risk management approach to climate change adaptation, *Adapting to Climate Change: A Guide for Ontario Municipalities*, is being developed and will be released in 2011. OCCIAR recognizes Bob Black, Jim Bruce and Mark Egener for their contributions in developing the climate change adaptation risk management guidelines.


- **Adapting to Climate Change: A Risk-based Guide for Ontario Municipalities** (2006) This document is intended primarily for Ontario municipalities and Conservation Authorities which share responsibilities for planning and managing important climate-sensitive systems in Ontario. It presents a risk-based approach that can be used to facilitate municipalities’ efforts to adapt to climate change through both longer term planning and short-term responses (Bruce et al., 2006). [http://adaptation.nrcan.gc.ca/projdb/pdf/176a_e.pdf](http://adaptation.nrcan.gc.ca/projdb/pdf/176a_e.pdf)
  This document aims to assist regional and local government planners, health officials, emergency managers, infrastructure managers and others understand the risks of potential climate impacts and the priorities and means of managing them (Bruce et al., 2009). It describes a risk-based approach that communities can use to adapt to climate change through long-term planning and short-term responses.

• **Adapting to Climate Change: A Risk-based Guide for Local Governments in British Columbia** (2010)
  This Guide will assist regional and local government planners, health officials, emergency managers, infrastructure managers and others understand the risks of potential climate impacts and the priorities and means of managing them. The guide should also be useful for other organizations such as local industry and businesses to help understand how to anticipate and deal with a changing climate (Bruce et al, 2010).

• **Adapting to Climate Change: A Guide for Ontario Municipalities (2011) – DRAFT in development**
  This Guide describes a straightforward, risk-based approach (described in the recently published International Standards Organization ISO 31000, *Risk management – Principles and guidelines*, first edition, November 15, 2009) that can be used to assist municipalities to adapt to climate change through long-term planning and short-and mid-term responses (Black et al., 2011, *DRAFT in development*).
Climate Change Considerations

The following questions provide a means of encouraging discussion of climate change at the local level.

Responses to climate change can be mitigative (reduce greenhouse gas emissions) – i.e. energy conservation, energy efficiency, greenhouse gas reductions, alternative energy sources, carbon capture/storage, and/or adaptive – i.e. managing stormwater/flood protection, heat alert plans, drought plans, water budgeting, tree planting and others. It is important to note that some actions, like the use of ‘green infrastructure’ including green roofs, trees, and swales, are both mitigative and adaptive. It is also important that any adaptation actions taken not increase greenhouse gas emissions – these are known as ‘mal-adaptations’.

1. Is there recognition within your community and watershed that changes in climate are affecting and will continue to have an impact on natural and built systems?

2. Has your municipality considered developing a climate change plan (mitigation and/or adaptation)? Has climate change been considered in any planning process?

Excess waste water and extreme weather events leading to flooding have been specifically challenging to cities and conservation authorities across the province. Changes to the timing and extent of peak river/stream flow challenge traditional ways of dealing with the natural waste water.

3. Do you think that changes to temperature and precipitation over the past 20-30 years have imposed greater challenges in managing stormwater? Has your municipality made any changes to reflect that? What barriers are there that may impede structural changes to those systems (budget constraints, limited human resources, lack of technology, lack of time, other priorities, other)?

4. Are there other sectors or components of sectors that would be threatened by climate variability/climate change, i.e. ice fishing, skiing, agricultural operations, forests (fire), local lakes, fish populations, buildings, bridges, groundwater wells, human health and well-being, locally valued species, invasive species or pests, etc?

The Province of Ontario is committed to reductions of greenhouse gases – 6% below 1990 levels by 2014 and 15% by 2020. Water and energy conservation are ways to combat climate change, both on the mitigation and adaptation front. Opportunities also exist for economic growth in the green energy sector through local power generation.

5. Has your community developed any programs or policies related to energy/water conservation or efficiency?
6. Have any local companies expressed an interest in developing green energy (products), i.e. wind, solar, wood pellets, fibre, biomass, etc?

**Impediments and facilitators for climate change planning and action exist and can be a function of capacity within a community setting. Although some Ontario communities tend to have fewer resources, they also have inherent strengths that give them an advantage when it comes to facing weather/climate adversity.**

7. Are there specific items that would enable mitigation/adaptation planning in your area (specifically for storm water management planning) (climate/weather data, information, tools, human resources, financial support, political support)?

**Additional Questions**

8. Has climate change been a consideration with emergency management personnel?

9. Are you aware of any benefits that may result from a changed climate and how might your community take advantage of such changes? E.g. extended summer tourism, agricultural opportunities, harvesting of stormwater for irrigation, etc.
Glossary

The definitions are drawn from the Intergovernmental Panel on Climate Change reports (2001, 2007), From Impacts to Adaptation (2008), and the Canadian standard “Risk Management: Guidelines for Decision-Makers” (CAN/CSAQ850-97) unless otherwise stated.

