Adapting to Climate Change

A Risk-based Guide for Ontario Municipalities

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Foreword

The Ontario government is committed to helping our communities to be strong, healthy and prosperous. That is why we have developed policies to improve the air we breathe, ensure the quality of the water we drink, promote clean, reliable energy supply, and reduce greenhouse gas emissions. That is also why we support our communities' efforts to manage risks associated with the impacts of climate variability and change.

Ontario's climate has changed over the last 35 years, and despite our best efforts to reduce greenhouse gas emissions, will continue to change well into the future. Our climate is projected to warm by 2˚-3˚C over the next 50 years and to become increasingly variable. These are not insignificant changes – by comparison, the Earth's mean temperature has warmed only 4-5°C since the last ice age.

These changes are beginning to have severe impacts, from more frequent and severe climate events that have direct effects on people and property, to fundamental changes to ecosystems that may undermine local economies, increase human health risks from infectious and non-infectious diseases, and affect the availability and quality of water. Climate change is, without a doubt, a real threat to our sustainability and quality of life.

The Ontario Ministry of Municipal Affairs and Housing, together with Natural Resources Canada and the Institute for Catastrophic Loss Reduction, supported the development of this Guide to help municipalities understand and manage risks associated with climate variability and change and remaining uncertainties about future changes. This is an important tool that can assist municipalities, Conservation Authorities and others, to reduce their vulnerabilities to the adverse impacts, of our changing climate.

1. Introduction

Global climate change is widely recognized as one of the world's greatest environmental, social and economic threats. In Canada, climate changes observed over the past 35 to 40 years account in part for the exponential rise in economic losses from extreme weather events, premature weathering of infrastructure, stresses on water supplies, worsening air quality and related health and economic impacts, among other effects on Canadians' quality of life and economy.

Efforts to adapt to and manage climate-related risks are not keeping pace with the challenges. Unfortunately, Canadians are becoming more vulnerable to impacts related to climate variability and change, due in part to increasing urbanisation, a growing and aging population and deteriorating public infrastructures. These changes put more people and property at risk and the climate will almost certainly continue to warm and become increasingly variable over the coming decades.

Municipalities share in many of the responsibilities for managing risks from a changing climate. Most Canadians live in municipalities, and municipalities have primary responsibility for, or can significantly influence, many of the factors that determine Canadians' vulnerabilities to climate-related risks.

The *Ontario Municipal Act (2001***),** the *Provincial Policy Statement (2005)*, the *Emergency Management Act (2003)* and the *Conservation Authorities Act* all require in one way or another that municipalities and Conservation Authorities in Ontario take action to prevent, mitigate or respond to threats to human health and safety, public property and the environment. More detail on these requirements and why municipalities and Conservation Authorities need this Guide – including how to respond to various pieces of provincial and federal legislation and directions can be found at Annex 2.

More and more, municipal officials are responding to the need to begin implementing adaptive strategies by raising their understanding of climate change and promoting adaptation responses. Unfortunately, few tools exist to help them in the process. This Guide is intended to help meet this need and to assist municipal planners, health officials, emergency management staffs and conservation authorities make optimal choices to adapt to a changing and more variable climate.

1.1. About the Guide

This Guide 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. It is envisioned to be used in three principal ways to assist municipal staff and risk management teams in planning and implementing adaptation strategies:

- As a reference manual for users to incorporate risk management into ongoing municipal planning and management activities, particularly those related to climate adaptation. It can also guide comprehensive strategic planning initiatives focussed on climate adaptation for all municipal operations.
- To illustrate successful examples and methods for managing climate-related risks to help build support for adaptation efforts.
- As a training facilitation tool for municipal staff.

The Guide is intended primarily for Ontario municipalities and Conservation Authorities which share responsibilities for planning and managing important climate-sensitive systems in Ontario. It was developed to reflect their priority issues and processes. However, while examples of use of the Guide are drawn from the Ontario situation, the techniques outlined can be used in other regions of Canada.

The Guide clearly shows through its descriptive text and the illustrative examples that using the risk management process can be a very simple, quick and logical process to help users determine optimum solutions to complex issues involving risk, such as climate adaptation. It can also be used for larger, more scientifically oriented risk management projects.

It is hoped that the Guide will be also be useful for regions and institutions to help them

understand risk management techniques and how they can be applied to climate change risks.

Chapter 2 provides insights into the changes in climate in Ontario for which Ontario municipalities will have to make adaptation decisions. It offers some suggestions to help officials integrate a risk-based approach into the planning process.

Chapter 3 is an overview of the risk management process, and explains why it is useful. During the1990's a team of Canadian risk management experts developed a National Standard for risk-based decision-making. The benefits of having a nationally consistent process are beginning to be realised.

Chapter 4 explains each step in the process in detail and includes:

- A description of the purpose of each step;
- An explanation of what to do and how to do it;
- A description of the expected output;
- A description of the decision to be made at the end of each step;
- An example showing how the step could be used; and
- A checklist of the major tasks at each step in the process.

The examples are based on the experiences of municipal and conservation authority participants discussed in a two-day workshop on climate change risk management held in June 2005 in Halton Region.

1.2. Risk management, adaptation and vulnerability reduction

Climate change literature refers to "adaptation", "adaptive capacity" and "vulnerability":

- Adaptation to climate change refers to adjustments in natural or human systems that moderate harm or exploit beneficial opportunities arising out of actual or expected climatic changes
- Adaptive capacity is ability of a system, region or community to adapt.
- Vulnerability refers to how susceptible systems are to adverse effects of climate change or climate variability including socio-economic aspects.

Adaptation to climate change, which includes efforts to enhance adaptive capacity, is typically aimed at reducing vulnerability to its adverse effects.

Risk management offers a framework for identifying, understanding and prioritising climate change risks and for selecting optimal adaptation responses to reduce risks to acceptable levels.

1.3. Why risk management?

Adaptation to climate change is characterized by uncertainty, complexity and risk. It can involve multiple decision-makers and other stakeholders with conflicting values and competing interests. As will be explained in the next section, projections of future climate and other important variables are uncertain, outcomes are debatable and there may be numerous adaptation options from which the optimal are to be selected. Adaptation decisions are generally evaluated as better or worse, not right or wrong.

For every given climate impact there is a spectrum of responses in time, complexity, cost and jurisdiction. For example to deal with increasingly frequent and severe extreme rainfall events short term responses might range from better warnings, increased maintenance of storm sewers, reduction of storage levels in dams and reservoirs. Longer-term responses might include replacement sewer pipes, re-routing major arteries, reduction of asphalt and concrete surfaces. Multi- jurisdictional responses could involve the construction of water diversion channels, dyking, construction of dams or reservoirs etc. As will be discussed below, the risk management process will help lead planners to the optimal solution or solutions as well as assisting in determining the range of possible responses.

In most municipalities, where current issues tend to be in the forefront, adapting to an uncertain future climate is not a problem that is often addressed. Identifying the best adaptation response can seem like an overwhelming challenge, and decision-makers may deny or defer important actions. The adaptation issue may be addressed by some municipalities as a strategic issue as some have done for their approach to the environment. Others will deal with the issue pragmatically addressing current climate related issues, such as smog-related

issues, heat issues, waste water concerns or emergency management approaches to climate change. Whatever the scope, the process described in this Guide will be useful.

Risk management offers a practicable and credible approach for prioritizing complex risk issues and for selecting optimal risk reduction strategies in order to achieve acceptable levels of societal risk. It also provides a means for balancing a range of considerations and for using predictive information.

An abbreviated form of the process can be used to make a rapid assessment of a risk issue to outline the possible scope and its complexity. The process also caters to a large-scale fully comprehensive assessment which could involve a large number of representatives from many agencies over a longer period of time. Regardless of the scope of the exercise, it is important that municipal staffs be familiar with the process. The documentation of the study will provide a persuasive business case to submit to the decision-maker.

Most Canadian organizations, including municipalities, are familiar with and use risk management techniques, either implicitly or explicitly. Managing risks is inherent in the job responsibility of most municipal managers.

2. Climate Change Adaptation Decision-making in Ontario Municipalities

The Earth's climate is naturally variable due to a number of factors, including the presence of naturally occurring greenhouse gases (GHG) in the atmosphere. The Intergovernmental Panel on Climate Change concluded that, up until the mid1960s, the Earth's warming was attributable to both human-caused and natural factors, but since about 1970, the Earth's warming is attributed almost exclusively to increased atmospheric GHG concentrations from human activities.

Given the current concentrations and the persistence of GHGs, and the projected further increases in GHG concentrations, it seems certain that the climate will continue to change. International efforts to reduce GHGs, such as the Kyoto Protocol, will only slow the rate of change. Thus, adaptation is an essential response to ensure that society is not unduly adversely affected by climate change impacts.

But adaptation to what? Some people mistakenly believe that climate change is simply a gradual global warming. It is increasingly evident that other aspects of climate are changing, too, especially the frequency and intensity of extreme weather events. These two changes, the general warming and the increased climate variability, have significant implications for many aspects of our sustainable livelihoods.

2.1 Climate trends and projections for Ontario

Over the last 35 years, Ontario's climate has changed in a number of ways. Some of the changes in southern Ontario's climate are presented in Table 1. It is instructive to compare recent climate trends to those projected for the coming decades, to consider whether modeled projections can reliably inform adaptation decision-making.

Table 1: Present estimates (2006) of observed and projected climate changes for Ontario

	To date	By 2050
Mean Temperature	0.6 degrees C	2 to 3 degrees C
Total Rainfall	+ 1% per decade	+1% per decade
Extreme Rain Events	+5-7% per decade especially in spring (May)	+5% per decade
Total Runoff and Groundwater	Little change	Decline 10-20% (more evaporation)
Great Lakes Levels (Flow at Niagara which integrates effects on lakes above the Falls)	-7% (30 years)	Decline 0.3 to 1 metre in levels
Severe winter storms	Increased Intensity	15-20% increase in intensity

Many social systems are already vulnerable to various climate-related and non-climate-related risks. Projected climate changes will exacerbate many of these pre-existing vulnerabilities. Adaptation measures to reduce these vulnerabilities are increasingly urgent.

Annex 1 contains additional information about climate change impacts for Ontario and Canada.

2.2 The municipal planning context

Municipal and conservation authority staffs are accustomed to dealing with climate-related issues in the course of their planning and management activities. For example, they manage water supplies, design drainage systems and flood protection, design and implement heat and smog alert systems, and control mosquitoes and other disease vectors.

But dealing with climate change is new and may be unfamiliar. Because it is a relatively new subject, the implications of climate change are not well understood across departments in many municipalities. As yet, there are few staff appointments explicitly responsible for adapting to climate change. Most municipal strategic or

long-range plans do not address adaptation to climate change. It can be difficult to get this issue on the municipal agenda.

In Ontario, the provincial government has a number of laws and policies which, although they may not reference climate change and adaptation directly, include strong provisions for dealing with risks to municipal infrastructure and the health, safety and environmental protection of their residents. This creates a strong and justifiable case for adaptation planning in a number of key areas. The same principles apply in general to the Conservation Authorities.

Another prominent problem facing municipalities is that, because of pressures on municipal staff, it is extremely difficult for them to attend to issues that do not have an immediate impact on municipal operations. Sometimes, in order to pursue a new initiative, such as a climate change risk management initiative, staff of municipalities may have to establish that it should have a priority over or at least equal to an existing responsibility. This could require a strong business case and a business plan for approval by senior management. This in itself may create a work issue for staff.

Whether the project is a large one, such as writing a strategic adaptation plan for the municipality or more focussed on particular adaptation issues or hazards, it is most important that the project has, and continues to have throughout its course the support of the Municipal Council and the senior administrative official and the assignment of adequate resources to do the needed work.

