Adapting to Climate Change

A Risk-based Guide for Alberta Municipalities

Robert A. Black
James P. Bruce
I.D. Mark Egener

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Foreword

Natural Resources Canada, the Institute for Catastrophic Loss Reduction, together with the Alberta government, supported the development of this Guide.

Governments in Canada are in various stages of developing and implementing adaptation strategies. This Guide is one of a range of tools that will be required for successful, timely and economic adaptation.

It is an important tool to assist municipalities, local governments, communities and other organizations to understand, reduce their vulnerabilities and manage risks associated with the adverse impacts of our changing and more variable 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 over the past 35 to 40 years are in part responsible 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 effects. Extreme events and rising temperatures are becoming more damaging as recent severe rainfalls, thawing permafrost and melting sea ice have demonstrated.

Efforts to manage and adapt to climate-related risks are not keeping pace with the challenges. It is virtually certain that the climate will continue to warm and become increasingly variable over the coming decades. We are becoming more vulnerable to the impacts of climate variability and change because of increasing urbanisation, a growing and aging population and deteriorating public infrastructure. These changes put more people, property and ecosystems at risk.

Regional and community governments have primary responsibility for or can significantly influence many of the factors that determine Canadians' vulnerabilities to climate-related risks and many of the decisions that help to manage these risks.

The provinces' and territories municipal legislation, environmental laws and emergency management arrangements among other legislation or policy[1], all require in one way or another that municipalities take action to prevent, mitigate or respond to threats to human health and safety, public property and the environment

Local government officials increasingly understand projected climate impacts and are beginning to implement adaptive strategies. Unfortunately, there are few tools available to help them.

[1] a companion document will be produced that provides an overview of the key acts and regulations that form the legislative framework for these responsibilities.

1.1. About the Guide

This Guide will assist regional and local government planners, health officials, emergency managers, infrastructure managers and others understand the risks of potential climate impacts and the priorities and means of managing them. The guide should also be useful for other organizations such as local industry and businesses to help understand how to anticipate and deal with a changing climate.

The Guide describes a risk-based approach that communities can use to adapt to climate change through long-term planning and short-term responses. It can be used in three main ways:

- As a reference manual to incorporate risk management into planning and management activities related to climate adaptation,
- Providing examples that illustrate techniques for managing climate-related risks and promoting adaptation efforts, and
- As a training tool for regional and local government staff.

The Guide explains how the risk management process can be a simple, quick and logical process to determine the best solutions to climate adaptation. This Guide suggests a straight-forward and simple approach will get communities started thinking and acting about adapting to climate. A time-consuming, expensive or complicated analysis process is not needed to reach decisions about climate adaptation.

Chapter 2 and Annex 1 provide insights into what could be expected in climate futures. It offers some suggestions to help officials incorporate a risk-based approach into planning.

Chapter 3 explains the risk management process that is based on the Canadian National Standard, *"Risk Management: Guidelines for Decision-makers"* (CAN/CSA-Q850-01). A standard provides the benefits of having a nationally accepted process and terms and is a credible starting point for the process.

Chapter 4 explains each step in the risk management process 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 explaining in detail how the step is used is included in Annex 2; and
- A checklist to help ensure that the main tasks for this step have been undertaken.

The example is based on observed and projected impacts of climate change and evidence to date of adaptation efforts.[2] It is also based on the actual experiences of municipal and other users in previous versions of the guide.

1.2 Reducing vulnerability to climate change

Climate change literature refers to "adaptation", "adaptive capacity" and "vulnerability" and for the purposes of this guide:

- **Adaptation to climate change** means making adjustments in natural or human systems to moderate harm or exploit benefits arising out of actual or expected climatic changes
- **Adaptive capacity** is the ability of a system, region or community to adapt.
- **Vulnerability** means how susceptible social, economic and environmental systems are to the adverse effects of climate change or climate variability.

Adaptation to climate change aims to reduce vulnerability to the adverse effects and to enhance adaptive capacity.

1.3 Why risk management?

Risk management is a framework that can be easily used to identify and understand the impacts and vulnerabilities of climate change and also for estimating and ranking risks. The process helps us select the best actions to reduce risks to acceptable levels even when there are uncertainties about future climate.

The impacts of a changing and more variable climate involve almost every aspect of society and create risks to the social, economic, cultural and environmental fabric of our communities. Making decisions about how to avoid these risks or to reduce them to an acceptable level can involve many different decision-makers and other players, some with conflicting values and competing interests.

The process outlined in this Guide is a simple way of getting started, engaging the people who are affected and identifying other key people who should be involved. It will also clarify the important issues that will have to be considered and how to decide what are the best adaptation options.

For every climate impact there is a range of possible responses in time, complexity, cost and responsibility area. For example to deal with increasingly frequent and severe extreme weather events short term responses might range from better warnings, increased maintenance of water management infrastructure, reduction of storage levels in reservoirs. Longer-term responses might include upgrading water management systems and better communications equipment. Multi-jurisdictional responses could involve the re-routing major transportation arteries and changes to building codes among others. The risk management process will help identify the best solutions and a range of possible responses.

Most local governments tend to be focussed on current issues. Adapting to an uncertain future climate may not be seen to be a high priority. In this environment, spending time and effort to identify the best adaptation responses may be a real challenge for an already overburdened staff. Decision-makers may delay or defer important actions. However, climate change impacts are increasingly evident making early adaptation important, even urgent.

In some communities the adaptation problem may be addressed as a strategic issue similar to the way that some have done for their approach to the environment. Others will deal with climate change problems as single issues addressing things such as smog, heat waves, wastewater or emergency management concerns. Whatever

[2] e.g. Chapters 7 and 8 of *"From Impacts to Adaptation: Canada in a Changing Climate 2007"*, NRCan, 2008 See http://adaptation2007.nrcan.gc.ca

the scope, the process described in this Guide will help municipal staff to identify the issues and produce well thought-out recommendations.

In summary, risk management offers a simple, practicable and highly credible approach for identifying and ranking risk issues and selecting the best risk-reduction strategies. The process can be used to make a rapid assessment of a risk issue to outline the possible scope and its complexity. This is the approach recommended in this Guide. However, the process can also cater to a larger fully comprehensive assessment that could involve a large number of representatives from many agencies over a longer period of time. Whatever the scope, the assessment will provide a persuasive business case for adaptation action to submit to decision-makers.

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2. Climate Change Adaptation Decision-making in Alberta 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, even if fully implemented, would only slightly slow the rate of change. Most assessments of future climate change impacts have been based on greenhouse gas emissions, and atmospheric concentration scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) and published in 2000. The International Energy Agency, in a 2007 report, indicated that greenhouse gas emissions to 2030 will increase more rapidly than the fastest of the IPCC scenarios. At the same time, the rate of increase of global atmospheric concentrations of CO2 have risen since 2000 to 1.9 or 2 parts per million per year compared to earlier (since 1970) increases of 1.6 ppm/yr. Thus, climate change impacts are likely to proceed at a more rapid pace than hitherto expected and generally reported upon. For example, Arctic sea ice and Greenland ice cap melting have recently occurred more rapidly than in earlier projections. 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 Alberta

Over the last 35 years, Alberta's climate has changed in a number of ways. . It is a certainty that what will be happening elsewhere in the future will be magnified in our high latitudes and the impacts (and possibly the benefits) will be much more. A good understanding of the likely changes to the climate is necessary if we are going to make sensible and prudent short and long-term adaptation decisions.

The climate changes that have been observed since 1950 and projections of future climate to 2050 are included in this Guide at Annex 1. This Annex summarizes a very large literature on the subject and a reference list is given for those who wish to pursue this further. For users of the Guide, the summary in Annex 1 should be sufficient to provide a workable projection of future conditions.

2.2 The municipal planning context

Municipalities 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. The implications of climate change are not well understood across departments in many municipalities and as yet, there are few staff appointments explicitly responsible for adapting to climate change. Most municipal strategic or long-range plans do not address climate change. It can be difficult to get this issue on the municipal agenda.

In Canada, the provincial and territorial governments have a number of laws and policies[3] 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.

Another major problem facing municipalities is that, because of pressure on 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 climate change, they 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. For example, this guide suggests that a simple preliminary application of the process will produce enough evidence of the need to take adaptive action to form the backbone of a business case to decision-makers for a more thorough study or perhaps to undertake initial implementation activities.

Whether the project is a large one, such as writing a strategic adaptation plan or a smaller, more focussed one on particular adaptation issues or hazards, it is important that the project has the support of council and senior managers so that it has adequate resources to carry it through.

[3] As noted above a companion document will be produced that provides an overview of the key acts and regulations that form the legislative framework for these responsibilities.

Overview of the Risk Management Approach

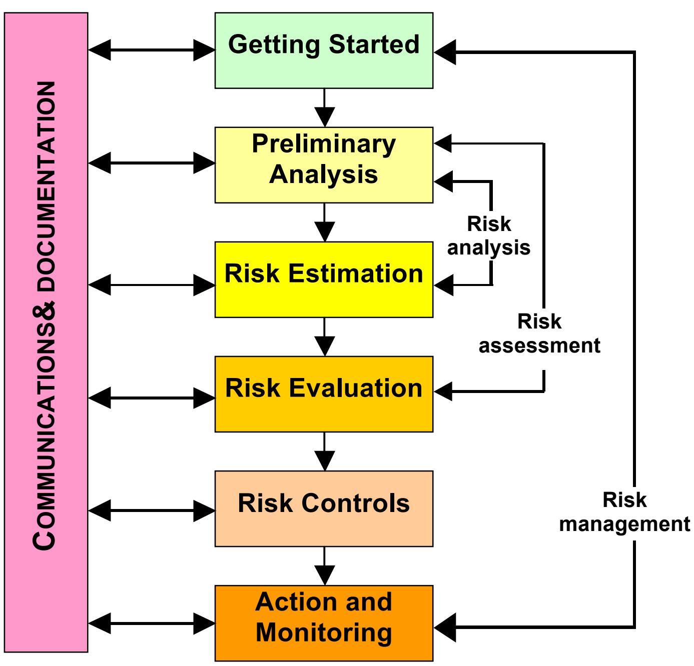
3.1 The risk management process

Risk management is a systematic process for selecting the best course of action in uncertain situations. It does this by identifying, understanding, analysing and communicating risk issues.