Adaptation

Adaptation is initiatives and measures taken to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Various types of adaptation exist, e.g. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature-shock resistant plants for sensitive ones, etc.

Adaptation benefits

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

Adaptation costs

Adaptation costs are the costs of planning, preparing for, facilitating, and implementing adaptation measures, including transaction costs.

Adaptive capacity

Adaptive capacity is the ability of a system to adjust to climate variability and change to moderate potential damages, to take advantage of opportunities, and/or cope with the consequences.

Barrier

A barrier is any obstacle to reaching a goal, adaptation or mitigation potential that can be overcome or attenuated by a policy, programme, or measure. Barrier removal includes correcting market failures directly or reducing the transactions costs in the public and private sectors by e.g. improving institutional capacity, reducing risk and uncertainty, facilitating market transactions, and enforcing regulatory policies.

Climate change

Climate change in lay terms refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines ‘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’. See also climate variability.
Climate scenario

A climate scenario is a plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate scenarios are based on a combination of GHG emissions and patterns of human consumption and growth.

Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate. A climate change scenario is the difference between a climate scenario and the current climate.

Climate variability (CV)

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

Emission Scenarios (of the IPCC Special Report on Emission Scenarios (SRES))

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.
B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

Ensemble
A group of parallel model simulations used for climate projections. Variation of the results across the ensemble members gives an estimate of uncertainty. Ensembles made with the same model but different initial conditions only characterize the uncertainty associated with internal climate variability, whereas multi-model ensembles including simulations by several models also include the impact of model differences.

Event
An event is an incident induced or significantly exacerbated by climate change that occurs in a particular place during a particular interval of time, e.g. floods, very high winds, or droughts.

Hazard
A hazard is a source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value. Note: This term is not used in ISO 3100 terminology (Bruce, Black and Egener, 2011)

Hazard identification
Hazard identification is the process of recognizing that a hazard exists and defining its characteristics.

Impacts (Climate change)
Impacts are the effects of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts:
• **Potential impacts**: all impacts that may occur given a projected change in climate, without considering adaptation.

• **Residual impacts**: the impacts of climate change that would occur after adaptation.

**Mean temperature** is defined as the average of temperature readings taken over a specified amount of time; for example, daily mean temperatures are calculated from the sum of the maximum and minimum temperatures for the day, divided by 2 (Environment Canada, 2008).

**Maximum temperature** is the highest or hottest temperature observed for a specific time interval and minimum temperature is the lowest or coldest temperature for a specific time interval (Environment Canada, 2008).

**Precipitation** includes any and all forms of water, liquid or solid that falls from clouds and reaches the ground and is expressed in terms of vertical depth of water which reaches the ground during a stated period (Environment Canada, 2008).  **Total precipitation** (mm) is the sum of all rainfall and the water equivalent of the total snowfall observed during the day (Environment Canada, 2008). According to Environment Canada (2008), most ordinary stations compute water equivalent of snowfall by dividing the measured amount by ten; however, at principal stations it is usually determined by melting the snow that falls into Nipher gauges. This method normally provides a more accurate estimate of precipitation than using the "ten-to-one" rule (Environment Canada, 2008).

**Projection**
A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized, and are therefore subject to substantial uncertainty.

**Residual risk**
Residual risk is the risk remaining after all risk control strategies have been applied.

**Resilience**
Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.
Risk is the chance of injury or loss as defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value.

**Risk assessment**
Risk assessment is the overall process of risk analysis and risk evaluation.

**Risk communication**
Risk communication is any two-way communication between stakeholders about the existence, nature, form, severity, or acceptability of risks.

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

**Risk estimation**
Risk estimation is the activity of estimating the frequency or probability and consequence of risk scenarios, including a consideration of the uncertainty of the estimates.

**Risk evaluation**
Risk evaluation is the process by which risks are examined in terms of costs and benefits, and evaluated in terms of acceptability of risk considering the needs, issues, and concerns of stakeholders.

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

**Risk management**
Risk management is the systematic application of management policies, procedures, and practices to the tasks of analysing, evaluating, controlling, and communicating risk issues.

**Risk perception**
Risk perception is the significance assigned to risks by stakeholders. This perception is derived from the stakeholder’s needs, issues, concerns and personal values.

**Risk scenario**
A risk scenario is a defined sequence of events with an associated frequency and consequences.

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

References and Resources


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http://www.cccsn.ca

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http://climate.weatheroffice.ec.gc.ca/climateData/canada_e.html

Environment Canada. Glossary. National Climate and Data Information Archive
http://climate.weatheroffice.ec.gc.ca/prods_servs/glossary_e.html