Annex 2 contains more information about legislation and policies that will support or require climate change adaptation strategies and plans for municipalities and conservation authorities. It also provides additional information about how to deal with the issues of “getting started” and introducing risk management and climate change adaptation into municipal plans and operations.

3. Overview of the Risk Management Approach

3.1 The risk management process

Risk management is a systematic approach to selecting the best course of action in uncertain situations by identifying, understanding, acting on and communicating risk issues. In the context of adapting to climate change, risk management provides a framework for developing adaptation strategies in response to potential climate changes that create or increase risk. As mentioned above, whether the issue is as large as large a municipal strategic plan for climate adaptation or a smaller study around specific issues such as extreme rainfall events, heat, health issues or others, the risk management process will Guide staff towards the optimal solutions.

The framework presented in this Guide is based on the Canadian standard *"Risk Management: Guidelines for Decision-makers"* (CAN/CSA-Q850-01). The decision-making process consists of six steps, which are shown in Figure 1. The process emphasizes continuous communications with stakeholders and good documentation of each important action.

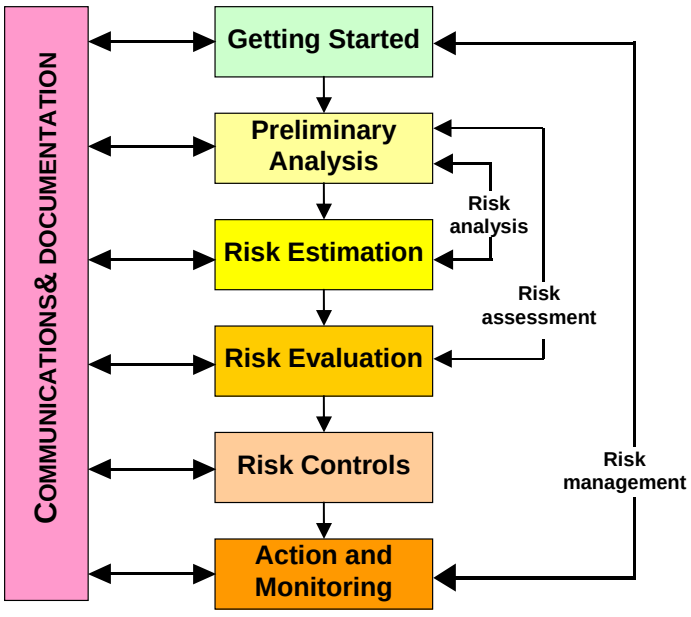


Figure 1: Steps in the risk management process

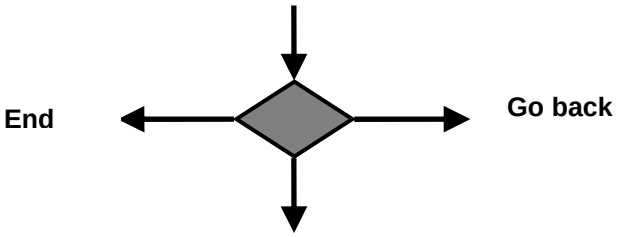
It is a systematic approach for identifying, estimating, evaluating, prioritising and implementing risk reduction strategies in order to achieve acceptable levels of risk. Key activities include:

- Determining the probability and potential consequences of events arising from situations or hazards;
- Identifying actions that can be taken to avoid negative consequences or lessen their impact, or to exploit potential benefits; and
- Understanding stakeholders' perceptions of probabilities and consequences.

In practice, information relevant to risk situations can be interpreted differently by various groups of stakeholders, resulting in quite different perceptions of risk. Given this, the risk management process emphasizes the need to understand how events might affect or be perceived by different stakeholders.

The completion of each steps leads logically to the next, unless the risk issue is resolved, in which case the process is terminated. Steps can be repeated to include different assumptions, new information or new analyses, as appropriate. The decision options at the end of each step are indicated in the "Decision Diamond" shown in Figure 2.

Figure 2: Decision diamond - decision options at completion of each step



The process is iterative and can be repeated as new information becomes available or new risk control options become feasible.

The process emphasizes continuous stakeholder communications and careful documentation of all actions taken. Communications with all stakeholders, even marginal ones, ensures that stakeholders' concerns are considered, and helps build support for the eventual results. Complete

documentation of each of the major elements of the process helps to ensure accountability and consistency during implementation. It provides a record for future reference. This is especially important for managing risks from climate change. There are still uncertainties about precisely how the climate will change and its implications for Ontario communities, so risk managers will want to revisit the decision process as new information becomes available. Depending on the complexity of the risk issue being analysed, the process can be completed in several days or weeks. A small risk team consisting of two or three people with moderate resources can undertake it. More complex risk problems may require a larger team and more time. A useful technique for getting started is to complete a simple "first cut" process using readily available data and a small risk management team. This will help the team explore the issues and possible outcomes rapidly and inexpensively. The results can be used to develop a business case for a more comprehensive and rigorous project and the documentation will have all the necessary logic and cost-benefit information to make a compelling argument for action.

3.2 Guiding principles

The risk management process is built upon several important principles:

- **Stakeholder engagement**
  Key stakeholders should be identified and involved during the entire process. The stakeholder team may be modified throughout the process as appropriate to particular issues being addressed.

- **Communication**
  The risk management team and stakeholders should develop an open and trustful dialogue that continues throughout the decision-making process, in order to:
  - Acquire relevant information;
  - Build public awareness of the particular risk and gain support for the process;
  - Facilitate consultation;
  - Evaluate stakeholder acceptance of risks; and
  - Serve as a part of the monitoring and review mechanism.

  In all communication activities it is important to remember the languages used by stakeholder groups.

- **Promotion of sustainable development**
  The outputs of the risk management process should be integrated into local development planning and should support local sustainable development goals.

- **Documentation**
  The process should be carefully and thoroughly documented and records appropriately stored in a "risk information library" so that it can easily be retrieved in the future. This will help to:
  - Ensure consistency in execution
  - Promote accountability and transparency
  - Develop records for future reference.

- **Use of existing tools, human and technical resources**
  The risk management team should make maximum use of existing resources, such as data sets, local knowledge and technical expertise, technical methods and previously documented experiences.

- **Public Education and Awareness**
  Public education and awareness is fundamental for successfully implementing the risk management process and ensuring broad stakeholder support of its results. Public education and awareness should cover both the potential implications of climate change and the risk management process itself.

4. Steps in the Risk Management Process

STEP 1: Getting Started

Purpose

- This step comprises the initial administrative process;
- Identifies the specific problem or hazard and the associated risks;
- Identifies the stakeholders and the project team especially those with the relevant expertise;
- Lists the responsibilities of each member of the project team and the resources needed to complete the risk management framework; and
- Drafts the workplan and estimates the schedule.

In some cases, there may be reluctance to commit busy staff to a risk management process. However, the increasing evidence of warming trends, intense smog events, extremely heavy rains and floods, is convincing most senior managers of the need to include these risks in their planning.

The time required by the team to undertake the full process need not be a very long, perhaps a concentrated week or several days per week for a month or longer depending in part on the extent of stakeholder consultations. However, as Step 2 suggests, a quick preliminary run through the risk management process is usually very helpful in scoping out the issue to see how simple or complex it is, determining the resources needed and helping to identify who should be involved in the team. If the issue is very large and complex a Steering Committee to oversee the process supported by sub-groups on particular technical aspects may be justified. The example at Annex 4 is illustrates the scoping approach.

In either case a dedicated team leader is essential from the outset. The team leader is usually a municipal planner or a senior member of the lead department involved. It is also very important to have and maintain the support of the Municipal Council and/or the senior administrative official.

What to do and how to do it?

(1) Establish the project team and its terms of reference, and develop the work plan and the key milestones.
   - Select team members with the necessary expertise to deal with the risk issues being considered.
   - Ensure that there are representatives from the organizations that will be responsible for implementing the risk controls identified at the end of the process. Support and clerical staff may be needed to handle the administrative and documentation matters. Others, such as members of the legal group may be involved at times or review or advise on certain aspects of the work.
   - Team members may change over the course of the project in order to have the expertise needed for each phase of the decision process.
   - The team leader should ensure that all members of the team know their roles and responsibilities with respect to the project and are familiar with the risk management process.

(2) Identify the resources required.
   - Determine the internal capacity that is available for the project, including available data, tools (e.g. GIS), human and financial resources.
   - Identify the external resources needed and prepare the justification to obtain them.

(3) Assign project team responsibilities, allocate resources and set schedules.

(4) Identify stakeholders and begin the stakeholder analysis
   - Identify any individuals or groups that can affect or may be affected by decisions or actions emanating from the risk management process. The stakeholder group can be quite large.
   - Consider the stakeholders' interests, concerns, rights and likely issues. Begin to think about how different stakeholders might perceive various risk issues differently and how this might affect the decision process and

communications with the various stakeholders.
    - Recognize that the stakeholder group may evolve throughout the process.

(5) Develop a risk communication plan and initiate a dialogue with stakeholders
    - Key questions to consider include: Who is responsible for the communication process? Who are the key audiences? How will the impact of the communications be evaluated? Should some on-going, formal structure be considered for communicating with stakeholders such as a stakeholders' panel?
    - Annex 3 provides additional information to help with risk communications.

(6) Start the risk information library.
    - The risk information library contains copies of all the information collected throughout the risk management process, including information on the risks, data that are used to analyse the risks, a record of decisions taken, stakeholder views, records of meetings and any other information that may be obtained during the risk management process.
    - Keeping these careful records will provide the means to trace the logic behind any decisions made. Also it will make it easy for the team to review the process, should any additional information become available.

Expected results and outputs

- Risk issues and potential management implications are defined.
- Project team established.
- Terms of reference and budget for project team developed and approved.
- Modalities for communication established.
- Stakeholders identified and preliminary analysis of their needs, concerns and probable issues completed.
- Collection of documentation begun for the risk information library.

Checklist

Step 1: Getting started	
Have you:	
	1. Defined the hazards and vulnerabilities, and their potential management implications?
	2. Established a project team, project workplan and team members' responsibilities?
	3. Identified the resources required to undertake the project, and any existing capacity that is available to the project team?
	4. Identified the stakeholders and begun to define their probable issues, needs and concerns?
	5. Developed a plan for communicating with stakeholders?
	6. Started a risk information library?

Example:

EXTREME STORM FOLLOWING A LONG HEAT-WAVE:

Climate estimates for the future indicate that there will be more extreme weather events and longer spells of very hot weather. One event that could become more frequent is an extreme weather event triggered by a week-long heat wave and stagnated air mass that could result in multiple emergencies including, a large number of people suffering from heat stress, extremely heavy precipitation resulting in local flooding and overtaxed drainage systems, wind damages and electrical power outages. The Municipal Council has asked the emergency coordinator whether the municipality could cope especially since staff of municipal and health agencies are already overburdened.

The overall risk problem is, could the already overburdened municipal system effectively and efficiently deal with such a scenario and if not what would be the likely outcomes? What actions should be recommended to avoid or reduce the negative outcomes?

Actual and potential hazards identified:

- Short duration <24 hr. high intensity rains more frequent and severe – increasing ~5%/decade with the largest increases in Spring – more erosion and flash floods.
- Very high temperatures in the upper 30's in the daytime and, also high at night.

- Smog episode with high ozone and particulate concentrations.
- Possible degradation of water quality.
- High possibility of violent thunderstorms and strong winds.

Risk Issues:

- Extreme rainfall could cause local flooding, washouts, possibly overwhelm the sewage treatment plant, surface runoff could significantly degrade the quality of water intake into the water treatment plant.
- Possible electrical power outage.
- Additional health problems including additional heat stress cases, possible illness due to lowered air and water quality would have to be handled by the public health system that is already under extreme pressure.
- Potential wind damage.