In adapting to climate change, risk management gives us a framework for developing strategies to respond to potential climate changes that create or increase risk. As mentioned above, whether it is as a study around a specific issue such as extreme rainfall events or as large as a community strategic plan for climate adaptation the risk management process will guide us towards the best solution.

The framework in this Guide is based on the Canadian national 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 below.

Figure 1: Steps in the risk management process



The key activities in the process of identifying, estimating, evaluating and ranking risks and selecting options to lower risks to acceptable levels include:

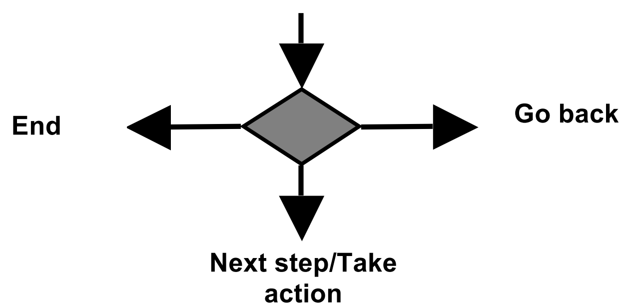
- Estimating the probability and potential consequences of events arising from situations or hazards;
- Identifying actions that can be taken to avoid negative consequences or lessen their impact, or to exploit potential benefits; and
- Understanding stakeholders' perceptions of probabilities and consequences.

A very important part of the process is a continuous dialogue with all those involved and affected by the issue.

In practice, information about a risk situation can be interpreted differently by various groups of people, resulting in quite different perceptions of risk[4]. For example parents may be more concerned about water quality for their children than consultants designing water delivery systems. For this reason the risk management process emphasizes the need to understand how events might affect or be perceived by different groups.

Each step leads logically to the next, unless the risk issue is resolved, in which case the process is ended. Steps can be repeated to include new information or new analyses, as these become available. At the completion of each step there is a decision to be made as shown in the "Decision Diamond" in Figure 2.

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



The process is should be repeated as new information becomes available or new risk controls become known.

Throughout the whole process it is important to have a continuous dialogue with stakeholders and to keep careful records of all actions taken.

[4] See Annex 3 for a fuller explanation of risk perception.

- **Communications** with all people and groups that are or might be affected by the issue, even marginal ones, ensures that their concerns are considered. This helps to build support for the results.
- **Good record keeping** of all the major activities in the process helps to ensure accountability and consistency. It provides a record for future reference. This is especially important so that the decision process can be revisited if new information becomes available.

For relatively simple risk issues, a short version of the process can be completed quite quickly, usually in one or two days. A small team consisting of two or three people with moderate resources can undertake it. More complex risk problems may require a larger team and take more time.

This Guide suggests using a short version of the risk management process as a useful technique for getting started. It focuses on using readily available data and a small risk management or project team. This will help the team explore the issues and possible outcomes rapidly and inexpensively. The results, supported by good documentation can be used to make a strong business case for taking action. The documentation from the overview process can also support a more comprehensive risk management study if one is needed.

3.2 Guiding principles

The risk management process is built upon several important principles:

- **Engaging important affected or involved groups**
  These groups and individuals should be identified and involved during the entire process. The project team may be modified to include member of these groups throughout the process if it will help deal with the particular issue being addressed.

- **Communication**
  The project team should develop an open and trustful dialogue that continues throughout the decision-making process, with groups and individuals who may be affected of involved with the risk in order to:
  - Acquire useful information;
  - Build awareness of the particular risk and gain support for the process;
  - Facilitate consultation;
  - Evaluate how the people involved or affected accept risks; and
  - Serve as a part of the monitoring and review mechanism.

- **Documentation**
  Records should be thoroughly and carefully taken of important meetings, information sources, and all activities 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 project team should make maximum use of existing resources, such as community data, local knowledge and technical expertise, and previously documented experiences.

- **Public Education and Awareness**
  Public education and awareness is important for successfully implementing a larger risk management process. It helps to ensure stakeholder support for its results.

4. Steps in the Risk Management Process

Introduction

This section describes each step in the risk management process, explaining its purpose the actions to be taken and the expected outputs. A checklist is also provided. The example at Annex 2 is a simple illustration of what is done in each step.

As explained earlier in this Guide, there may be reluctance to commit busy staff to a risk management process that is often believed to be lengthy, difficult and costly. However, faced with increasing evidence and the risk of warming trends, extremely heavy rains and floods, and other climate related events most senior managers are now convinced that they need to include these risks in their planning.

The initial process recommended in this guide is an overview or simplified examination of the risk or risks that face the community using a small project team and readily available information. This will help define the issues and provide some readily useable results. The outcome may also support the need to do a more comprehensive analysis with which this guide can also assist.

It might be helpful to the reader to know that the example at Annex 2 and referenced at each step described below, was actually developed by community representatives in a one-day workshop during the testing of this Guide. It may also be helpful to know that all the forms and tables suggested in this Chapter 4 are available for photocopying in the **Workbook, Annex 5**, page 47.

STEP 1: Getting Started

Purpose

This step starts the process and completes the following preparatory activities;

- Identification of the specific problem or hazard and the associated risks to people, property or the environment.
- Identification of the members of the project team and principal people or groups that may be affected or involved;
- Determination of the responsibilities of members of the project team and the resources needed to complete the study; and
- Development of a draft of the workplan and the schedule for a larger project..

The team leader is usually a community planner or a member of the lead department involved. It is important to have the support of a senior manager or if it is a large study, the community council.

The time required by the team to complete the process depends on the scope of the study, i.e. a study of a specific climate impact or a larger strategic study of all impacts. However, as suggested in the previous section, it is recommended that a relatively simple overview of the problem using readily available data, as explained in Steps 2 and 3, would be very useful in developing a better understanding of the issues and scope of the problem. To do this, the team would require only a day or several days to complete a preliminary overview.

Out of this quick preliminary run through of the risk management process the team could expect to:

- Have a better understanding of how simple or complex the issue is,
- Obtain a sense for what the main risk control measures could be, and
- Determine whether the preliminary study is sufficient or a larger more comprehensive study is needed,
- Readily estimate the resources and time needed, if it is thought that a larger follow-on study is needed. Also, who should be members of the project team, who are the important stakeholders and whether the available data is adequate to support a larger study.

What to do and how to do it?

(1) Establish the project team and its terms of reference, and for a larger study, 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 main organizations that will be responsible for implementing the risk controls. For a larger study, some support or clerical staff may be needed to handle the administrative and documentation matters. Others, such as legal, technical or financial advisors may be involved at times or review or advise on certain aspects of the work.
- For a larger study, 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 members of the team know their roles and responsibilities with respect to the project and are familiar with the risk management process.

(2) Ensure that the team is clear about the risk issue to be investigated and any restrictions on the scope of the study.

(3) For a larger study, estimate 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 if needed.

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

(5) Do a preliminary analysis to identify the principal people or groups that may be affected or involved and begin an estimate which would:

- Identify any individuals or groups that can affect or may be affected by decisions or actions resulting from the risk management process. This group could be quite large.
- Consider their probable interests, concerns, rights and likely issues. Begin to think about how members might perceive various risk issues and how this might affect the decision process and communications with them.
- Recognize that this group may evolve throughout the process.

(6) For a larger project develop a risk communication plan and initiate a dialogue with principal people or groups that may be affected or involved:

- 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 this group such as a panel?
- Annex 3 provides additional information to help with risk communications.

(7) Start the record keeping and for a larger project, a risk information library:

- The records or risk information library should contain copies of all the information collected throughout the project, including information on the risks, data that are used to analyse the risks, a record of decisions taken, views of the people or groups that may be affected or involved, records of meetings and any other information that may be obtained during the risk management process.
- These careful records will provide the means to trace the logic behind any decisions made. Also it will make it easy for the project 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.
- Principal people or groups that may be affected or involved have been identified and preliminary analysis of their needs, concerns and probable issues completed.
- Communications or dialogue with groups that may be affected has been considered.

- Collection of records and documentation begun.

Decision

There are three decision options (see the decision diamond in Figure 2 on page 6: End, Go back or Next step/Take action.

- **End** the process if the hazard(s) and risk(s) are considered by the project team to be acceptable.
- If the risk situation continues to be a concern, proceed to the **Next Step, Step 2 Preliminary Analysis**.

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 principal people or groups that may be affected or involved and begun to define their probable issues, needs and concerns?
	5. Developed a plan for communicating with stakeholders?
	6. Started a risk information library?

See Step 1 of example in Annex 2 (page 31)

STEP 2: Preliminary Analysis

Purpose

This step is the beginning of the risk assessment part of the process where the sequence of events or scenario and vulnerabilities are carefully laid out for more detailed examination. The project team now starts:

- To define the climate-related hazard and the potential risks that may cause harm, in terms of loss of life, injury, damage to property, monetary losses to the community or impacts on the environment.
- To consider what the time scales are around the possible outcomes from the risk situation.
- To determine in a very general sense how complex the process is likely to be, confirm the probable time-frame for completing the work and a get a sense for whether the project team and resources assigned are sufficient.

What to do and how to do it?

(1) Develop risk scenarios or sequences of events that could result from the hazards and vulnerabilities identified in Step 1.
  - Outline the sequence of events that could flow from each climate-related hazard that could cause adverse effects.
  - Expand each risk scenarios to show the types of losses or impacts that could occur. Losses or impacts could include:
    - Injuries or deaths,
    - Health losses due to illness,
    - Property losses,
    - Other economic losses and
    - Environmental or ecosystem losses or impairment.
  - The risk scenarios will form the basis for more detailed risk estimations and evaluations in Steps 3 and 4.
  - A simple table, such as Table 2 below, may provide an easy way to develop and record this information.

Table 2: Preliminary Hazard and Risk Scenario Assessment

HAZARD: .

RISK	VULNERABILITY	FREQUENCY			CONSEQUENCE			COMMENT or POSSIBLE CONTROL
		1	2	3	1	2	3	
Add as many rows as needed								

Notes: Make rough estimates of (these will be expanded in Step 3)

Frequency:
1. Unlikely to occur
2. Moderately frequent occurrence
3. Almost certain to occur

Consequences:
1. Low
2. Moderate
3. High

(2) Collect data and identify the risk baselines. The first time through the process use whatever data, community opinions anecdotal information and other sources that are readily available:

- Review the existing information on current vulnerability and climate-related risks, based on previous studies and experiences and expert opinion. For example for a flood hazard what information can be taken from the most recent flood experience in your community or others in the region?
- Identify and describe the risk controls currently in place to manage the specific climate-related hazard being considered. Describe their effectiveness and any gaps. Examples of risk controls for a flood situation would be a warning system and evacuation plan, stockpiled sandbags and so on.
- Develop a risk baseline that summarizes the current level of risk using recent historical data and current climate variability, such as recent flood levels, injuries and losses from the last floods, any improvements that were made to protection systems.
- 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) Make initial rough estimates of frequency and severity of the events in the risk scenarios. Useful information may be found in historical records, climate change projections (such as those in Annex 1) and by consulting subject matter experts, other communities and other sources to help develop these initial estimates.

(4) Continue the analysis of those people or groups that could be affected by the risk scenarios:

- Now that there is more information on the potential risks, identify any additional stakeholders that should be involved.
- Refine the analysis of their needs, interests and concerns.
- Consider engaging key people of representatives of groups that may be affected by the risks in the management process, if you have not done so already.
- Create a database of these people or groups that includes their contact information and the results of your stakeholder analysis. Update the database throughout the process.

(5) If your project team thinks that you may need a risk communication plan start to outline what this would consist of and begin to implement a dialogue with key people and groups.

(6) Update the risk information library:

- Organize all the information collected in this step and keep it in a safe, dedicated space. This is where all the information, assumptions, concerns, decisions and changes made throughout the process are kept.
- 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 meetings with them or other records of stakeholder communications;
  - A record of all decisions and assumptions
- Record the source of the information and the date it was collected, and any weaknesses or inaccuracies in the data

Expected results and outputs

- Risk scenarios are developed and a preliminary analysis is completed for each, event showing initial estimates of potential losses and frequency.
- Baseline information has been collected, or plans are in place to collect additional baseline information.
- Additional analysis of people or groups who might be affected by the risks has been completed.
- An outline of a communications plan for these people or groups has been developed if it is needed.
- The risk information library is started.
- Important reference material is documented and stored.

Decision

There are three decision options (see the decision diamond in Figure 2 on page 6): End, Go back or Next step/Take action.

- **End** the process if the hazard(s) and risk(s) are considered by stakeholders and the project team to be acceptable.
- **Go back** to Step 1 or the beginning of Step 2 if the project 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.**

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?

See Step 2 of example in Annex 2 (page 32)

STEP 3: Risk Estimation

Purpose

This step is where further consideration is given to the probability or frequency and consequences of the events in the risk scenarios in initial estimates that were developed in Step 2

What to do and how to do it?

(1) Consider what methods your team should use for estimating frequency and severity. Some options are:

- Historical records, including community records and newspapers, to determine trends of climate events and impacts,
- Technical data and projections from Annex 1, IPCC reports (on line), NRCan publications (also on line) or from provincial, territorial, or other federal government sources, and
- Expert or knowledgeable opinions.

(2) Estimate the frequency or likelihood of possible outcomes**

- For the simple analysis suggested in this guide, an easy 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, events should be estimated to a future date that stakeholders can relate to, for example 10 or 20 years into the future, or for major projects, 40 or 50 years out.
- For familiar hazard and events such as floods, fires or diseases, estimates can typically be derived from readily available historical data such as, in research reports, insurance company records or from similar risk situations in other communities, regions or countries.
- If the team has the technical experience, the use of 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.

(3) Estimate the consequences of possible outcomes**

- 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.
- 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.

(4) Assess the perceptions of risk by those people or groups who might be affected. As explained in more detail in Annex 2, these perceptions of the importance, particularly of the consequences of risks, 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 consider the expected consequences under several sub-categories, for example, social, economic and environmental aspects. This may make comparing the losses or consequences easier 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 the project team should give some consideration to what factors are important to them.

** It may be useful to repeat these estimates 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 / Event	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Events from 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			
	Health & Safety	Displace-ment	Loss of Livelihood	Cultural Aspects	Property Damage	Financial Impact	Impact on communit y	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 think that it implies more accuracy than actually exists. The project 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 the key people or groups that might be affected or concerned and refine the stakeholder analysis

- If the project team considered it important in Step 2 to engage them in a meaningful dialogue this should begin to be implemented now. Discussions should be held about the risk estimates and their issues and concerns. In a simple study this may be through conversations with a few representatives of the most important stakeholders. For larger studies, the project team might consider using focus groups, workshops or public meetings.

- Communicate information openly and in language and detail that these people of groups can understand. Provide information on the risk baseline (that is 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 people may not agree with the frequency or consequence estimates. Record their 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.
- Consider using a chart such as the one shown in Table 3.3 below to list the stakeholders and their attitudes about various risks.

TABLE 3.3 Suggested display for stakeholders and risk perception.

Climate Factors: (Hazards)	Risk Scenarios - Aspects of Hazards and Risks to Community	Stakeholders and perception of Risk

(7) Update the risk information library with all data from this step. Carefully document all sources used.

Expected results and outputs

- Estimates of frequency and consequences of risk scenarios.
- Presentation of frequency and consequence estimates 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 important stakeholders are comfortable with the level of uncertainty associated with the analysis.
- Proceed to the **next step** if the project team is 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 event in the 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?

See Step 3 of example in Annex 2 (page 33)

STEP 4: Risk Evaluation

Purpose

In this step, the project team develops a process for comparing or ranking each risk scenario. They do this by:

- Evaluating the risks in terms of costs, benefits and acceptability, considering the needs, issues and concerns of the principal people or groups that may be affected or involved.
- Identifying unacceptable risks and ranking them for risk reduction or control measures.

What to do and how to do it?

To this point in the process, only the hazards, events and risks have been analyzed. Now the risks will be compared in terms of the values that were used in Step 3. Other factors may also be brought into consideration such as the costs and benefits of that might accrue, such as changing authorized land uses or the location of recreation facilities.

(1) Compare the risks considering the probability and consequence analyses from the previous step that assessed the important social, economic and environmental consequences. It is suggested that the team use a simple and convenient consequence 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. The chart below in Figure 3 is an example for such a display. Combine the frequency and consequence ratings for each risk as determined in Step 3 into a single value to be entered into the matrix. Establish acceptability values against which the various risks can be compared. This chart uses qualitative measures such as "very low", "low", "moderate", "major" and "extreme". Other comparators such as numerical values may be used so long as they do not imply an unrealistic accuracy.
- Because experts and non-experts generally view risks differently, it is important to maintain an open and interactive dialogue with the principal people or groups that may be affected or involved in order to accurately gauge their level of acceptance of risks.

(2) It is helpful at this stage to also consider the costs and benefits of each risk scenario including not only the direct costs and benefits but also the important indirect ones. For example, shorter freezing cycles may create problems for winter recreational facilities but it may also bring benefits such as less snow removal costs.

> The indirect costs and benefits can be extensive, so it is important that the project team can access the expertise to assess them. An example would be the impact of reduced use of a wastewater treatment facility because of expected higher water levels. To build a new facility would be very costly. In the short term the community might have to forgo other developments. In the longer term, better facilities might strengthen the community's treatment capacity and allow more residents and businesses without additional infrastructure costs. . Any of these outcomes has associated economic and social costs and benefits that could affect the consequence ranking.

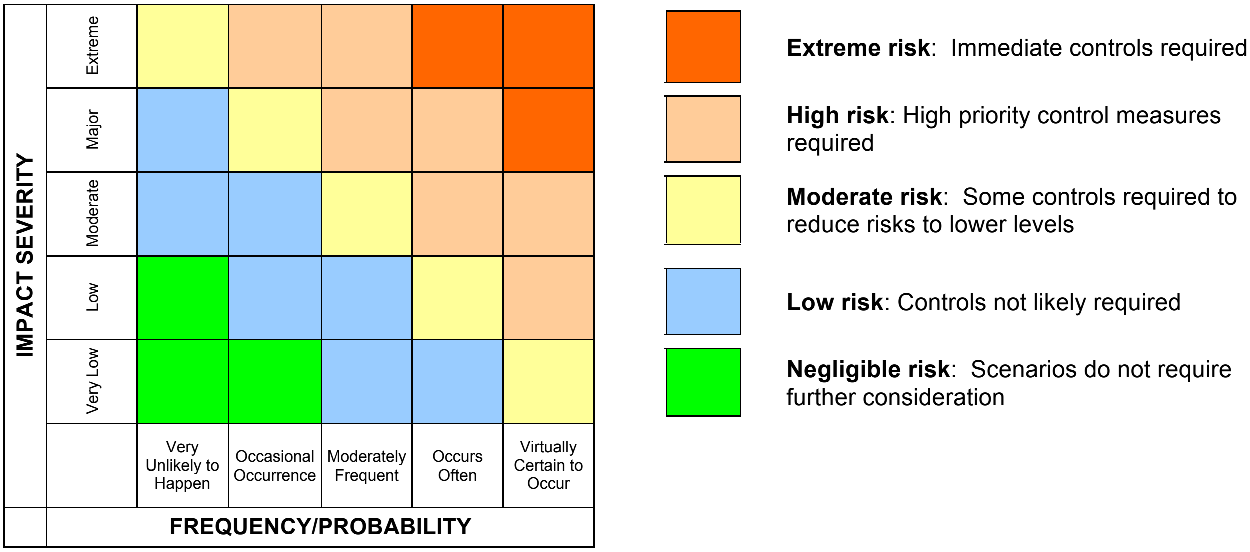
(3) Analyze the perceptions of each risk by key stakeholders.

(4) Assess how the principal people or groups that may be affected or involved view the acceptability of risks in your risk matrix.