Project Team. The project team would likely be headed by a staff member of the emergency management group and would include representatives of the key affected municipal departments such as: public works, public health, social services, utilities and transportation. The team could also have representatives from other groups such as; an elected representative, conservation authority, land use planning, environmental planning, emergency services (police, fire, ambulance), school boards, corporate communications, clerical staff and others. The team leader would identify a contact within the municipal government for legal advice should that be required during the process.

The team would refresh its understanding of the risk management process and ensure that all members have appropriate reference material about the process.

Initial Stakeholder Identification and Probable Issues Concerns and Needs. Elderly and very young persons with compromised health conditions, emergency services, energy sector, public works, utilities (including telecom providers, electrical suppliers, water and wastewater treatment services), roads and transportation departments. food distributors, social services, NGOs, schools and the business sectors.

Existing Capacity

- Staff of five
- Office space
- IT resources

Needed Resources

- Disseminate information to peers and within organization
- Newsletter, briefing sessions
- Brainstorming sessions
- Key stakeholder group briefings and question and answer sessions
- Corporate communications to develop communication strategy and identify means to get key messages out.

Documentation
This would include for storage in risk information library.

- Terms of reference for project
- List of project team members and alternatives, their coordinates and other useful information
- Lists of hazards and vulnerabilities and copies of key documents about them.
- Records of any meetings held.
- Initial list of stakeholders including contact information and notes on probable concerns and issues.
- Copies of other documents used or created.

DECISION: GO TO NEXT STEP

(End of example for Step 1)

STEP 2: Preliminary Analysis

Purpose

- To define the climate-related hazard and the potential risks that may cause harm, in terms of injury, damage to property, the environment or monetary losses to the community.
- To identify possible outcomes from the risk situation.
- To conduct a quick overview of the process to help determine the complexity of the project, the probable time-frame for completing the work and a sense for whether the project team and resources assigned are sufficient.

What to do and how to do it?

(1) Develop risk scenarios based on the hazards and vulnerabilities identified in Step 1.
   - Develop scenarios based on a sequence of events caused by the climate-related hazard that might result in adverse effects.
   - Each risk scenarios will be developed or expanded to show the types of losses or impacts that could occur as a result of exposure to the hazard. Losses could include:
     - Health losses due to illness,
     - Injury or death,
     - Property losses,
     - Economic losses and
     - Environmental or ecosystem losses or impairment.

     A "fault tree" or "event tree" or similar type of analysis mechanism could be useful in developing the risk scenarios.
   - The risk scenarios will form the basis for more detailed risk estimations and evaluations in Steps 3 and 4.

(2) Collect data and identify the project baseline
   - Review existing information on current vulnerability and climate-related risks, based on previous studies and experiences and expert opinion.
   - Describe risk controls currently in place to manage the specific climate-related risks being considered and describe their effectiveness and any gaps.
   - Develop a project and risk baseline that summarizes the current level of risk with respect to recent historical and current climate variability.
   - Risks related to climate change will be compared later against current or baseline risks in order to evaluate the need for and benefit of additional risk controls.

(3) Assign initial estimates of frequency and severity to the risk scenarios. Useful information may be found in historical records and by consulting with subject matter experts to help develop these initial estimates.

(4) Continue the stakeholder analysis
   - Now that there is more information on the potential risk issues, identify any additional stakeholders that should be involved.
   - Refine the analysis of stakeholders' needs, interests and concerns.
   - Engage key stakeholders in the risk management process, if you have not done so already.
   - Compile a database of all stakeholders that includes their contact information and the results of your stakeholder analysis. Update the database throughout the process.

(5) Outline the risk communication plan and initiate risk communications with stakeholders

(6) Update the risk information library:
   - Organize all information collected throughout the risk management process in a risk information library. The library will be the central repository for all information, assumptions, concerns, decisions and changes made throughout the process.
   - The library should include:
     - Baseline data and information on the hazards or trends;
     - Roles and responsibilities of the risk management team;
     - Identification of decision-makers, and scope of decisions to be made;
     - Complete descriptions of the risk scenarios;
     - All stakeholder information, including minutes of stakeholder meetings or other records of stakeholder communications;
     - Record of all decisions and assumptions
   - Record the source of the information and the date it was collected, and any weaknesses in the data

Expected results and outputs

- Risk scenarios are developed and a preliminary analysis is completed for each, showing potential losses
- Baseline information has been collected, or plans in place to collect additional baseline information

- Additional stakeholder analysis completed
- Stakeholder communications initiated
- Risk information library is started and rules for document collection are established;
- Important reference material is documented and stored
- Outline of risk communications plan has been completed.

Decision

There are three decision options (see the decision diamond in Figure 2 on page 4: End, Go back or Next step/Take action.

- **End** the process if the hazard(s) and risk(s) are Considered by stakeholders to be acceptable.
- **Go back** to Step 1 or the beginning of Step 2 if the risk management team considers that it is necessary to improve on any aspect of the information developed in those steps or to make any changes, if appropriate. Given the nature of the climate change issue, it is not unusual to have to improve data collection and revisit assumptions in order to enhance the credibility of the entire risk management process.
- If the risk situation continues to be a concern, proceed to the **Next Step, Step 3 Risk Estimation**.

Checklist

Preliminary analysis	
Have you:	
	1. Developed risk scenarios and completed a preliminary analysis of their probabilities and consequences?
	2. Established a baseline of data for each of the risk scenarios?
	3. Developed a stakeholder database?
	4. Refined your stakeholder analysis?
	5. Updated the risk information library?

Example

EXTREME WEATHER EVENT DURING A LONG HEAT-WAVE (continued from Step 1) As discussed in the example in Step 1, Council has asked for an opinion as to whether the municipality could cope with this type of multiple emergency event especially when staff are already heavily committed because if the long heat wave.

Possible Hazards. Long extended hot weather in high 30C, smog, extreme storm cells, strained or overloaded health and emergencies systems, extreme rainfall.

Possible Risks.

- Community facilities overloaded and unable to cope with demand
- Emergency system overburdened and cannot respond
- Safety of personnel, vehicles at risk
- Mould
- Flooding
- Sewer back-up
- Heat stress, respiratory problems and other health impacts
- Property damage

Preliminary Analysis of Risk Scenarios.

- Extreme rainfall and extreme amounts of water runoff in short time - wash down of paved area – pollution
- Localized violent flooding
- Sewer back-up
- Road and rail washouts
- Underpasses blocked and/or flooded
- Vehicles stalled blocking main arteries - emergency vehicles unable to reach medical emergencies, injured people
- Electrical outages
- Stores closed
- Bank machines stop – no money available
- No gasoline available
- Health issues related to sewer back-up
- Food security
- People dependent on system for survival

Establish Baseline.

- Hospitals already crowded
- EMS already overworked
- Power systems already overloaded
- Verify historical data on all elements
- Policing for looting, traffic control, security
- Storm ponds nearly full
- Storm water system (infrastructure) compromised because of age
- Temperatures – number of very hot days

- Baseline should address the circumstance or the time – in this case, temperature escalation has already taken place and the next emergency will now be added to response exposure

Stakeholder Database.

- Internal Stakeholders (key stakeholders are represented on the risk management team, others are linked through a risk communications dialogue. These groups are particularly important when risk controls are considered)
  - Emergency services
  - Water utilities
  - Electrical utilities
  - Telecommunications
  - Hospitals and other health services
  - Public health
  - Roads and transportation
  - Land use planning
  - Social services
  - Others
- External Stakeholders (these include residents, community groups and others who may be or may feel that they are impacted by the risk scenarios)
  - Vulnerable individuals including the elderly and health impaired
  - Business and industrial groups,
  - Religious groups
  - Schools and youth groups
  - Insurance industry
  - Others

Stakeholder Analysis

- All information regarding needs, etc. or stakeholders – are they cooperative? Supportive? what are their attitudes? what are the special needs of each particular group? any who can help? resources? In addition, an analysis should be done of how to best contact and engage each stakeholder group, develop a database of contact information and keep this information current.

Risk Information Library. Make and keep separate copies of all key information about the risk scenarios, baseline data on each risk, stakeholder information and communications plans.

DECISION: GO TO NEXT STEP

(End of example for Step 2)

STEP 3: Risk Estimation

Purpose

- To identify the frequencies and consequences associated with each of the risk scenarios[1].

What to do and how to do it?

(1) Select methods for estimating frequency and severity:
  - Consider using historical records to determine trends of climate events and impacts, technical data and projections from the IPCC or from provincial or federal governments, and
  - Expert opinions.

(2) Estimate the frequency or likelihood of possible outcomes**
  - For familiar hazard and risk issues, estimates can typically be derived from historical data. Look for data and information in research reports, insurance company records. Look also at data and information from similar risk situations in other regions or countries.
  - Use sensitivity-type analyses, technical projections, expert judgment or other practicable and credible methods to put some boundaries or estimate of uncertainty on the projection of the frequency of the outcomes.
  - A simple four or five tier comparative rating system (such as a scale from "occurs very often" to "occurs almost never") is useful for assessing the relative frequency of risk scenarios. For climate change assessments, risks should be estimated for current conditions and say 2020, or for major projects, 2050.

[1] Further information about the technical aspects of risk estimation can be found in CSA Standard CAN/CSA-Q634.

(3) Estimate the consequences of possible outcomes**
   - Estimate the magnitude of the various impacts of a risk situation, in the event that the risk scenario occurs. Use measurable, verifiable data wherever possible. Again, look for data and information in research reports, insurance company records or information from similar risk situations in other regions or countries.
   - As with frequency estimates, a simple comparative impact rating system (such as a four or five tier scale from "very minor effects" to "extremely serious effects") may be useful for making relative estimates of various consequences from a particular risk scenario. If extensive loss and other impact data are available, explicit values could be used in a tabular form so that the comparative severity can be compared. At this stage, definitive measures are not necessary as this is a ranking process to determine which risk is the most severe and thus should be dealt with first.

(4) Assess the stakeholders' perceptions of risk. As explained in more detail in Annex 3, stakeholder perceptions of the importance to them particularly of the consequences of risk scenarios is very important and may have a very big influence on the ranking of risks.

(5) Display the frequency and consequence estimates in a tabular or graphical format that clearly indicates the relative importance of each scenario.
   - Determine how best to present the frequency and consequence estimates. Consider how stakeholders may interpret the estimates. Table 3-1 shows one way of displaying frequency or probability
   - It may be helpful to determine the expected value of the loss in each of the areas that were selected to categorize the expected consequences (for example, social, economic and environmental aspects). This may help in comparing the losses or consequences in each risk scenario and provide a baseline for later evaluation of risk control measures. Table 3-2 shows one way of displaying these. The headings in this table are generic and are not intended to be prescriptive. Headings could be selected to describe local conditions.

** It may be useful to repeat these tasks several times, each time applying different information or assumptions about future climate or other factors that might influence risk. The frequency and consequence ratings for each scenario will vary depend on the planning time horizon (that is whether he plan is a short-term plan for the next 2 or 3 years or a longer term plan covering 10 or 20 years). This requires choosing an appropriate time frame for a climate scenario and vulnerabilities from which the scenario is constructed.

TABLE 3-1: Frequency / Probability Rating

Frequency / Hazard	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Hazards from risk scenario (list each)	Not likely to occur during the planning period	May occur sometime but not often during the planning period	Likely to occur at least once during the planning period	Likely to occur several times during the planning period	Happens often and will happen again during the planning period

TABLE 3-2: Impact Rating Matrix

Impact / Degree	Social factors				Economic factors			Environmental factors			
	Displace-ment	Health & Safety	Loss of Livelihood	Cultural Aspects	Property Damage	Financial Impact	Impact on Municipal Finances	Air	Water	Land	Eco-systems
Very low											
Low											
Moderate											
Major											
Very Severe											

Note: In both tables 3.1 and 3.2 the measurements are expressed in comparative terms ("very unlikely" to "virtually certain" and "very low" to "very severe"). It is also possible to express these in numerical values so that adding or multiplying them gives a quantified relative frequency or impact consequence. The problem with using numerical values is that the reader may perceive them to imply more accuracy than actually exists. The risk management team should consider the method to be used to compare relative frequency and impact or consequence values and agree on the most appropriate way of assigning relative values.