(5) During the dialogue with stakeholders about their perceptions and the acceptability of the risks, begin to identify 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

Figure 3: Risk Evaluation Matrix



Expected results and outputs

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

Decision

- **End** the process if:
  - Stakeholders agree that all the risks are acceptable; or
  - The risks are completely unacceptable, cannot be reasonably dealt with, and all stakeholders agree that the process should be ended.
- **Go back** if:
  - There is insufficient data or information to make a decision;
  - The principal people or groups that may be affected or involved were not adequately consulted; or 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?

See Step 4 of example in Annex 2 (page 36)

STEP 5: Risk Controls and Adaptation Decisions

Purpose

In the previous step, the risks were evaluated and ranked, and a dialogue was held with the principal people or groups that may be affected or involved 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 adaptation measures or risk control strategies will be identified for reducing unacceptable risks to acceptable levels.
- The effectiveness of the adaptation measures 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 all potential adaptation actions that could reduce the frequency or the consequences of the risks.
  - Typically, an adaptation or risk reduction strategy will consist of a portfolio of measures, for example some short-term actions to deal with immediate concerns and some more comprehensive longer-term actions. 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 the professional judgement or the project team.
  - Identify and assess residual risks caused by the control option.
  - Communicate with the principal people or groups that may be affected or involved 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:
    - Its effectiveness in reducing losses or impacts or changing probabilities.
    - The implementation and maintenance costs.
    - The needs, issues and concerns of affected stakeholders.
    - A suggested table for displaying this information is shown on page 52.

(3) For a larger study it may be desirable to develop an implementation plan for the adaptation or risk control measures.

(4) Develop a risk communications plan related to residual risks
  - Sometimes it may be possible to encourage private adaptations to further reduce residual risks. For example, communities can encourage residents to keep valuables out of lower levels that may flood during a heavy precipitation event. The community can influence the amount of losses from extreme weather events.

(5) Update the risk information library

Expected results and outputs

- Feasible risk control options are identified
- An adaptation plan is completed based on priority risks/hazards identified in earlier steps.
- The implementation of adaptation measures has been considered
- The principal people or groups that may be affected or involved have accepted risks and residual risks.
- 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?
	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?

See Step 5 of example in Annex 2 (page 39)

<u>STEP 6</u>: Implementation and Monitoring

The implementation and monitoring component should be considered even in the preliminary overview that is the primary focus of this Guide. It would be done only in cursory form until the risk management study has been reviewed and approved by the senior administrator or by the municipal council.

Some of what is discussed below would be required only in a larger study or if the study is approved to move ahead to a more detailed planning stage.

Purpose

- To develop and implement the adaptation plan.
- To ensure that the implementation plan will be monitored for 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 outline of how the adaptation plan will be implemented.
  - Consider priorities for action for each adaptation measure and develop an outline implementation plan.
  - Link the implementation plan to other community programs, where appropriate. For example, there may be a program to strengthen existing initiatives to protect public health in water quality episodes. Your risk control or adaptation measures for flood risks 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, defer implementation of some components until a future date.
  - Establish a date to review the adaptation plan 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 communities, and compare your results to theirs.
  - Look for opportunities to collaborate with other communities or organizations. Unfortunately, climate change impacts will not be related to political boundaries, but adaptation responses could be.

Collaborate where possible to improve the effectiveness of adaptation responses.

- As part of the implementation plan identify special expertise or external assistance that may be required.

(2) Develop and establish the monitoring process

- Monitor the adaptation measures or risk controls by measuring environmental or performance indicators, stakeholder reactions, costs and benefits, or other indicators. Some may have been suggested during Steps 2, 3 or 4, or during the various stakeholder communications.
- The project team could suggest that a monitoring and review team be established to continue this function for as long as needed.

(3) Submit the implementation plan for approval.

(4) Continue to communicate with the principal people or groups that may be affected or involved.

- At this stage, communications might include ongoing public education and outreach or information sharing with other communities 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.
- Record all communications in the risk information library.

(5) Review and repeat 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

- Outline implementation plans that include:
  - An overview of costs and milestones.
  - A list of experts and expertise that was revealed during the risk management process that can contribute to the adaptation response and risk controls.
  - A database of ongoing activities that could facilitate the implementation of the plans.
  - Consideration of information exchange across sectors and between other communities.
  - Mechanisms for training and capacity building in the risk management process and on climate change impacts.
  - Considerations for reporting on progress and evaluating results.
  - An evaluation and monitoring process plan.
- 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 outline implementation plan?
	2. Identified links with ongoing activities in the community and beyond (e.g. national, regional or local initiatives)?
	3. Identified resources to implement the plan?
	4. Established an effective monitoring and review program?
	5. Submitted the implementation plan for approval?
	6. Developed a communication strategy to support implementation?
	7. Ensured that the risk information library is updated?

See Step 6 of example in Annex 2 (page 40)

All the forms and tables suggested in this Chapter 4 are available for photocopying and uses in the **Workbook: Annex 5** at page 47.

5. Summary and Conclusions

This Guide is intended to be a tool to help community and local governments and other organizations make sensible and practicable decisions to adapt to a changing and more variable climate.

It uses a process that is based on a national risk management standard that is accepted by senior managers, scientists and the financial community across Canada. The guide is written to emphasize the simplicity and practicality of the process. It also recognizes that larger studies of climate risks and adaptation responses may be desired or necessary and the process is equally applicable to these situations.

It is not easy to get started; municipal governments have many pressing issues that demand attention and their staff are torn between conflicting priorities. In spite of mounting evidence that gives credibility to climate change and increasing variability some communities have not fully accepted the need to start now to examine their situations and what the future may hold.

Another important aspect is that the costs of climate change are already becoming apparent in every aspect of community life; damages from sever weather events, additional construction costs for unstable soils and so on. The sooner that adaptation measures can be implemented the sooner that measures can be developed to control costs related to climate change.

This Guide suggests that some preliminary analyses could be undertaken at little cost that would provide a convincing case for adaptation action. Officials of local governments could use these analyses to promote a higher priority for, and early consideration of, climate risk.

Even though it is evident that climate change is already occurring there is still time to take effective adaptation actions. Climate change predictions indicate that there are major challenges and opportunities facing our communities. The Guide includes a summary of the most important current documentation and a list of references if further research or information is desired.

The risk management process outlined here provides a simple and very credible technique for assessing the most important actions that will be needed to address the changing climate risks. It is not only methodical and easy to use but it also emphasizes the importance of communicating with those affected by these risks and gauging acceptability of proposed adaptation measures.

The process does not end with the first iteration. It requires that the adaptation or risk control measures be monitored and periodically validated. It also requires that new information and new technologies that would alter the risk estimations be included in a repeat of the analysis.

The example at Annex 2 and the component that relates to each step in the process is intended to illustrate how to do the process. In order to keep the text as short as possible, the example has purposely been kept simple to demonstrate the process not the detail of the risk. The forms and tables used in Chapter 4 and in the illustrative example at Annex 2 are available for photocopying at the Workbook: Annex 5, page 47.

Finally, a brief description of the importance of risk perception and a glossary of risk terminology is included. The recognition that different people and organizations perceive the same risks very differently is vitally important to a successful risk management process. Also, differing risk terminology has been and is still being used by various professional bodies and sciences. The glossary of terms that is taken from the Canadian national standard will provide some relief for users of this guide from the inevitable arguments about terminology.

Annex 1: *Climate Change Projections for Alberta*

I GENERAL INTRODUCTION:

The following summary of observed and expected climate change in Alberta is drawn from an extensive literature. Questions of impacts of the changes and adaptation options are not discussed here since they are extensively covered in Chapters 7 and 8 of the publication of Natural Resources Canada, *“From Impacts to Adaptation: Canada in a Changing Climate 2007”.*
http://adaptation2007.nrcan.gc.ca

Among the major concerns in the changing climate that will require adaptation are:

1. Reduction of winter snowpack and of glaciers on the East Slopes of the Rockies.

2. Changes in river flow and water availability due to these snow and glacier changes, especially in central and southern Alberta.

3. Increased frequency and intensity of extreme events, drought, intense rains especially in spring causing flash floods, land slides in northern areas with thawing permafrost, and an increase in forest area burned by fires and affected by insects and disease.

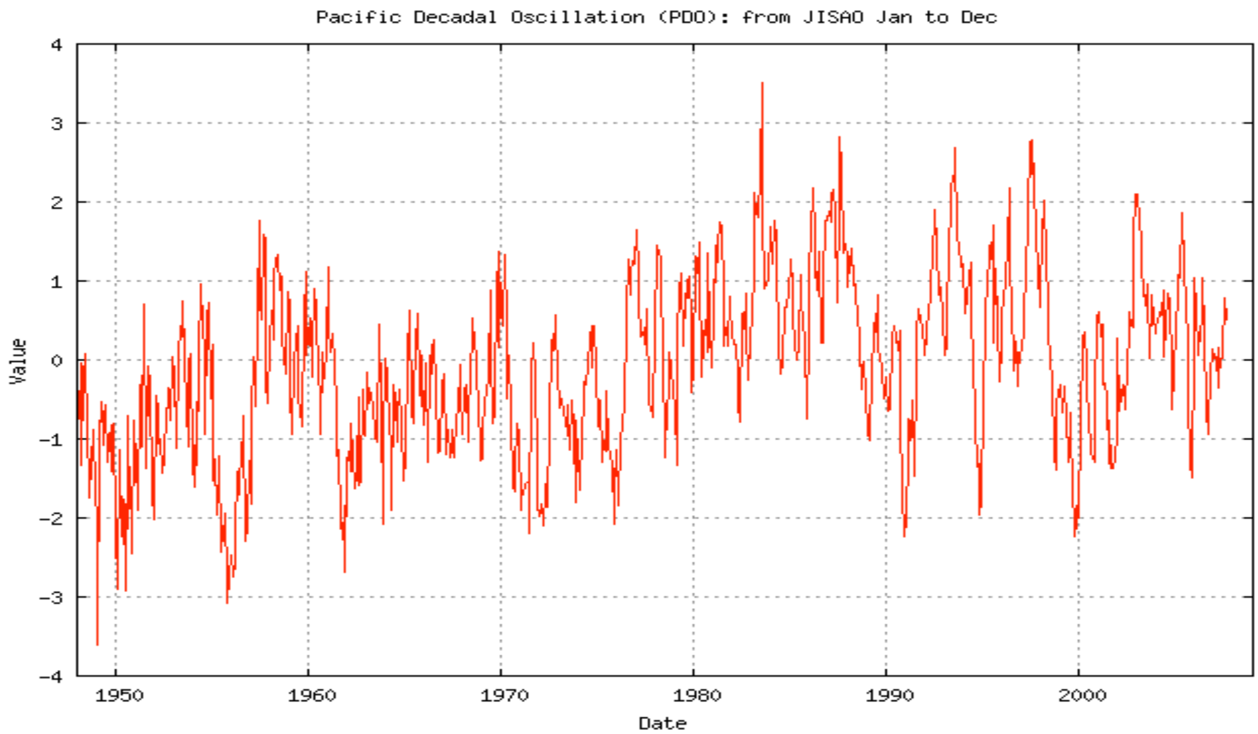
These issues are discussed more fully in sections 4, 5, 6, after a general discussion of how the greenhouse gas increases and natural forces affect Alberta’s changing climate.