(6) Consult with stakeholders and refine the stakeholder analysis
   - Engage stakeholders in a meaningful dialogue in order to communicate the risk estimates and to clarify their issues and concerns. Consider using focus groups, workshops or public meetings.
   - Communicate information openly and in language and detail that stakeholders can understand. Provide information on the risk baseline (i.e. the risk frequency and consequences that exist now), methods for developing the risk scenarios and for estimating frequencies and consequences, assumptions, third party analyses and any other relevant information.
   - Some stakeholders may not agree with the frequency or consequence estimates. Record stakeholders' different views. Later in the process, return to this step, if necessary, to test and discuss the sensitivities of the proposed adaptation measures to these different views of frequency or consequences.
   - Stakeholders' issues and concerns will probably change as they become more familiar with the risk scenarios and the risk management process. Document these changes on an ongoing basis.

Expected results and outputs

- Estimates of frequency and consequences of risk scenarios, and estimate of expected consequences of each scenario
- Frequency and consequence estimates presented in a format that is easy-to-understand by non-experts
- Estimates of the acceptance by stakeholders of risk, or a record of reasons for non-acceptance, based on a dialogue with the stakeholders and a careful documentation of their perception of the risks.

Decision

- **End** the process if the estimated risks are much lower than initially estimated in the preliminary analysis, and stakeholders agree that there is no longer a significant concern.
- **Go back** if:
   - There is new information that needs to be considered;
   - Additional risk scenarios need to be considered;
   - There are doubts about data quality or analytical methods; or
   - Not all stakeholders are comfortable with the level of uncertainty associated with the analysis.
- Proceed to the **next step** if the risk management team and stakeholders are

comfortable with the data, assumptions and outcomes of the risk estimation process.

Checklist

Risk estimation	
	1. Are you satisfied with the quality of your data?
	2. Have you analyzed and assigned appropriate levels of frequency to each risk scenario?
	3. Have you calculated the expected loss or other consequences from each risk scenario?
	4. Are you comfortable that stakeholders' perceptions have been assessed for each of the risk scenarios? Have stakeholders endorsed your analysis?
	5. Has the process been carefully documented and the risk information library updated with all relevant information?

Example:

FLASH FLOODS IN URBAN/SUBURBAN AREAS and RELATED SOURCE WATER QUALITY PROTECTION

Risk scenarios and impacts.

Climate Factors: (Hazards)	Risk Scenarios - Aspects of Hazards and Risks to Community	Stakeholders
1. Trend towards greater short duration (<24 hr) heavy rains, especially in Spring and early Summer (See Annex 1)	The following hazards and risks from this change in climate were identified.	
	a) Greater possibility and frequency of flooding beyond previously designated flood plains – exacerbated by upstream development in watersheds: Public/private property loss increases, greater threat to life. (especially children/elderly)	Conservation authorities – near-flood plain property owners, public and private – emergency managers – media.
	b) Capacity of culverts and storm sewer systems more frequently exceeded: road damage, bridge washouts, underpass and basement flooding, increased repair bills and insurance costs	Transportation department – traffic police – public works dept., insurance – building owners susceptible to sewer backup – media
	c) Water pollution incidents from increased erosion, with attached pollutants to eroded particles and polluted runoff (chemicals, E-coli) as well as pollution from storm sewer overflows, into sanitary systems, and overflow of hazardous waste sites. All lead to compromise of potable water availability.	Municipal water dept. and water treatment facilities, drinking water and water recreation warnings – media – general public
	d) Power and telephone lines downed more frequently requiring repair, replacement: reduced social contact and business.	Electricity and telephone suppliers – media – public
	e) Flooding of work places: temporary or perhaps permanent loss of livelihood.	Business recovery planners – unemployment insurance managers
	f) Persons displaced to public or private shelters more frequently – if public shelters adequate.	Hotels, B&B's, etc. – municipal building operators.
	g) More frequent loss of crops and livestock and greater soil losses from erosion in agricultural lands near streams.	Farmers in affected areas
	h) More rapid silting of downstream river beds, reservoirs and deltas, compromising fish habitat and reducing channel capacity	Conservation authority – municipal works departments – fish and wildlife associations
	i) Land slides more frequent on unstable slopes with insufficient vegetation or protection – identify hazardous slopes.	Property owner (private/public) in anticipated hazardous lands – municipal works and heavy equipment operators
2. More rapid snow and ice melt in spring combined with heavier rains	As above, but greater threat of ice jams and ponding of water upstream of bridges and other obstructions.	

Probability or frequency estimation of risks

Frequency / Risk	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Flooding beyond previously designated flood plains		20 – 50 year return rate			
Culverts and storm sewer systems capacity exceeded					At least once every year
Water pollution incidents from increased erosion				Extreme rainfall events heavy enough to affect water treatment every 2 – 5 years	
Major power and telephone lines outages			Every 7 – 10 years		
Major flooding of homes and work places	50 – 75 year return rate				
Large scale evacuations	50 – 75 year return rate				
Loss of crops and livestock and serious agricultural soil losses from erosion		20 – 50 year return rate			
Silting of downstream river beds, reservoirs and deltas,			Every 7 – 10 years		
Land slides				Extreme rainfall events heavy enough to affect slope stability every 2 – 5 years	

Consequence ratings are shown for the first two risks, flooding beyond the designated floodplains and exceeding culvert and storm sewer capacity.

Impact Rating Matrix - Flooding beyond previously designated flood plains

Impact / Degree	Social factors				Economic factors			Environmental factors			
	Displace-ment	Health & Safety	Loss of Livelihood	Cultural Aspects	Property Damage	Financial Impact	Impact on Municipal Finances	Air	Water	Land	Eco-systems
Very low				√				√			
Low			√				√				
Moderate	√	√				√					
Major					√				√		√
Very Severe										√	

Impact Rating Matrix - Culverts and storm sewer systems capacity exceeded

Impact / Degree	Social factors				Economic factors			Environmental factors			
	Displace-ment	Health & Safety	Loss of Livelihood	Cultural Aspects	Property Damage	Financial Impact	Impact on Municipal Finances	Air	Water	Land	Eco-systems
Very low	√			√				√			
Low		√	√				√		√		√
Moderate					√	√				√	
Major											
Very Severe											

Risk Information Library. Ensure that all the data used to develop the estimations of the frequency or probability and consequences or impacts are recorded and carefully stored in the risk information library. This data may have to be reviewed or updated if the steps are repeated in the future and the baseline data will be very important in this process. Also, the rating matrices and the rationale for the qualitative values assigned in these charts should be carefully annotated and stored for future reference.

Ensure also that the stakeholder analysis and data bank is updated.

DECISION: GO TO NEXT STEP

(End of example for Step 3)

STEP 4: Risk Evaluation

Purpose

- Develop a process for comparing or ranking each risk scenario.
- Evaluate the risks by examining them in terms of costs, benefits and acceptability, considering the needs, issues and concerns of stakeholders.
- Identify unacceptable risks and prioritize them for risk reduction or control strategies.

What to do and how to do it?

To this point in the process, only the hazards and risks have been analyzed. Now the operational aspects and costs and benefits that accrue in each scenario will be considered.

(1) Develop the costs and benefits of each risk scenario including not only the direct costs and benefits but also the important indirect ones.

(2) Analyze risk perceptions of key stakeholders, including those representing the general public.

(3) Assess the acceptability of risks associated with the risk scenarios and potential outcomes.

(4) Compare the risks using appropriate criteria such as a summary of the consequence data from the previous step assessing the important social, economic and environmental consequences using a convenient scale ranging from very low to extreme along with the frequency or probability estimates.

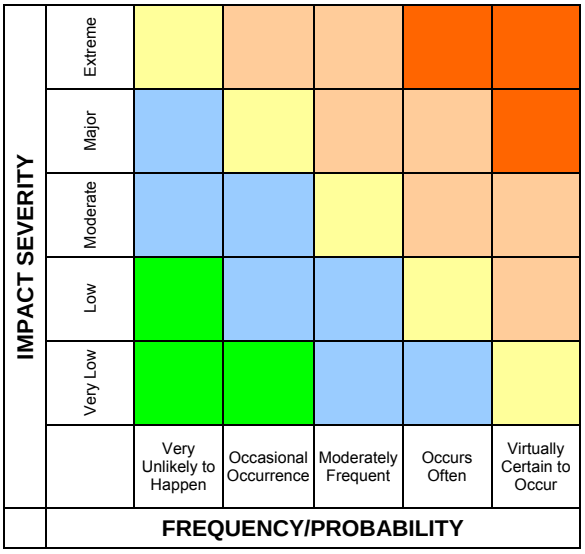
- Consider using a "risk evaluation matrix" to assist in comparing or prioritizing the various risks. Combine the frequency and consequence ratings for each risk as determined in Step 3 into a single matrix. Establish acceptability values against which the various risks can be compared. The chart below is an example for such a display. This chart uses qualitative measures such as "low", "moderate", "major". Other

The indirect costs and benefits can be extensive, so it is important to have the relevant expertise to assess them available to the risk management team. An example would be the impact of reduced water availability to a golf course. Water prices might rise, making irrigation prohibitively costly. In the short term, the golf course might lose patronage and suffer a financial impact. Workers might lose jobs. In the longer term, the golf course might have to close, and the land could be converted into parkland or residential housing. Any of these outcomes has associated economic and social costs and benefits.

measures such as numerical values may be used so long as they do not imply an accuracy that is not implicit in the comparative values.

- Because experts and non-experts generally view risks differently, it is important to maintain an open and interactive dialogue with stakeholders in order to accurately gauge their level of acceptance of risks.

Risk Evaluation Matrix



Extreme risk: Immediate controls required

High risk: High priority control measures required

Moderate risk: Some controls required to reduce risks to lower levels

Low risk: Controls not likely required. Some actions, such as public education, may be desirable

Negligible risk: Scenarios do not require further consideration

(5) During the dialogue with stakeholders about their perceptions and the acceptability of the risks, begin to identify plausible risk control options to help reduce unacceptable risks to acceptable levels. These will be considered in the next step.

(6) Update the risk information library

Expected results and outputs

- Risks evaluated in terms of probability, consequence, costs and benefits.
- Risks prioritized.
- Unacceptable risks identified.
- Meaningful dialogue with stakeholders about acceptability of risks.
- Risk information library updated.

Decision

- **End** the process if:
  - Stakeholders agree that the risks are acceptable; or
  - The risk is completely unacceptable cannot be reasonably dealt with, and all stakeholders agree that the process should be ended. This would only happen if the risk or activity generating it was not mandatory or inevitable.
- **Go back** if:
  - There is insufficient data or information to make a decision;
  - Stakeholders were not adequately consulted;
  - Not all key stakeholders agree with the conclusions; or
  - There is new information that might materially change the frequency or consequence estimates.
- Proceed to the **Next Step** if stakeholders agree that the risks are unacceptable and that risk control measures will have to be implemented

Checklist

Risk evaluation	
	1. Are the risk evaluation and ranking completed?
	2. Are all of the major considerations accounted for?
	3. Have you consulted with all key stakeholders on the acceptability of risks?
	4. Have you given preliminary consideration to controls for unacceptable risks?
	5. Is the risk information library updated?