At the conclusion of this Annex is a summary, Table providing an estimate of changes in climate and related factors from 1950 to 2000, and projected further changes to 2050.

1. FACTORS INFLUENCING CLIMATE

Future climate in Canada’s western-most provinces will be influenced by long-term (decades to centuries) changes induced by increasing greenhouse gas concentrations in the atmosphere, and by behaviour of the natural modes of variation in the climate system. For western Canada, the oscillation between El Nino and La Nina (ENSO) in the tropical Pacific Ocean and the Pacific Decadal Oscillation (PDO) in the North Pacific, influence the year to year or even decade to decade climate. In some publications, the warming of the west has been attributed almost entirely to the shift in PDO from negative to positive about 1976. However, as can be seen from Fig. 1, the PDO was not consistently positive from 1976 on but was in a negative phase in late 80s and early 90s, and again in the period around 2000. However, the ENSO phenomenon appears to be more important especially in extreme cases. For example, in the record Alberta drought in 2001-2002, the PDO was mostly negative, normally resulting in wetter conditions. However, in this period an El Nino condition prevailed and apparently dominated in the influences of the Pacific Region resulting in drought conditions especially in Alberta. El Nino and La Nina events occur on average every 7 years, but are quite irregular in timing and intensity.

A positive PDO and El Nino results in winter temperatures up to 2.5°C above normal in most of Alberta. In contrast a negative PDO and La Nina indicate winter temperatures below normal, and by as much as -2°C over Alberta. In general, positive PDO results in warmer and drier conditions on average in the whole region than does PDO in its negative phase, but this can be significantly modified by the ENSO conditions (Shabbar, 2008).
The change in the mid 70s to a generally warmer phase of PDO is attributable in part of enhanced climate forcing by greenhouse gases. (Meehl, et al., 2009)



Shabbar, Amir, EC

Recent papers, (Bonfils, et al., and Pierce, et al., Dec. 2008), have sought to determine the factors to which may be attributed observed changes in temperature, and snowpack on April 1, in mountainous western U.S.A. However, the results have applicability at least in southern parts of B.C. and the East Slopes in Alberta. They found observed winter temperature trends were only slightly less (~0.5^{o}C) from 1950-1999, near and just over the Canadian border, when PDO/ENSO effects were taken out. The Bonfils, et al., 2007) study also considered effects of solar variability and volcanic emissions on temperature trends, and found that they were insignificant compared to the anthropogenic (greenhouse gas and aerosol) forcing. Pierce, et al., found that for the observed decline in snow water equivalent at 1 April, divided by precipitation for that year to show the effect of winter melt, was about ½ due to anthropogenic forcing over this whole western U.S. area. The balance was due to natural variability effects of PDO/ENSO.

2. OBSERVED TRENDS IN GREENHOUSE EFFECT

Greenhouse gas concentrations in the global atmosphere have been increasing since the late 1800s. By 1970 the additional energy they induce in the climate system had overcome the effects of natural forcing factors such as changes in solar energy reaching earth, and volcanic emissions (IPCC, 2007). Thus, trends of climate factors from say 1950 have been increasingly driven by the greenhouse effect and have covered several Pacific Decadal Oscillations. These trends are useful indicators of future climate trends since greenhouse gases will overwhelmingly dominate changes to mid 21st century and beyond. One must envisage a generally warming trend with temperatures temporarily above and below the trend line depending on the state of the PDO and ENSO.

3. ACCELERATION OF CLIMATE CHANGE

Recent information on GHG concentrations, emissions and impacts lead to the view that climate change is advancing more rapidly than estimated earlier. CO2 global atmospheric concentration increases averaged 1.6 ppm/year from 1970 to 2007, but 1.9 ppm/year from 2000 to 2007 (Levinson, 2008).

At the same time the International Energy Agency in late 2007 reported that global energy use and greenhouse gas emissions have been rising very rapidly. They project a 55% increase in world energy needs between 2005 and 2030 and a 57% increase in greenhouse gas emissions. This could be tempered by aggressive global efforts to reduce emissions, not evident to date. Of course, an economic downturn could have short term effects on these rates of change.

A 57% increase to 2030 is substantially more rapid an increase than the most rapid increase in the IPCC Special Report on Emission Scenarios that have been used in previous climate projections. The evidence in the climate system of the acceleration of greenhouse gas emissions and concentrations can be seen in several manifestations. The decline in ice cover in the Arctic has been more rapid than any of the IPCC scenario modeled results. Ice melt in Greenland, and effects in Antarctica have recently exceeded the rates of change projected by IPCC.

Thus, it would not be unreasonable to assume that the rate of change is accelerating.

II SPECIFIC PROJECTIONS FOR ALBERTA

1. INTRODUCTION:

The observed trends of temperature and precipitation since about 1950 cover several PDO sign reversals and a number of El Nino and La Nina situations. These trends then can be assumed to be due largely to the greenhouse effect (Bonfils, et al., 2008)

2. TEMPERATURE TRENDS OBSERVED:

Table III - 1

Positive Trends in daily maximum and minimum temperatures ºC, Alberta 1950-1998
(Zhang, et al., 2000)

	Winter		Spring		Summer		Fall		Annual	
	T. max ºC	T. min ºC	T. max ºC	T. min ºC	T. max ºC	T. min ºC	T. max ºC	T. min ºC	T. max ºC	T. min ºC
North	2.5 to 3	2	*2.5 to 3	2.5 to 3	.5 to 1.	1.0 to 1.5	-.5 to -1	-.5 to -1	2	1 to 2
Central	2 to 2.5	2	2.5 to 3	2.5 to 3	.5 to 1	1 to 1.5	0 to -5	-.5	1.5 to 2	*1.5 to 2
South	1.5 to 2	2	3	2.5 to 3	.5 to 1	.5 to 1	.5 to -.5	-.5	1 to 1.5	.5 to 1

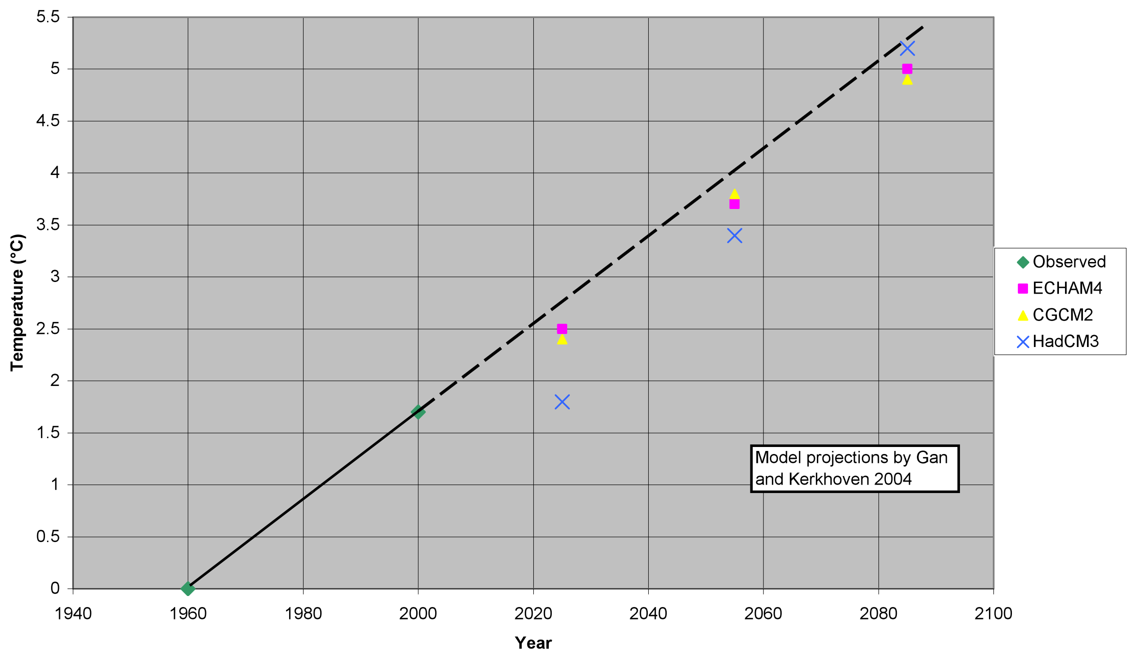
T. - Temperature

* - significant at 95%

Projected additional Temperature increases to 2050

To compare the trend from the observed annual warming from 1960 to 2000 and annual temperature increases from various atmosphere-ocean climate models with the high IPCC SRES emission scenarios, consider Figure 4 (below). In this, the observed warming in the Athabasca River basin in the central part of Alberta is extended linearly. The result is compared with temperature projections by 3 different AOGCMs. It can be seen that the observed-extended values are only slightly higher than modeled projected values. For example, for 2050, extension of observed trends suggests an increase from 1960 of 3.9^{o}C (or 2.2^{o}C greater than year 2000 value) whereas model results range from 3.4 to 3.8^{o}C. This gives some confidence in using extension of trends or modeled results to estimate future temperatures.

Figure 4
Temperature Trends and Projections
Athabasca River Basin



Modeled Seasonal Temperature Projections for 2050
(with high IPCC-SRES emission scenario, change from period of 1961 to 1990)

Table III - 2

	Winter °C	Spring °C	Summer °C	Fall °C	Annual °C
North	4 to 6	~ 4	~ 2	2 to 3	~ 4
Central	4 to 6	~ 4	~ 2	2 to 3	3 to4
North	4 to 6	2 to 4	~ 2	2 to 3	2 to 4

(Sauchyn and Kulshreshtha, 2008)

3. PRECIPITATION:

Table III - 3

Precipitation Trends observed 1950 to 1998 (Vincent and Mekis)					
	Winter %	**Spring %**	**Summer %**	**Fall %**	**Annual %**
North	-5	+5 to +10	+5	+5	+5 to +10
Central	0 to -10	+5	-5 to +15	+5 to 15	+5
South	-5 to -15	+5	-5	+5	0 to +5

Note: The ratio of snow to total precipitation declined 0 to 9% in winter, and 0 to 15% with more widespread declines, in spring

Projections of future total precipitation to 2050 are much more difficult than for temperature, since AOGCMs do not reasonably replicate observed precipitation from 1961-1990. For example, for central Alberta, 4 different models, Australian (CCSR), Canadian CGCM2), German (ECHAM4) and British (HadCM3) all overestimated annual precipitation in this period. Only HadCM3 reasonably simulated winter precipitation, the others overestimated, but HadCM3 significantly overestimated spring and summer precipitation. ECHAM4 was closest in summer. Given this situation, it is suggested that extending the trends of observed precipitation from the table above may provide the most reliable estimate of trends for the coming 4 to 5 decades, although it appears likely that the negative winter trend in the North is likely to become positive.

4. ALBERTA'S SNOWPACK AND GLACIERS:

With milder winters and springs and a greater rain to snow ratio in spring, snow pack on April 1 has been declining in Alberta as in most of western North America (Mote, 2005). The glaciers which are the headwater of the Athabasca and North and South Saskatchewan Rivers have been retreating, with their volumes in decline. For the Athabasca the decline has been 25% over the past century (Watson, 2004), and the adjacent Peyto glacier, which has been extensively studied, at the head of the North Saskatchewan has lost 22% of its mass balance between 1965 and 2004. It is generally recognized that as headwater glaciers shrink, they initially contribute more base flow to the river, but eventually reach a "tipping point" when they have shrunk to the extent that their contribution to flow declines. Studies have concluded from the historical streamflow and meteorological data, that this increased flow phase has already past, and that the basins have entered a potentially long-term trend in declining flows (Demuth and Pietroniro, 2003). While this conclusion was primarily for the North and south Saskatchewan basins, it applies as well to the adjacent Athabasca River and glacier.

5. ALBERTA'S WATER RESOURCES:

Downward trends in annual river flows have been observed over most of the province from 1967 to 1996 (Zhang, et al, 2001), except for the Peace River in the northwest where winter and spring flows rose. Mean annual discharges are projected to continue to decline in southern and central regions. Declines projected to 2050 include, for example, (Pietroniro, 2006):

- Red Deer River at Bindloss 13%
- Bow River at mouth 10%
- Oldman River at mouth 4%
- South Saskatchewan River at Lake Diefenbaker (Sask.) 8.5%.

For Athabasca, the German ECHAM4 model projects a further decline of 25% in annual flows at Fort McMurray, (Gan and Kerkhoven, 2004). In general peak spring flows have been earlier, winter flows greater and summer low flows are declining. Summer is also the time of peak demand from agriculture and urban areas, and population growth could increase demand by 52 to 136% by 2046 (Sauchyn and Kulshreshtha, 2008). With current pressures, the Alberta government will not provide any additional allocations from the Bow and Oldman Rivers.

6. EXTREME EVENTS IN ALBERTA:

The severe drought of 2001 – 2002 was the most costly extreme climatic event faced by Alberta. However, as assessed by the Palmer Drought Severity Index, this was not the most widespread and extreme drought in Alberta. Although the PDSI reached its extreme stage in east central Alberta in the summer of 2002, more extensive "extreme" PDSIs were recorded in 1919 (Bonsal and Regier, 2007). However, Alberta and Saskatchewan have been shown to be one of the centres on the globe with greatest trends towards drought (highest trend of PDSI) in the past century (Dai, et al., 2004). Projections with the Goddard Institute for Space Studies model indicate that severe droughts could be twice as frequent in southern Alberta and Saskatchewan by 2050. Tree ring analysis also indicates that much more severe droughts have occurred in the past, and by implication may occur in future (Sauchyn, et al., 2003).

Although Alberta has not experienced as much of the North American trend towards more high intensity rainfalls as other regions, it is not immune. (e.g. 150mm in one hour in Edmonton 2004). The frequency of heavy events in this part of Canada has risen by up to 5% per decade in spring and early summer months (April-July) over the past century (Stone, et al., 2000). Very wet days >95th percentile have increased in frequency, over the century, but only slightly (Vincent and Mekis, 2006).

Heavier rain events in Spring may well contribute runoff to the remaining high flows due to snow melt resulting in flash floods (e.g. Elbow River, 1995 and 2005, Vales, et al., CWRJ, 2007). Projections by the Canadian climate model indicate that the return period of heavy rain events by 2050 is likely to decrease by a factor of about 2, i.e. 20 year return period events become 10 year return period (Kharin and Zwiers, 2005).

In northern parts of Alberta, melting **permafrost** in the extensive region of discontinuous permafrost is resulting in land slides, diverting of river channels, and disruption of building foundations, pipelines and roads.

Forest fires in boreal regions and **insect infestations** will continue to increase in the warmer boreal forest region. The area burnt in Canada as a whole has increased in parallel with increases in late spring and summer temperatures and is projected to increase by another 75 to 120% by 2100 (Flannigan, et al., 2005).

Table III - 4: Present estimates (2008) of observed and projected climate changes for Alberta

Change	To date (2000 from 1950)	By 2050 From 2000
Mean annual temperature	1 to 2ºC	2 to 4ºC
Mean Winter temperature	1.5 to3ºC	4 to 6ºC
Frost free days	+5 per decade interior	+17 per decade interior
Total Annual precipitation	Near 0% in South to +10% in North	Near 0% in South to +20% in North
Snow as % of total	-9% Winter, -15% Spring	-20% Winter, -30% Spring
Summer rainfall	-5% in South to +5 to15% in North	Near 0% in South to +10 to 30% N
Extreme rainfall	+5% Spring and Summer	20 year event will be 10 yr event
Total runoff and groundwater	-4% to 1%	-4% to -25%S and Central +20%N
Drought	Rapid increase *Palmer Drought Severity Index*	2 x present frequency
Glaciers	-25% over century	-40% ??
Forest Fires *(insect infestations)*	Increased area burned (Canada) 100,000 km^2	+75% to 120% by 2100
Permafrost Thaw	30% of area in North	+60% of area in North
Deleted shown above		

Note: The above figures are estimates of average changes. Trends in specific locations may be significantly different.

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Annex 2: Illustrative Example

FOREST FIRE/WILDFIRE FOLLOWING A LONG, HOT, DRY SPELL

Introduction:

As climate predictions foretold, Alberta has undergone longer spells of very hot, dry weather. Events such as forest fires and large grass fires triggered by lightning or human activity have become more common and more severe. These extreme events have resulted in multiple emergencies including, large tracts of lost forest and grasses, threats to human settlements, large scale evacuations, loss of critical infrastructure such as power transmissions systems, major bridges, roads and railways, homes and urban facilities, heavy smoke contamination and associated health problems in humans and animals, among others.

Although Alberta has had experience with recent major fire events and has extensive emergency preparedness plans to deal with these types of events and special programs such as "Firesmart"™ have been implemented, there is a growing sense that this situation is rapidly deteriorating. In particular, municipal authorities have become much more concerned regarding the threat of serious wildfires and have directed their administrations to take the necessary planning steps to prevent, mitigate, and prepare for severe wildfires.

The situation in the Alberta Capital Region has become particularly worrisome. The hot and dry weather over the past five years has dramatically increased the threat of wildfire. Not only rural farming and parkland but also the North Saskatchewan River valleys have become tinder dry. Care has been taken to prevent any major wildfires in the Capital Region but ironically this has only added potential fuel to a future wildfire event. While the flow of water in the North Saskatchewan River continues to be relatively stable other water sources, such as sloughs, smaller streams and rivers and holding tanks, have become seasonal or dried up completely. Water has become a precious commodity in the Capital Region.

Several factors have worsened the situation in the Capital Region. The price of oil quickly recovered from its low prices of 2009 and is now trading in the $120 per barrel range. This has made the construction of planned upgraders and secondary facilities affordable and most of the construction proposed in 2007/08 has either been completed or is in progress. This construction has placed a huge burden on Regional infrastructure, including first response agencies, utility providers and transportation facilities.

In Edmonton the strategy of residential infill has been extremely successful, reducing the amount of suburban development but moving more people into the downtown core, in close proximity to the River Valley. Any wildfire in the Valley will now prove a serious threat to many more people than was previously the case.

The renewed construction boom has also brought in a huge influx of people to the region, driving the demand for new housing and services. In many cases this has resulted in new developments in close proximity to tinder-dry farm and parkland in the Counties.

As an element of the recently-organized Capital Region Authority, the Capital Region Emergency Preparedness Partnership (C-REPP) has been tasked to conduct a risk management study dealing with future risks from forest and wildfires to identify the nature of future fire risks, the adequacy of the region's prevention and preparedness plans and to identify areas where improvements could and should be made.

The chair of C-REPP has asked you to lead the project and has assigned two members of partnering municipalities and one office support person to assist you in setting up the project.

You and your team have just had a preliminary meeting to get started and have decided to follow the recently received publication, *Adapting to Climate Change: A Risk-based Guide for Alberta Municipalities.* You have also decided to follow the advice in the Guide and do a fairly quick overview study to get a better understanding of the issue and its probable results. After briefing the C-REPP Chair and obtaining approval for this approach your group meets again to begin work:

Step 1: Getting Started

The overall risk problem:

- An increasingly dry and hot spring/summer, potential regional water shortages (other than N. Sask R.), a growing urban population that has placed stresses on all municipal infrastructure and services has made a review of regional vulnerabilities and response capacities to fire/wildfire imperative to ensure that risks continue to be acceptable.