Example

FLASH FLOODS IN URBAN/SUBURBAN AREAS AND RELATED SOURCE WATER QUALITY PROTECTION (example continued from Step 3)

Data and information needs for estimation. Key needs are:

- Current flood plain maps and period of data upon which they were based and culverts design size
- Designated hazardous lands
- Changes in heavy rain frequency and severity to date and projected for 3 to 4 decades (see Annex 1 for estimates)
- Determination of frequency of threshold rain intensities for producing peak floods and overflows, now and projected for 4 decades
- Review very recent 2003 to 2006 incidents of extreme rainfalls in southern Ontario and assess ability of water treatment facility to cope with greater suspended sediment and accompanying chemical and pathogen pollution.
- Obtain weather radar date to augment station rainfall date (from Meteorological Service Canada)
- Determine seasonality of changes in intense rains
- Inventory of properties at risk and values now and within 4 decades and projected economic losses and numbers of people displaced
- Determine current rates of siltation and project to future
- Assess frequency and severity in past decade of degraded water quality due to flood flows, and projected for 4 decades
- Estimates of costs to extend flood plain designations, and increase culvert sizes and storm drainage capacities

This information when collected and analyzed would determine frequency and severity of events.

Based on information available to team and trends of frequency and intensity, the following Risk Evaluation table was developed as shown below (note: See the frequency and consequence tables in the example in the previous step. Only the flooding beyond the designated floodplains and the exceeding culvert and drainage system risks were illustrated there. For this example the remainder of the risks were also included to illustrate how the risks could be ranked.)

These ratings combine the completed tables 3-1 and 3-2 in the previous section on step 3. Consequences assessment or "severity of impacts" was based upon a subjective review of the Social, Economic and Environmental Factors, discussed in Step 2. It is considered that additional loss of life is unlikely unless systems in place fail. (e.g. Walkerton water supplies or flood warnings)

Decision

A dialogue with stakeholders, after completing these analyses was considered to be needed before moving to Step 5 – Risk Controls and Adaptative Decisions. However some cost effective potentially "win-win" adaptation measures could be suggested with present information.

These include:

1. Update flood-plain mapping
2. Ensure fail-safe potable water treatment and improve water quality advisories
3. Strengthen flood warning systems
4. Revise design standards for new drainage and storm management facilities
5. Re-visit operation plans for upstream dams
6. Put in place water intake and well-head protection measures for water supplies
7. Improve public and stakeholder education programs.

The team reviewed the check-list for Step 4 and concluded:

1. They were not satisfied that they had all of the data needed for identifying potential adaptation measures.
2. With available data, levels of frequency and consequences could only be roughly estimated.
3. Levels of risk have been identified qualitatively but not quantitatively.
4. Stakeholder consultations were not done and are urgent.
5. Relevant available information was recorded.

DECISION: REPEAT STEP 4 AND OBTAIN BETTER DATA.

Risk Evaluation Table

SUMMARY OF IMPACT SEVERITY	Very Unlikely to Happen	Occurs Occasionally	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Extreme	Major flooding of homes and work places			Land slides	
Major				Water pollution incidents from increased erosion	
Moderate	Large scale evacuations	Flooding beyond previously designated flood plains			
Low		Loss of crops and livestock and serious agricultural soil losses from erosion	Major power and telephone lines outages Silting of downstream river beds, reservoirs and deltas		Culverts and storm sewer systems capacity exceeded
Very Low					
	FREQUENCY / PROBABILITY				

Extreme risk: Immediate controls required

High risk: High priority control measures required

Moderate risk: Some controls required to reduce risks to lower levels

Low risk: Some actions, such as public education, may be desirable

Negligible risk: Scenarios do not require further consideration

(End of example for Step 4)

STEP 5: Risk Controls and Adaptation Decisions

Purpose

In the previous step, the risks were evaluated and ranked, and a dialogue was held with key stakeholders about the acceptability of the risks. For unacceptable risks, some consideration was given about potential risk control or adaptation measure being introduced to bring risks down to acceptable levels. In this step:

- Feasible strategies will be identified for reducing unacceptable risks to acceptable levels.
- The effectiveness of the adaptation or risk control strategies will be evaluated including the costs, benefits and risks associated with the proposed adaptation measures.
- Optimal adaptation or risk control strategies will be selected and consideration will be given to the acceptability of residual risks.

What to do and how to do it?

(1) Identify feasible adaptation or risk control options:

- Identify the full complement of potential adaptation responses that could reduce the frequency or the consequences of the risks. Consider the different types of adaptations discussed in the box below

Anticipatory or proactive adaptation: adaptations implemented before a climate change impact, in order to reduce or prevent an adverse effect.

Reactive adaptation: adaptations implemented post a climate change impact, in order to reduce its adverse effect.

Note: Since initial impacts of climate change may have already been observed in some sectors but more severe impacts are anticipated in future, many adaptations may be thought of as a combination of reactive and anticipatory.

Private adaptation: adaptations that are initiated and implemented by individuals, households or private companies. Private adaptation is usually in the actor's rational self-interest.

Public adaptation: adaptations that are initiated and implemented by governments. Public adaptation is usually directed at collective needs.

Autonomous or spontaneous adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but is triggered in ecological changes in natural systems and by market or welfare changes in human systems.

Planned adaptation: Adaptations that are the result of deliberate policy decision, based on an awareness that conditions have changed or are about to change, and that actions are required to return to, maintain, or achieve a desired state.

- Typically, an adaptation or risk reduction strategy will comprise a portfolio of measures. Together, these measures should offer a cost-effective means for reducing unacceptable risks to acceptable levels.

(2) Evaluate the adaptation or risk control options in terms of effectiveness, cost, residual risks and stakeholder acceptance.
- Estimate the effectiveness of the proposed options using historical data and professional judgement.
- Identify and assess residual risk scenarios generated by the control option, which may result in other beneficial to adverse effects.
- Communicate with stakeholders on potential control options in order to gauge their acceptance of risk controls and perceptions of residual risks.
- Evaluate the risk control options in terms of:
  - Effectiveness in reducing losses or impacts or changing probabilities.
  - Implementation costs.
  - The needs, issues and concerns of affected stakeholders
  - The impact on other stakeholder interests.

(3) Develop the implementation plan for the adaptation or risk control measures:
- Select the complement of adaptation or risk control options that will ensure that risks are reduced to acceptable levels in ways that optimize cost, efficiency, stakeholder and other considerations.
- Consider structural measures such as , better roads or water systems and non-structural measures such as public warning systems business continuity plans, land use planning measures and public education and awareness.
- Determine the costs and benefits associated with the adaptation plan.
- Determine how to finance the implementation and begin to try to secure financing.
- Some criteria that could be useful in making these decisions are shown in the box below:

(4) Develop a risk communications plan related to residual risks
- In some instances, it may be prudent for municipalities to encourage private adaptations to further reduce residual risks. For example, municipalities can encourage residents to keep valuables out of basements that may flood during a heavy precipitation event or use public transit to reduce smog. The municipality can influence total losses from these types of events and also limit its own liability exposure.

(5) Update the risk information library

Expected results and outputs

- Feasible risk control options identified
- Adaptation plan completed based on priority risks/hazards identified in earlier steps.
- Strategies for financing implementation of adaptation measures
- Risks and residual risks accepted by stakeholders.

- Risk information library updated.

Decision

- **End** if there are no feasible adaptation options.
- **Go back** if:
  - Adequate data are not available for evaluating the cost-effectiveness of potential risk controls.
  - Key stakeholders have not been consulted.
  - Assumptions and uncertainties associated with estimates are not acceptable to stakeholders, or
  - New risks will be introduced if the proposed control options are implemented.
- Proceed to the **Next Step** if:
  - Feasible adaptation or risk control options are defined and can be implemented.
  - Proposed actions are feasible from a cost and effectiveness perspective and are acceptable to stakeholders, and
  - Residual risks are acceptable to stakeholders.

Checklist

Adaptation and risk control	
Have you:	
	1. Identified and evaluated feasible adaptation or risk control options, in terms of costs, effectiveness, stakeholder acceptance and other criteria?
	2. Selected the complement of adaptation or risk control options that best reduce risks to acceptable levels?
	3. Determined the costs and benefits of the risk control measures, and a means for financing them?
	4. Assessed and addressed any outstanding stakeholder concerns?
	5. Developed a risk communication plan for the proposed adaptation or risk control measures and for the residual risks?
	6. Ensured that the risk information library is updated?

Example

(This example was developed based on a health risk related to worsening urban smog.)

The risk management team concluded that the health risks are unacceptable from the combined effects of warmer summers, especially night-time temperatures that are rising more rapidly than day-time highs, thus providing little relief to sufferers in heat waves and increasingly frequent smog events.

The team identified many feasible adaptation measures or risk control options that could be implemented in the near-term and over the longer-term. The team evaluated the options and recommended the following portfolio of controls for implementation:

Immediate:

- Policy measures (e.g. incentives to promote public transit and reduce vehicle use) and operational changes (e.g. cancel non-essential municipal operations) to help reduce the severity of smog events;
- Public education and outreach to ensure that vulnerable populations are informed of the health risks and appropriate responses; and
- Ensure that hospitals and clinics are equipped to cope with large admission events.
- Business continuity plans for key municipal organizations are important adaptation measures in this situation.

Over a longer period:

- Plan new land uses and developments to promote the “compact urban form” and the use of public transit;
- Retrofit programs for public transportation systems;
- Develop short-term emission limitation actions; and
- Advocate for stronger responses to urban air pollution and greenhouse gas emissions by higher levels of government and international agreements.

The team concluded that these responses balanced the need to reduce the frequency or severity of the events, but also to limit the health effects from events that do occur. The near-term measures were determined to be low-cost, voluntary and publicly acceptable measures that will result in an immediate reduction in health impacts and health care costs. The land-use and development planning recommendation is in

line with the requirements established by the Provincial Policy Statement of Ontario, (2005).

The risk management team thought that the advocacy role was especially important for the municipality. Because much of the precursors to smog originate from outside of the municipality, regional and international air emission reductions can significantly improve local air quality. Also, the team thought that by assuming a strong advocacy role, the municipality would build credibility among its residents and be more successful in implementing the other measures.

The team did not identify any risk financing issues. However, there are major direct costs associated with health effects, but these are reflected in health care costs and budgets which were not included in the analysis.

The team was unable to quantify the residual risk with precision. They recommended that the municipality implement the options identified above, monitor the effects of these measures, and revisit the risk management process in two years to decide if additional risk control measures are required.

(End of example for Step 5)

STEP 6: Implementation and Monitoring

Purpose

- To develop and implement the adaptation plan.
- To monitor and evaluate the effectiveness and costs of the adaptation responses.
- To decide to continue or terminate the risk management process.

What to do and how to do it?

(1) Develop the implementation plan
   - Develop implementation plans including priorities for action for each adaptation measure.
   - Plans should be linked to existing municipal programs, where appropriate. Review any relevant non-climate-related social, economic or environmental action plans, and consider linking the risk control efforts as closely to these as possible. For example, there may be a program to strengthen existing initiatives to protect public health in smog episodes. Your risk control or adaptation measures could be linked to this program.
   - Decide the timing for the implementation of adaptation or risk control measures. Some risk issues may not surface for years, or it may not be feasible to address them immediately. In these cases, it may be prudent to defer implementation of some components until a future date.
   - Establish a review date and record it in the risk information library.
   - Before submitting the implementation plan for approval, review any similar climate change risk management initiatives, for example, from neighbouring municipalities, and compare your results to theirs.
   - Look for opportunities to collaborate across boundaries. Unfortunately, climate change impacts will not be related to political boundaries, but adaptation responses will. Exploit any collaborative potential to improve the effectiveness of adaptation responses.
   - As part of the implementation plan identify all special expertise or external assistance that may be required.

(2) Develop and establish the monitoring process
   - Monitor all relevant aspects of the adaptation measures or risk controls by measuring environmental or performance indicators, stakeholder reactions, costs and benefits, or other appropriate indicators. Review the risk information library for any suggested monitoring strategies or measurement criteria suggested to-date. Some may have been suggested during Steps 2, 3 or 4, or during the various stakeholder communications.
   - If appropriate, the planning team should be or should establish a monitoring and review team to continue this function for as long as needed.