Actual and potential hazards identified:

- Grassland fires.
- Forest fires.
- Urban building and critical infrastructure fires.

Vulnerabilities and risk issues:

- Smoke:
    - Air quality/health issues.
    - Visibility in transportation corridors, airports.
    - Industry impacts.
- Fire:
    - Health and safety of humans and animals.
    - Community isolation.
    - Residential and industrial property and infrastructure damage.
    - Power and utility outages.
    - Service disruptions.
    - Secondary fire and explosion risks from industry.
- Environmental damages (land, water, air and eco-systems).

Project Team Members and Responsibilities:

- Core Members:
    - 3 members of C-REPP partnering municipalities (emergency/fire managers) – one is team leader.
    - Office support – risk library, appointments and budget.
- Assisting or Consulting Members (some or all) – advisors and subject matter experts:
    - First Nations representative if involved.
    - Urban planner.
    - Forestry representative
    - Agricultural representative.
    - Environmental representative.
    - Utilities/public works representative(s).
    - Transportation representative.
    - Airport representative.
    - Health representative.
    - Occupational health and Safety representative.
    - Industry representative(s).
    - Communications specialist.
    - Provincial and/or federal representative(s) if needed.

Budget and other resources needed: As this is an initial evaluation, budget requirements are minimal – participants' time, minor travel costs, meeting expenses, photo copying.

Initial stakeholder identification and probable issues, concerns and needs:

- Most key stakeholders are represented on the project team or the assisting/advisory group.
- Others could include:
    - Hospitals, elder care facilities – impact of smoke, casualties, potential evacuations.
    - Commercial/industrial associations and Chamber of Commerce – impact on operations, safety of workers.
    - Tourism and recreational groups - notification and safety of visitors.
    - Schools and child care facilities – safety of children, potential evacuation.
    - Security, remand and penitentiary facilities – potential evacuations.

Need for stakeholder communications and outline plan: None at this time.

Documentation and risk library:

- Copies of initial directive, all contact information, lists of members and advisors, budget estimates, meeting notes and initial risk estimation and vulnerability material filed. File system developed.

Decision: Go to Step 2

Step 2: Preliminary Analysis

Risk scenarios based on the hazards and vulnerabilities identified in Step 1 using the template at Step 2 in Chapter 4 of the guide.

Table 2: Preliminary Hazard and Risk Scenario Assessment

Hazard: Forest fires and/or wildfires in an increasingly hot and dry spring and summer in the Alberta Capital Region. The baseline for this hazard is that dry spring weather is quite common in the capital region and the risk of grassfires has been high. Most emergency preparedness plans in C-REPP include severe grassfires. Extreme hot and dry weather with very long periods between rain events is becoming more common. As yet, Firesmart™ and other precautionary programs have not been very active in the capital region although the risk of severe fires in the wooded areas of the river valley and the forested communities in the northern areas of the capital region are increasing. As yet there are not large numbers of dead trees in this region.

RISK	VULNERABILITY	FREQUENCY (Initial estimate)			CONSEQUENCE (Initial estimate)			COMMENT or POSSIBLE CONTROL
		1	2	3	1	2	3	
Forest fire in river valley	Residential fires-property damage, human health and safety.		X				X	Serious, potential evacuations. Consider fire bans
	Serious traffic disruption in urban areas		X		X			River valley crossings
	Smoke and poor air quality			X		X		Needs attention
	Refinery row and chemical plants	X			X			Well set back and protected
	Power grid	X			X			Crossings
	Utilities		X			X		Water and waster treatment
	Environment and ecosystems		X		X			
	Emergency services overburdened		X			X		Mutual aid
Grassland fire in west and south	Airport		X		X			Well prepared for this
	Smoke transportation corridors		X			X		
	Smoke and poor air quality		X			X		Needs attention
	Agriculture, cattle		X		X			
	Residential fires – property damage, human health and safety		X			X		Not so dense as river valley areas. Consider fire bans

RISK	VULNERABILITY	FREQUENCY (Initial estimate)			CONSEQUENCE (Initial estimate)			COMMENT or POSSIBLE CONTROL
		1	2	3	1	2	3	
	Environment and ecosystems		X		X			
Forest fire in northern urban area	Residential fires property damage, human health and safety		X				X	Serious, potential evacuations. Consider fire bans
	Infrastructure fires		X				X	
	Environment and ecosystems		X		X			
	Smoke and poor air quality		X			X		Needs attention

Notes: The frequency and consequence estimates at this step are very preliminary and serve to indicate where attention needs to be focussed.

Frequency:
1. Unlikely to occur
2. Moderately frequent occurrence
3. Almost certain to occur

Consequences:
1. Low
2. Moderate
3. High

Continue and expand the stakeholder analysis and database:
- Consider consultations with healthcare facilities, schools and elder care facilities re: potential air quality problems and potential evacuations.
- Industrial associations re: concerns about fire impingement on their facilities.
- Consider consultations with security, remand and penitentiary facilities – air quality and potential evacuations.
- Consider involvement of community associations.

A risk communication plan is not considered necessary for this preliminary review of risk levels.

The risk information library is updated with the risk scenario analysis, all preliminary estimates of frequency and consequence, all meeting/discussion notes and stakeholder analysis development.

Decision: Go to Step 3

Step 3: Risk Estimation

Subject matter experts (see advisory group members) and fire records should provide sufficient data to estimate frequency and severity of risk scenarios.
These estimates are displayed on templates 3.1 and 3.2 from Step 3 in chapter 4 of the Guide A five level scale is used in this step to provide more definition of the probability and consequence estimations using the expertise and data suggested above..

Table 3.1 Estimates of Probability or Frequency of Risks.

Table 3.1.A: Forest Fires in the River Valley

Event \ Frequency	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Residential fires-property damage, human health and safety.			X		
Serious traffic disruption in urban areas			X		
Smoke and poor air quality			X		
Refinery row and chemical plants	X				
Power grid	X				
Utilities		X			
Environment and ecosystems		X			
Emergency services overburdened			X		

Table 3.1.B: Grassland Fires in the West and South of the Capital Region

Event \ Frequency	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Airport			X		
Smoke affecting transportation corridors			X		
Smoke and poor air quality			X		
Agriculture, cattle		X			
Residential fires – property damage, human health and safety			X		
Environment and ecosystems			X		

Table 3.1.C: Forest Fires in the Northern Urban Areas of the Capital Region

Event \ Frequency	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Residential fires property damage, human health and safety		X			
Infrastructure fires		X			
Environment and ecosystems		X			
Smoke and poor air quality			X		
Emergency services overburdened			X		

Table 3.2: Estimates of Consequences of Risks

(Note only some of the risks from in Step 2 are developed in this example)

Table 3.2.A Residential Fires in the River Valley

Degree \ Impact	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			X	X							
Low							X		X		X
Moderate								X		X	
Major	*X*	X			X	X					
Very Severe											

Table 3.2.B Fires in the River Valley Impact on Utilities (water, waste and waste water)

Degree \ Impact	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	X		X	X							X
Low						X					
Moderate		X			X						
Major							X		X	X	
Very Severe											

Table 3.2.C Grassland Fires in the South and West Impact on Air Quality

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			X	X	X		X		X	X	
Low	X					X					X
Moderate		X									
Major								X			
Very Severe											

Table 3.2.D Infrastructure Fires in the Northern Urban Areas of the Capital Region Impact on Residents

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				X							
Low			X				X			X	X
Moderate	X	X						X	X		
Major					X						
Very Severe						X					

Assess the stakeholders' perceptions of risk

Table 3.3: Stakeholder Risk Perception. (Note: some examples only)

Climate Factors: (Hazards)	Risk Scenarios - Aspects of Hazards and Risks to Community	Stakeholders and perception of Risk
Extreme hot and dry spring/summer weather in Alberta's Capital Region.	Forest fires in the river valley	• Residents – serious • Utilities – serious • Tourism and recreational groups – very serious • Environmental groups – very serious
	Grassland fires in the West and South of the region	• First Nations – very serious • Agriculture groups – serious • Residents –serious • Airport – moderate • Transportation groups - moderate
	Forest fires in the in the Northern urban areas of the region	• Residents – serious • Industry groups – very serious • Forestry groups - moderate

The risk information library is updated with all estimates of frequency and consequence including the source date and expert opinions. The stakeholder contacts and estimates of their perceptions of risk should all be recorded and filed including all notes from meetings or telephone discussions.

Decision: Go to Step 4.

Step 4: Risk Evaluation

Risks are compared using the estimates for frequency and consequence shown in the tables in Step 3.

The various consequence factors considered and shown on the 3.2 tables are averaged to one estimate and entered on the risk evaluation matrix shown below. The comparison of the various risks are visually shown, those higher in severity and more likely to happen (further to the right) should receive priority attention in developing risk controls to reduce risks to acceptable levels.

Risk Evaluation Matrix (Note: only some of the risks evaluated are shown here)

IMPACT SEVERITY	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Extreme	Industrial Facilities Compromised				
Major	Critical Infrastructure Damaged		Forest fires in the river valley and northern urban areas on residents		
Moderate		Prolonged power outages Water Supply Problems	Reduced air quality		Emergency Services Capacity Impaired (all areas)
Low					
Very Low					Transportation Routes Compromised by Smoke
	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: Controls not likely required

Negligible risk These do not require further consideration

Consideration of some of the costs and benefits of the consequences

(only some are considered here):

Risk Scenario	Potential Costs	Potential Benefits	Comments
Impact on industrial facilities (all scenarios)	May require increase to setbacks/buffer zones	Increased protection from releases/accidents	Extremely expensive in many cases to retrofit setbacks.
Forest fires in river valley and northern urban areas	Property damage and evacuation costs are very high.	Natural burns improve forest health.	Increased attention to removal of underbrush and damaged/infected trees would be preferred.
Increase emergency services capacity	Extremely expensive to increase emergency services capacity.	Increased capacity would provide more resilience.	Mutual aid arrangement with other jurisdictions may be more cost effective.
Smoke impairs transportation routes.	Increased accidents.	Route closures and detours.	Current practices are probably adequate.
Etc.			