(3) Submit the plan for approval and when approved begin the implementation of the plan.

(4) Continue to communicate with stakeholders.
   - At this stage, communications might include ongoing public education and outreach, media communications, or information sharing with other municipalities and sectors on your experience with the risk management process. Consideration should be given to ensuring that the residual risks are understood and communicated and that they will continue to be acceptable to the key stakeholder groups.
   - Record all communications in the risk information library.

(5) Review and reiterate the process, as needed:
   - Consider repeating the risk management process if it involves complex issues that are not fully understood.
   - In the second iteration, include new information as it becomes available and improve the analytical methods for drawing results and conclusions.

Expected results

- Comprehensive implementation plans that include:
  - Costs and milestones.
  - A database of experts and expertise that can contribute to the adaptation response and risk controls.
  - A database of ongoing activities that could facilitate the implementation of the plans.
  - Mechanisms to enhance information exchange across sectors and between nearby municipalities or watersheds.
  - Mechanisms for training and capacity building in the risk management process and on climate change impacts.
  - Mechanisms for the required public education and outreach.
  - Mechanisms for reporting on progress and evaluating results.
  - An evaluation and monitoring process plan.
- Factors that may influence implementation identified and addressed.
- Implementation initiated
- Risk information library updated. Include documentation of the methodology for implementation that can be made available to other vulnerable sectors and other regions.

Checklist

Implementation and Monitoring	
Have you	
	1. Developed a feasible implementation plan?
	2. Identified synergies with ongoing activities (e.g. national, regional or local initiatives)?
	3. Procured adequate resources to implement the plan?
	4. Established an effective monitoring and review program?
	5. Obtained approval to implement the plan?
	6. Developed a communication strategy to support implementation?
	7. Ensured that the risk information library is updated?

Example

This is the final result of the risk problem in the example in Step 1 and Step 2: could an already overburdened municipal system effectively and efficiently deal with an extreme weather event triggered by a week-long heat wave and stagnant air that could result in multiple emergencies and if not what would be the likely outcomes?

The strategy was to develop a Feasible Implementation Plan. Include a HIRA (hazard identification and risk assessment) for each risk in the risk scenario. The implementation plan focuses on taking the cheapest, fastest actions that could significantly reduce the strain on municipal services and lessen the impacts on the community.

The plan identifies synergies with on-going municipal activities. Infrastructure development programs and programs offering special financial assistance from senior governments were selected.

The plan with support from key stakeholders was submitted for approval. When approved resources will be in-place for the Implementation Plan. The plan also contains effective measurement and monitoring activities to verify whether the objectives are being achieved. Stakeholder groups, or peer reviewers, to ensure independence and validity of information, can conduct monitoring.

Conduct a focus group or brainstorm session with key stakeholders to identify everything that is needed in the documentation library, including knowledge transfer, financial resources and authorities.

Finally, the plan contains an effective communication strategy for program support. This should include communication about the residual risks. Target audiences have been identified and information and other supporting materials (such as t-shirts, brochures etc.) have been specified.

Annex 1: Summary of Climate Change Impacts in Ontario and Canada

Many factors have influenced major changes in the climate system over the centuries. The natural ones include changes in the earth's orbit and its albedo (or reflectivity), changes in the sun's energy, and in volcanic emissions from which suspended particles cause cooling episodes.

The Intergovernmental Panel on Climate Change reviewed many research papers which examined the relative importance of these natural climate forcing factors, relative to forcing by the rising greenhouse gas concentrations driven by human activities.

Fluctuations in global mean temperatures responded mainly to the natural factors up until about 1950. From 1970 on, the rapidly rising global mean temperatures can only be explained by the increasing greenhouse gas concentrations. Greenhouse gases will also dominate future climate trends, so trends from 1970 can be considered to be a good indicator of climatic trends for the coming decades. (IPCC 2001)

Carbon dioxide, CO_2 is the most important greenhouse gas and once emitted stays in the climate system for a century or more, and becomes well mixed in the atmosphere, no matter where it is emitted. Pre-industrial concentrations were about 280 ppmv. The levels in the atmosphere in 2005, are at 380 ppmv, and if emissions continue on a "Business as Usual" course, will be about 740 ppmv or moving towards 3 times pre-industrial concentrations by late in this century. In worst case scenarios, we could reach 1000 ppmv, and in the best case, with effective global emission controls, this century would end at 560 ppmv, or double pre-industrial concentrations by 2100. Most studies of impacts are based on a CO_2 doubling, a very hopeful scenario. The difficulty in turning around our fossil fuel based economies means that it will be necessary to adapt to significant climate change in coming decades – as well as reduce emissions as much as possible.

Projections of future climate are made by Global Climate Models which model mathematically, the interactions between the atmosphere and oceans, and between the air and land surfaces. Their projections take into account both the warming effects of the greenhouse gases, and the much smaller cooling due to increases in sulphate aerosols from industrial emissions.

Table 1 gives information on the changes affecting Canada observed to the end of 2000, and the projected changes into the present century. The latter are based mainly on the outputs of the Canadian Global Climate Model – an Atmosphere-Oceans General Circulation Model. This model has predicted reasonably well the changes that have occurred in Canada to date. (Boer et al. 1998) In these model outputs, it is assumed that atmospheric greenhouse gas concentrations will continue to increase at recent or slightly increased rates, due to continued global increases in emissions primarily from burning of fossil fuels. In a few cases in Table 1, the consensus projections of the Intergovernmental Panel on Climate Change 2001 Report are cited instead of Canadian model outputs.

SOUTHERN ONTARIO AND GREAT LAKES-ST. LAWRENCE BASIN

In this industrialized and heavily populated region, mean temperatures to date have risen by about 0.6^0C and are expected to continue to rise by another 2-3^0C by 2050. Models give conflicting signals as to whether annual precipitation will increase slightly or decline, so a hypothesis of little future change in total might be assumed, but with more of the precipitation in rain and less in snow. Under most models, evaporation losses are expected to more than offset any changes in precipitation. Water issues, including levels of the Great Lakes and pollution problems are major climate change concerns, but health issues with more prolonged neat waves and smog episodes in and near urban areas, flash floods and drainage design, agriculture, and recreational impacts are also of significant concern.

Great Lakes – St. Lawrence System:

The extent of impacts on Great Lakes levels and flows of a changing climate remains a subject of some disagreement among scientists. While

most models suggest increasing evaporation losses especially from the large Upper Lakes (Superior-Huron-Michigan) and little precipitation change, at least one (Hadley Centre 2) [2] suggests considerably more precipitation over the basin (although the Hadley Centre 3 model results are drier and close to other model outcomes). Thus, the majority of models indicate a significant lowering of lake levels (Mortsch et al., 2000). For the Canadian model, these declines would be by 2050, 0.3m for Lake Superior, 1m for Huron, 0.8m for Erie and 0.5m for Ontario. These declines would result in a loss of 1.3m water depth in Montreal Harbour on the St. Lawrence. A drop in Harbour water levels of only 30cm in the 1988-91 period resulted in a 15% reduction in tonnage handled.

Recently experienced falls in lake levels (except on Lake Ontario), but with levels still slightly above long term record lows, indicate the concerns that continuing lower levels and flows would bring. Commercial shipping would be hampered not only in Montreal harbour. For a 2.5cm lowering of Lakes Michigan-Huron a cargo ship must reduce loads by 90 to 115 tonnes worth some $25,000US per trip. Hydropower production at Niagara and on the St. Lawrence would be reduced, losses were 19% and 26% of production respectively in the 1960s low water period. Dredging of channels would be costly and would stir up contaminated sediments. On the other hand, shore property owners would inherit more land – e.g. a 1.6m water level decline on shallow Lake St. Clair would displace the shoreline by 1 to 6 km. (Mortsch et al. 2000, Mortsch 1998).

Groundwater and Tributary Water Supplies:

With warmer summers, both water demand from groundwater and tributary rivers to the Great Lakes system, like the Grand and Ottawa, are increasing for both consumptive and recreational uses. Trends to date in streamflow and water levels have been mixed with some streams showing declines in low flows and others, small increases. Groundwater provides 50% of Great Lakes tributary streamflow in Ontario, and 90% of rural residents use ground water for domestic purposes. Projections to 2050 with the Canadian GCM output suggest a 19% drop in groundwater levels and their contribution of base flow or minimum flows to streams. (Piggott 2005).

More Intense Rains:

There is increasing evidence of increases in heavier short duration (24 hour or less) rain events in southern Ontario, since 1970 (Adamowski 2003, Stone 2001). The Canadian climate model, and other models, have been used to project future trends in high intensity rains. (Kharin and Zweirs 2000) Table 2 summarizes the average trends in the amount of the annual maximum rain events. This suggests that the approximately 5% per decade increase in 24 hour amounts observed over the past three decades may continue in future decades. Recent extreme rain intensities in North Toronto 19 August 2005, Peterborough, July 2004, and northern Grand River basin June 13-14, 2004, suggest there may be even more rapid trends towards increasing magnitude of heavy rain events in isolated storms.

Such high intensity events have important implication for drainage design, storm water management systems, soil erosion and polluted runoff from croplands and animal wastes. The Soil and Water Conservation Society (2003), has used data from runoff plots and small watersheds, with a range of soil types, slopes and vegetation, to estimate impacts on erosion rates and runoff of increases in rain intensities. To illustrate a 10% increase in rain due to intensity changes resulted in an average 24% increase in erosion and 25% increase in runoff.

Urban Air Pollution:

Smog episodes will be longer and more intense in this region. An estimated 1900 premature deaths and many hospital emissions per year occur at present in Ontario from smog and air pollution. More intense and prolonged heat waves in future will make this an even more serious public health issue, when both air pollution and high heat stress affect vulnerable populations of asthmatics and the elderly. Remedial actions are urgent. These can be approached by various adaptation measures. In addition, by reducing dependency on fossil fuels, both local air pollutants and contributions to greenhouse gas forcing of climate can be reduced at the same time.

[2] The Hadley Centre was established by the UK and well endowed to become one of the world's leading climate change modelling and climate studies institutes.

Recreation:
Winter snow-based recreation in southwest Ontario will have shorter seasons in future, due to less ice on the lakes. A longer summer recreation season is expected.

Winter storms and disasters:
More intense winter snow and ice storms in the Northern Hemisphere are projected by climate models (Lambert 1995) and evidence of trends in this direction have been documented although snow amounts could increase at ski resorts to the east of Lake Huron and Georgian Bay with a longer period of lake-effect storms (McCabe et al. 2001). Public Safety and Emergency Preparedness Canada has documented an approximate 7-fold increase in numbers of climate/weather related disasters between the 1960s and the 1990s, while the number of geophysical disasters remained steady.

Table 1 for Annex I:
Climate Change Projections and Observations for Canada

	Projected	Observed to Date (2000)
Global Mean Temperature	1.4 to 5.8ºC (1990-2100)	0.6 plus or minus 0.2ºC (20th century)
Canadian Mean Temperature	2 to 4ºC (CGCM – 1975-95 To 2040-60)	**> 1ºC** **(20th century)**
Total Precipitation	(2040-2060) 0 to 20% more in north slightly less in mid continent in summer (HadCM3)	**1950-1998 ++ at high altitudes,** **+ at mid latitudes** **Southern Prairies little change**
Streamflow (or soil moisture) Mid-continent	-30% by 2050 2 x CO_2 (CGCM)	-10% Southern Prairies (1967-1996)
Date of Spring Breakup	Earlier	Earlier: 82% of basins (1967-1996)
Extreme Rainfall	2 x frequency of heavy rains for 2 x CO_2 (CGCM)	Up to 20% increase in heavy 1-day falls in US and SE Canada (early summer)
Water Vapour in Troposphere (lower atmosphere)	Increase	Statistically significant increase over N. America except NE Canada
Mean Sea Level Rise	40-50 cm (mean IPCC projections) 1990-2100	10-20 cm (1900-1999)
Arctic Sea Ice extent	-21 to -27% by 2050	-3% per decade since 1978 (year round ice extent)
Snow Cover Extent Dec, Jan, Feb.	-15% by 2050 N. America (CGCM)	-10% (1972-2000) Northern Hemisphere
Late Season Snow Pack in Rockies – Apr. 1	Less (more melt over winter)	30% less since 1976 Fraser River Basin
Glacier Retreat South of 60ºN e.g. Glacier National Park	None left (by 2030)	2/3 reduction in numbers (from 150 to 50) (1850–1990s)
Severe Winter Storms Frequency and intensity	15% to 20% increase $CO_{2\ \text{level doubled}}$ (CGCM)	(1959-1997) **N of 60ºN** **- Increased frequency and intensity** S of 60ºN - Increased intensity

Source: Data from Akinremi et al., 1999; Angel and Isard, 1998; Boer et al., 2000; Carnell and Senior, 1998; Gregory et al., 1997; IPCC, 2001; Karl et al., 1995; Lambert 1995; McCabe et al., 2001; Mekis and Hogg, 1999; Moore, 1996; Ross and Elliot, 1996; Sarnko et al., 2002; Stone et al., 2000; Zhang et al., 2000; Zwiers and Kharin, 1998.

Notes: Had CM3 = Hadley Centre (UK) Climate Model version 3
2 x CO_2 = doubled pre-industrial level of CO_2 equivalent (by latter half of twenty-first century)
CGCM = Canadian Global Climate Model (CCCma) (Environment Canada, University of Victoria)
++ = significantly more
+ = more

Table 2 for Annex I: RAINFALL TRENDS Summary of results (all positive over the region)		
	Observed trends 1970-2000	*Projected trends to 2050*
30 minute extremes	5% per decade (Adamowski) 4.5% per decade to 1996 (SWCS)	5% per decade
daily extremes	7% per decade (May, June, July) (Stone) 5% per decade (over year) to 1996 (SWCS)	3% per decade over the year (20 year return period) 2 ½ - 6% per decade (rainfall with probability <5%)
annual rainfall	1% to 3% per decade	1% per decade

Annex 2: Introducing Adaptation to Climate Change to Local Authorities

1. The municipal institutional context

Municipal and conservation authority staffs are accustomed to dealing with climate-related issues in the course of their planning and management activities. For example, they manage water supplies, design drainage systems and flood protection, design and implement heat and smog alert systems, and control mosquitoes and other disease vectors.

But dealing with climate change is new and may be unfamiliar. Because it is a relatively new subject, the implications of climate change are not well understood across departments in many municipalities. As yet, there are few staff appointments explicitly responsible for adapting to climate change. Most municipal strategic or long-range plans do not address adaptation to climate change and it can be difficult to get it on the municipal agenda.

In Ontario the provincial government has provided and a number of laws and policies which, although they may not reference climate change and adaptation directly, make strong provisions for dealing with risks to municipal infrastructure and the health, safety and environmental protection of their residents to create a strong and justifiable case for adaptation planning in a number of key areas. The same principles apply in general to the Conservation Authorities.

Similarly the "duty of care" incumbent upon municipalities could add weight to the argument that a municipality might be held liable for failing to consider the implications of climate change where such failure could increase the risk to its citizens.

Another prominent problem facing municipalities is that it is extremely difficult to attend to issues that do not have an immediate impact on municipal operations. Sometimes, in order to pursue a new initiative, such as a climate change risk management initiative, municipal staff have to establish that it should have a priority over or at least equal to an existing responsibility. This would require a strong business case and a business plan for approval by senior management. This in itself may create a work issue for staff.

2. Policy and operational responsibilities

In Ontario there is however a strong policy foundation to manage risks associated with climate change:

- The *Ontario Municipal Act (2001***)** assigns broad authority and accountability to municipalities in ten spheres of local jurisdiction, including four that are directly affected by and related to climate change:
  - Public utilities,
  - Culture, parks, recreation and heritage,
  - Structures, and
  - Economic development services.
- The *Provincial Policy Statement (2005)* provides the policy foundation for development that supports and integrates the principles of strong communities, a clean and healthy environment and economic growth. The statements quoted below provide a strong rationale for incorporating climate change adaptation strategies into long-term or strategic development plans related to them:
  - "A coordinated, integrated and comprehensive approach should be used when dealing with planning matters within municipalities…" (p. 7)
  - "Planning for sewage and water services shall…ensure that these systems are provided in a manner that 1) can be sustained by the water resources upon which such services rely; … and 3) protects human health and the natural environment." (p. 10)
  - "Long-term economic prosperity should be supported by … planning so that major facilities and sensitive land uses are appropriately designed…to prevent adverse effects…and to minimize risk to public health and safety." (p. 13)
  - "Planning authorities shall support … improved air quality through land use and development patterns which

promote compact urban form and the use of public transit; focus travel-intensive land uses on sites which are well served by public transit or design these to facilitate the establishment of public transit in the future; improve the mix of employment and housing uses to shorten commute journeys; …" (p.14)

- "Planning authorities shall protect, improve or restore the quality and quantity of water by minimizing potential negative impacts, including cross-jurisdictional impacts; … and ensuring storm water management practices that minimize storm water volumes and contaminant loads …:" (p. 16)
- "Development shall be directed away from areas of natural or human-made hazards where there is an unacceptable risk to public health or safety or of property damage." (p.22)

- The *Emergency Management Act (2003)* requires all Ontario municipalities to develop comprehensive, risk-based emergency management programs based on prevention, preparedness, response and recovery. Municipalities are required to establish their "enhanced"-level program which identifies specific areas that would have to include the vulnerabilities to climate change:
  - Development of a Hazard Analysis and Risk Assessment (HIRA) analysis of their municipality
  - Development of a prevention/mitigation strategy for identified high risks;
  - Publication of a recovery plan for identified high risks;
  - Development of a response strategy for identified hazards;
  - Implementation of guidelines for risk-based land use planning; and
  - Implementation of a detailed risk-based public education program

- Under the *Conservation Authorities Act*

None of these policies or operational requirements explicitly prescribe the authority to pursue adaptation to climate change, but they certainly demand consideration of climate change as it relates to these specific aspects of municipal administration. In fact, it would be difficult to satisfy these requirements without accounting for possible climatic changes. Adaptation, then, is emerging as a critical dimension of existing municipal functions.

Conservation Authorities are responsible for flood plain mapping, flood warning systems, source water protection, including reducing erosion and runoff from vulnerable lands.

In Canada, municipalities can be held liable in negligence for "operational" decisions, but not for "policy" decisions. Where a municipality has a duty of care to its citizens it might be held liable for failing to consider the implications of climate change. For example, in planning for sewage and water services so that the systems protect human health and the natural environment a municipality might be considered negligent if it failed to consider increasing rain intensities and frequency that could overwhelm sewage services creating unacceptable risks to human health and the environment. As more and more municipalities include the implications of climate change in their plans and operations, the precedent will be more firmly established.

3. Internal policies and administration

Municipalities conduct their business within a hierarchy of official plans and related plans (e.g. environmental strategic plan, growth management plan, etc.), all of which are referenced to each other. It is within this context that municipal functions are institutionalized and may arise when local emergencies escalate into regional emergencies sustained over time. Given the uncertainties related to climate change and its implications for municipalities, a one-time risk management initiative is nearly certain not to produce "successful adaptation to climate change". Over time, municipalities will need to stay abreast of new knowledge about the changing climate and account for it in their infrastructure developments, storm water management policies, public education activities and other relevant management activities. Thus, to be most successful, "climate change risk management" needs to be institutionalized into municipal decision-making, via inclusion in the official plan or related plans.

Like many organizations, municipalities are typically structured in functional departments which tend to spawn "silos" of activity. Silos can significantly hinder adaptation to climate change.

Climate change impacts across many areas, and successful adaptation requires a coordinated, multi-dimensional response that can not likely be implemented by a single department. Some municipalities have established the important role of "bridge-builder". Bridge-builders[3] build networks across departments and external organizations in order to draw together the stakeholders and expertise to tackle various issues. They are critically important people in efforts to initiate and sustain successful adaptation to climate change.

Governance conflicts may arise in two-tiered municipalities. Responsibilities may lie with the upper-tier government, but potential impacts may occur at the lower-tier level. Effective working relationships, shared objectives and a conscious effort to streamline governance and avoid duplicated efforts are necessary in order to avoid conflicts and inefficiencies. In the case of emergency management, additional issues In the case of emergency management, additional issues may arise when local emergencies escalate into regional emergencies.

4. The challenge of getting started

Ontario municipalities commonly share the following attributes that hinder efforts to initiate climate change risk management initiatives:

- Few or no surplus people or other resources for pursuing the climate change issue;
- Limited understanding of climate change across relevant departments; and
- Tendency to attend to crises during or immediately after a crisis event, but not between events.

Many municipal staff are fully occupied with existing responsibilities so it can be very difficult to attend to new issues. In order to pursue a new initiative, such as a climate change risk management initiative, they need to establish it as a priority over, and thereby displace an existing responsibility. To do so, staff would typically need to prepare and present a strong business case and business plan for approval by a senior management team. However, with little or no time to dedicate to preparing a business plan, doing so can be a challenge. It is a classic chicken and egg problem.

In general, there are relatively few staff in any given municipality that are well-versed on the climate change issue, so it can be difficult to mobilize and maintain support for an adaptation initiative. Workshop participants emphasized the importance of engaging and educating council, staff and the general public, and of demonstrating the links between adaptation and existing responsibilities.

A risk management process should generally be initiated (and subsequently delivered) through existing interdepartmental networks. Staff could look to external partners, such as their conservation authority partner or a local non-governmental organization, to help compile the information required for a winning business plan and establish the initiative as a legitimate priority. Staff might also refer to information from this Guide, especially from Annex I which summarizes observed and projected climate changes and risk issues for Ontario, as they prepare a business plan. The business plan should link risk issues to established corporate goals, community values, significant aspects identified in a municipality's Environmental Management System (if there is one) and any other plans or established priorities.

Environmental psychologists have observed a "crisis effect", which indicates that attention to a crisis is greatest during and immediately following a crisis event, but drops to very low levels between crisis events. The phenomenon, which seems common across society, creates windows of opportunity for advancing risk management objectives. For example, following the summer 2005 heavy rain events that afflicted several southern Ontario communities and caused an estimated $400 million in damages, the City of Hamilton city council appointed an expert panel to examine how to prevent or reduce damaging floods.

[3] Bridge-builders' role titles may vary across municipalities. Two municipal participants, a Director of environmental policy and a Manager, Sustainability Projects, self-identified as bridge-builders.

Annex 3: Risk communications and Perceptions

Introduction:

An individual or a work team that will be making decisions about risk should understand the risk in terms of the needs, issues, and concerns of the affected stakeholders. There will also be a requirement to communicate with a broad variety of individuals, organisations, informal groups, the news media and governments about risk. This Annex provides some insights into the difficulties of understanding perceptions about risk and some thoughts about how to effectively communicate about risks.

Risk Perception - How Different People Value Things Differently:

The value associated with something that may be lost or is at risk differs from one individual to another. It can also differ for the same individual, depending on his or her circumstances at the time. Consider individual responses to extremely hot weather. A worker in an air conditioned building, who travels to work from an air conditioned apartment complex in air conditioned public transit may not feel much stress or discomfort. On the other hand, an outside worker who lives in an uncooled apartment and drives to work in a car without air conditioning would find the heat very stressful. The two individuals perceive the value of air conditioning quite differently because of their differing needs and priorities at the time. The inside worker would find the risk of losing his air-conditioned environment much more disturbing than the outside worker

This sense of value may also vary a lot depending on the time or other transient factors. For example, the inside worker's valuation of his air-conditioned environment may be substantially lower in the cool early morning than in the heat of the afternoon. If the air conditioning is too cold, it may not be wanted at all. In fact over air conditioning may generate a negative value if the person gets sick from being too cool.