Perceptions of key stakeholders about the most serious risks (only some are considered here):

Risk	Stakeholder	Probable Risk Perception	Comment
Compromised Industrial Facilities	Industry	Serious concerns	Consider forming industry advisory group to look at risk controls.
	Nearby residents	Serious concerns	Consider having selected residents included in advisory group meetings
Forest fires in the river valley and northern urban areas	Residents	Serious concerns	May resist some Firesmart™ practices such as retrofitting roofs, site clearing.
	Municipalities	Serious concerns	Unlikely to favour increased regulations.
	Forestry experts	Serious concerns	Will probably favour Firesmart™ practices.
	Environmental groups	Serious concerns	Will probably favour Firesmart™ practices.
Etc.			

This analysis clearly shows that the risk to industrial facilities, residential impact of forest fires and impaired emergency services are unacceptably high and will have to be addressed on a priority basis.

The risk information library is being updated with all information on the analysis of risk, the additional stakeholder information and all meeting notes and discussions.

Decision: go to Step 5.

Step 5: Risk Controls and Adaptation Decisions

The analysis in Steps 3 and 4 has given us enough information to begin to identify feasible adaptation and risk control options.

Starting with the highest risks, the project team identified all the adaptation and risk control measures that would reduce the risks to an acceptable level, in the short, medium and long terms and evaluate them in terms of cost, effectiveness and acceptability.

Risk Controls and Adaptation Measures
(some examples only)

Risk	Control or Adaptation	Time Frame	Cost	Effect-ive	Accept-ability	Comment / Evaluation
Compromised Industrial Facilities	Improved insurance coverages	short	modest	high	high	Industries should review and upgrade coverage
	Implement Firesmart™	short	modest	high	high	All aspects available
	Improve setbacks	long	high	high	mid	Need extensive consultations
	Improve response capacity	medium	medium	medium	mid	Most already have effective response arrangements which could be improved
	Etc.					
Forest fires in the river valley and northern urban areas	Implement Firesmart™	short	modest	high	high	Public education campaign needed
	Improved insurance coverages	short	modest	high	high	Public education campaign needed
	Increase fire suppression capacity	medium	high	medium	high	Better mutual aid may offset need
	Improved emergency public warning system	short	medium	high	high	Already being considered

Risk	Control or Adaptation	Time Frame	Cost	Effect-ive	Accept-ability	Comment / Evaluation
	Etc.					
Reduced air quality	Improved emergency public warning system	short	medium	high	high	Already being considered
	Shelter –in-place	short	low	high	medium	Requires review and public education
	Improved air monitoring capacity	medium	medium	high	high	Already being considered
	Etc.					
Etc.						

A considerable improvement could be achieved quickly and at moderate cost by:

1. Improving the implementation of the Firesmart™ program and initiating a public information and education campaign.
2. Improving the emergency public warning system (EPWS) in Alberta to include other communications means, such as cellphones podcasts and the internet. This is already under consideration and could be completed within a two year period at moderate cost.
3. Adding air-monitoring capacity. This is already under consideration.
4. Reviews should be undertaken about other mid to long-term adaptation measures.
5. Encourage industry to review their preparedness situation with respect to wildfires and forest fires and taken action to improve their resiliency. Governments should be informed about action being taken.
6. Etc.

Recognizing that this is a preparatory review being undertaken in advance of the more comprehensive C-REPP study project, the project team has indicated some of the measures that could be undertaken quickly and at moderate cost. The full C-REPP review which will follow, with a larger advisory/project team will identify shortcomings in the present situation and recommend an implementation plan to remedy those. In addition, the study will assess residual risks after implementation.

The risk information library will be updated with the results of the Step 5 analyses and notes from the meetings and discussions around risk evaluations and risk controls/adaptation measures.

Decision: Go to Step 6.

Step 6: Implementation and Monitoring

As noted above, this is a preparatory review being undertaken in advance of the more comprehensive C-REPP study project, the project team has indicated some of the measures that could be undertaken quickly and at moderate cost and is prepared to establish a larger more inclusive project team to undertake the full study. The project team now has a good sense of the magnitude of the study as well as a preview of the probable outcomes.

They also recognize that the recommended implementation plan at he end of the larger study will have to include strong monitoring and progress review aspects as well as stakeholder involvement.

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. For example, 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 principal 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 that 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 a 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 are the stakeholders' needs, issues and concerns 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 affected citizens 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 that 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)

Annex 5: Workbook

This Annex contains the templates suggested in Chapter 4 to display:

- The risk scenarios (Step 2)
- Estimates of Frequency and Consequence of risks (Step 3)
- Stakeholder Risk Perceptions (Step 3)
- Evaluation of Risks (Step 4)
- Adaptation Measures and Risk Controls (Step 5)

The templates can be photocopied for use by risk project teams.

Table 2: Preliminary Hazard and Risk Scenario Assessment (Step 2)

HAZARD: Describe.

RISK	VULNERABILITY	FREQUENCY			CONSEQUENCE			COMMENT or POSSIBLE CONTROL
		1	2	3	1	2	3	

Notes: Make rough estimates of (these will be expanded in Step 3)

Frequency:

4. Unlikely to occur
5. Moderately frequent occurrence
6. Almost certain to occur

Consequences:

4. Low
5. Moderate
6. High

Table 3.1: Estimates of Frequency of Risks (Step 3) (Use as many rows as needed)

Frequency / Risk Event	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur

Table 3.2: Estimates of Consequences of Risks (Step 3) Risk Event ____________

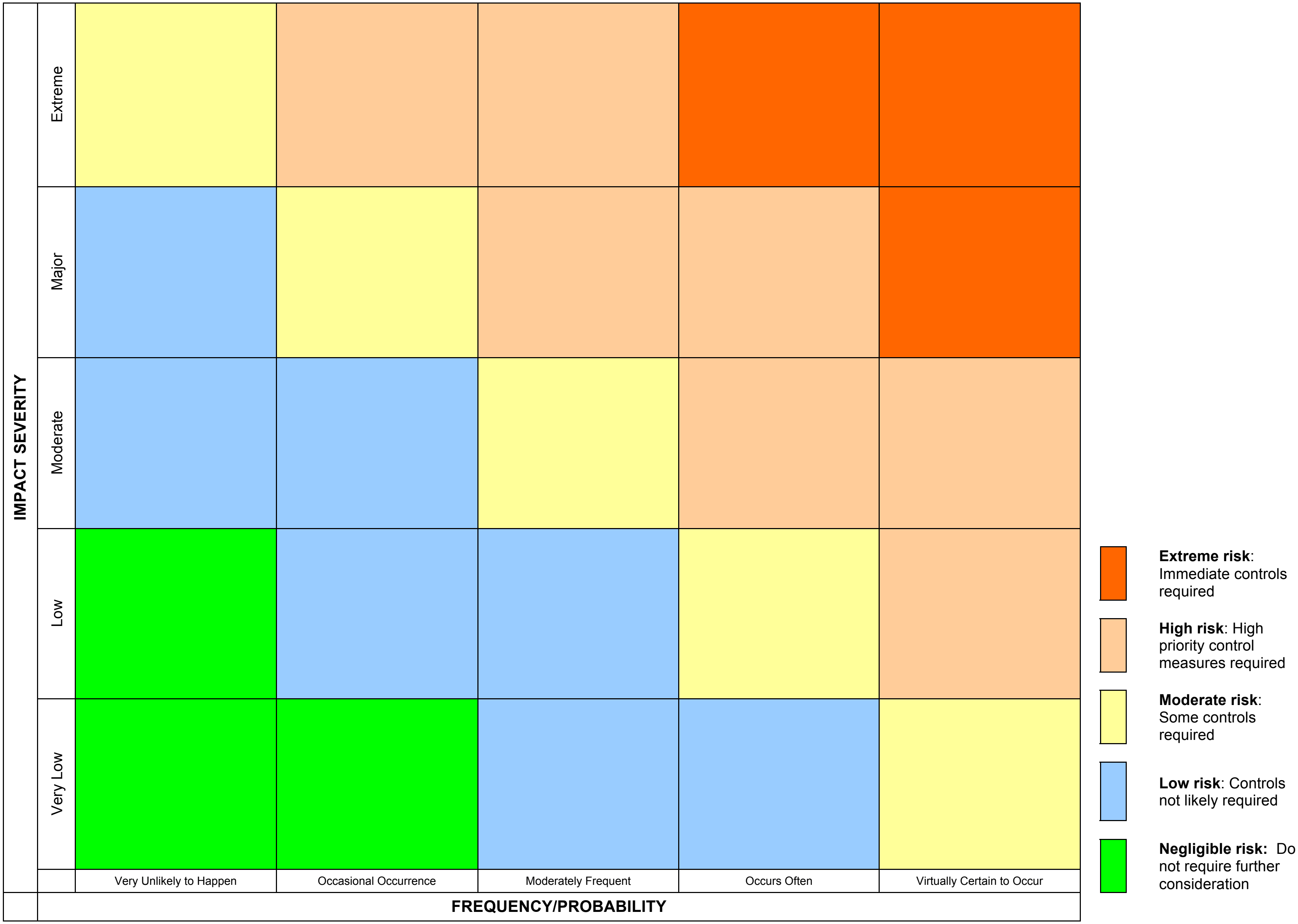
(Use one table for each risk event)

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											

TABLE 3.3: Suggested display for stakeholders and risk perception Step 3).

Climate Factors: (Hazards)	Risk Scenarios - Aspects of Hazards and Risks to Community (Use as many rows as needed)	Stakeholders and perception of Risk

Figure 3: Risk Evaluation Matrix (Step 4)



Risk Controls and Adaptation Measures (Step 5)

Risk (Use as many rows as needed	Control or Adaptation Measure (Use as many rows as needed	Time Frame	Cost	Effectiveness	Acceptability	Comment / Evaluation

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