Now consider the risk of losing the air-conditioning completely. If the weather is very hot, the inside worker may find any risk of losing the air-conditioning unacceptable. If, on the other hand, the weather is very cool, he or she may be indifferent to losing the air-conditioning.

The acceptability of the risk depends on the value or utility placed on the item at risk (in the example above, air-conditioning), which depends on the needs of that individual, at that specific time.

Not all considerations of utility are time-sensitive. For example, if we value the environment, we probably always will value the environment. If we are concerned about a changing climate, we will probably always be concerned about the changing climate and how to adapt to it. The terms "needs", "issues", and "concerns" are often used to refer to those factors that affect our perceptions of risk.

Different people can value the same loss differently because the loss may affect their overall satisfaction, or their needs, issues, and concerns, differently.

The issue of perceived value has been often overlooked in dealing with risk situations when the risk is based on the simple equation:

Risk = Probability x Consequence

Many think that this equation is inadequate as a practical definition of risk when the perception or acceptability of risk is included and that a more appropriate expression of risk would be:

Risk = Probability x Consequence x Perception

Consider another example related to the perception or acceptability of risk of lowered water levels in a lake by two communities with different concerns and perceptions. One community derives much of its income and employment from commercial marine traffic in its harbour. Another community, also situated on the lakeshore, values the lake for its scenery and for light recreational use.

As a result of a changing climate, both communities are told that lake levels are likely to be between 1 and 1.5 metres lower by 2050. The first community will face disastrous employment and economic losses because the main shipping channel for which it is the main port will be too shallow for the heavy marine traffic that now uses it. An alternate channel with greater depth will still be navigable and

another port city would benefit from the shift in traffic.

The impact of lower water levels on the second community would be relatively minor and its shoreline is fairly steep and would still accommodate recreational boating and marinas.

How each community perceives the risk and what kinds of actions will be needed on the part of decision-makers will depend upon the value placed on the impact of the changed water levels. For the first community, huge amounts of resources will be needed to deepen the main shipping channel and the harbour facilities themselves. This in turn may be very threatening to the marine ecosystems in the area. For the second community, very little financial or environmental costs are anticipated.

Even though both communities face the same risk of lowered water levels the first sees this as a major challenge which threatens the viability and economic well-being of its residents. The second views it as a minor inconvenience. Even though the probability associated with lowered water levels is the same, and the consequence of the potential loss is very different.

The acceptability of the risk and how it can vary from one community to the next is not the same because the value placed on the potential loss can differ completely. This is because the needs, issues, and concerns differ widely. Decision-makers often overlook or ignore these differences in perceived value and, as a result, many decisions create controversy.

Risk Communications – How to Talk to People about Risks:

General: Risk communication goes beyond simple messages providing information. It is based on a dialogue that allows stakeholders to participate in the decision-making process.

Some reasons why providing information through simple public relations releases or one-way public education are not useful strategies include:

(a) They will not reduce the conflict that will probably develop concerning a risk and what to do about it,
(b) Because people do not have the same ability to understand and relate to a particular risk, these strategies do not ensure that decisions will be easily understood and supported by stakeholders, and
(c) Providing people with scientific information alone will not enable them or the decision-maker to resolve important risk issues.

Not to communicate with stakeholders or to delay communicating about risk is not effective an effective strategy and may be very costly in the long term. The reasons are that stakeholders resent risks that are imposed on them and risk decisions made without their input. Most people believe that they have a right to be involved in the decisions that affect them and that the decision-making process should be accessible. Involving stakeholders builds acceptance and can bring out constructive ideas. Effectively communicating about risks is important.

Effective Risk Communication: Effective risk communication is the responsibility of the decision maker, not the stakeholder. The most important benefits of an effective risk dialogue strategy are that it leads to shared understanding, shared goals and better decisions. It builds trust and encourages buy-in by reducing misperceptions and improving the understanding of the science and technical aspects of the risk.

On the other hand, ineffective risk communications may lead to some or all of the following:

- Irreplaceable loss of credibility,
- Unnecessary, costly and possibly bitter and protracted debates and conflicts with stakeholders,
- Difficult and expensive approval processes for projects,
- Diversion of management attention from important problems to less important problems,
- Non-supportive and critical co-workers and employees, and
- Unnecessary human suffering due to high levels of anxiety and fear.

Credibility: Credibility, being seen by stakeholders as trustworthy and competent, is a key goal. The characteristics of credibility include candour, commitment, competence, dedication, empathy, honesty, resolve, respect, and understanding. Credible messages must be based on known facts and with previous

statements. They should be framed in stakeholder terms, not self-serving language or jargon, and be consistent with the messages of others. Credibility is very difficult to establish, easy to lose and almost impossible to regain once lost. For this reason some specialised training in risk communications is recommended prior to initiating the risk management process.

Stakeholders: It can be extremely important to include even minor stakeholders in the process if these stakeholders believe that the outcome of the decision is important to them. These "minor" players may be much more influential than the risk management team anticipates. Even a small group of stakeholders may effectively mobilize public opinion and halt or delay an activity they feel presents an unacceptable risk.

> *For example, a local environmental group rallied to stop greenhouse gas collection project being built because they believed the facility could worsen the community's air pollution problem. Even though the risk was very small from a technical point of view the environmental group believed that it was still unacceptable. Because the company sponsoring the project failed to address these specific concerns and even though all the other key stakeholders supported the project, this small group effectively mobilized public opinion against it. The company, after spending a large amount of time, effort, and money, was forced to withdraw its permit request.*

It is important that stakeholders with the potential to stop a project be identified as early in the process as possible.

Regardless of whether stakeholders might actually be affected by an activity or decision, they must be included as legitimate stakeholders if they believe themselves to be affected. These stakeholders may be able to mobilize public opinion against a proposed project regardless of the scientific risk. They may also choose to leave the decision process if they receive enough credible information to understand that the activity really does not affect them.

> *For example, in the greenhouse gas collection project described above, if the company had analysed the environmental groups' concerns it would have found that their information was based on a number of misconceptions related to some technical and social aspects of the activity. Through a dialogue process, the concerns of the environmental group were addressed, and the misconceptions about the technical issues were corrected. As a result the group's concerns were alleviated and the project went ahead.*

This stresses the need for an effective communication process to facilitate this transfer of information between the decision-maker and other stakeholders.

It is important that the risk management team clearly decides what the stakeholders' needs, issues and concerns are before proceeding with a stakeholder dialogue. There are numerous examples of decision-makers addressing the wrong issue.

> *For example, again in the greenhouse gas collection project when the company carefully analysed the environmental groups' concerns they believed that the key issue for the group would be emissions from the project. However, through a careful dialogue with the group the company also found out that a secondary issue was related to transportation. The group thought that the new GHG collection facility, because it was the first the region, would result in a dramatic increase tourist traffic that would create a risk for their children. Once this and the emissions issues were addressed, the stakeholders were satisfied.*

Trust: Stakeholders often believe that the process of communicating with them about an issue is as important as the eventual resolution of the issue. It is through the dialogue process that the risk management team has the opportunity to gain stakeholders' trust. If the risk management team fails to communicate to the satisfaction of the stakeholders, trust in the process could be quickly lost.

Research in the area of stakeholder perception has shown that "trust" is a key determinant of stakeholders' acceptance of risk. That is, if stakeholders trust those who are charged with managing the risk, they are more accepting of higher levels of risk. Where this trust is absent,

stakeholders demand higher levels of safety, and may refuse to accept any risk at all.

The development of trust between stakeholder and decision-maker is only one of the benefits of an effective communication process. Stakeholders are often the source of information critical to the decision-process.

> *For example, during a prolonged extreme heat episode, a municipality issued instructions through the Chief of Police that people who were suffering heat stress effects should report to the local militia armouries for help. Very few people showed up even though there was a lot of evidence to suggest that many citizens were suffering.*

> *The Mayor had a new announcement put out through the city's Medical Officer of Health for people with heat stress to come to the local high school for help. Most responded positively to this announcement.*

The communication process is necessary so that information may be passed effectively from the risk management team to stakeholders. The same process is used to evaluate stakeholder acceptance of risk. Sometimes stakeholders just want to be involved in the decision process so that they can monitor the performance of the decision-maker and to see what is going on. Again, by involving stakeholders "who just want to watch" provides the decision-maker with the opportunity to build trust with these stakeholders.

Annex 4: Terms Used in this Guide

The following definitions apply to the terms used in this Guidebook. The definitions are drawn from the Canadian standard *"Risk Management: Guidelines for Decision-Makers"* (CAN/CSA-Q850-97) unless otherwise specified.

Adaptation – Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC, TAR, 2001)

Adaptation benefits – the avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures. (IPCC TAR, 2001)

Adaptation costs – costs of planning, preparing for, facilitating, and implementing adaptation measures, including transaction costs. (IPCC TAR, 2001)

Adaptive capacity – the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or cope with the consequences. (IPCC TAR, 2001)

Adverse effects – one or more of:

- Impairment of the quality of the natural environment for any use that can be made of it;
- Injury or damage to property or plant or animal life;
- Harm or material discomfort to any person;
- An adverse effect on the health of any person;
- Impairment of the safety of any person;
- Rendering any property or plant or animal life unfit for human use;
- Loss of enjoyment of normal use of property; and
- Interference with normal conduct of business.

(Environmental Protection Act)

Climate change – a change of climate that 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. (UNFCCC)

Climate scenario – projection of future climatic conditions

Climate variability – climate variability refers to fluctuations in climate over a shorter term - the departures from long-term averages or trends, over seasons or a few years, such as those caused by the El Niño Southern Oscillation phenomenon. (UNFCCC)

Consequences – Risk is often expressed as the product of the consequences flowing from an event and the frequency of the event. In this manual, we use the term "impacts" for consistency with the terminology of climate change.

Dialogue – a process for two-way communication that fosters shared understanding. It is supported by information.

Hazard – 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; or some combination of these.

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

IPCC – Intergovernmental Panel on Climate Change. A large (several thousand) group of qualified experts which reviews and assesses periodically, all climate change research published in many countries.

Impact – Something that logically or naturally follows from an action or condition related to climate change or climate variability.

Kyoto Protocol – an agreement (1997) under the UNFCCC by most countries of the world, by which most developed countries will begin to limit their greenhouse gas emissions by 2008 to 2012.

Loss – an injury or damage to health, property, the environment, or something else of value.

Organization – a company, corporation, firm, enterprise, or institution, or part thereof, whether incorporated or not, public or private, that has its own functions and administration.

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

Risk – 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 analysis – the systematic use of information to identify hazards and to estimate the chance for, and severity of, injury or loss to individuals or populations, property, the environment, or other things of value.

Risk assessment – the overall process of risk analysis and risk evaluation.

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

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

Risk control strategy – a program which may include the application of several risk control options.

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

Risk evaluation – 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 collection of all information developed through the risk management process. This includes information on the risks, decisions, stakeholder views, meetings and other information that may be of value.

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

Risk perception – the significance assigned to risks by stakeholders. This perception is derived from the stakeholders' expressed needs, issues, and concerns.

Risk scenario – a defined sequence of events with an associated frequency and consequences.

Stakeholder – any individual, group, or organisation able to affect, be affected by, or believe it might be affected by, a decision or activity. The decision-makers are also stakeholders.

Stakeholder analysis – Identification of individuals or groups who are likely to have an interest in the risk management issue including a consideration of what their needs issues and concerns would be and how the stakeholder should be included in the process.

TAR – Third Assessment Report of the IPCC

UNFCCC – United Nations Framework Convention on Climate Change (1992)

Vulnerability – the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is the function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC TAR, 2001)