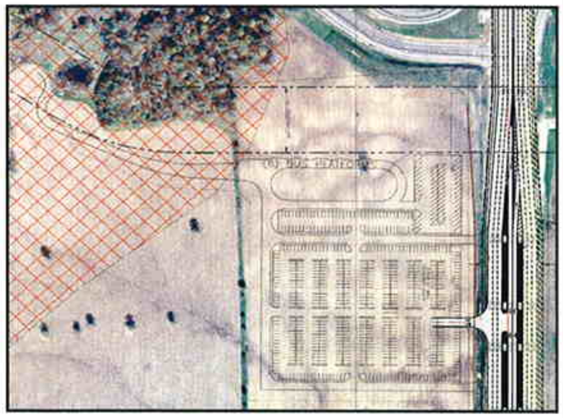
ClimateSMART

CLIMATE CHANGE: DEVELOPER'S RISK MANAGEMENT GUIDE

AUGUST, 2007



HALIFAX REGIONAL MUNICIPALITY

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Federation of Canadian Municipalities / Fédération canadienne des municipalités

ClimAdapt

Table of Contents

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Disclaimer

This document is for guidance purposes only. Information contained in the document is based on current knowledge of projected climate changes that may affect Halifax Regional Municipality and professional judgment of the potential impacts of climate change on socio-economic and environmental components described. The projected climate changes and potential impacts are subject to change as climate change science evolves and the user should satisfy themselves with currency of the data. No guarantees are implied by Halifax Regional Municipality, the Government of Canada, the Province of Nova Scotia or the authors.

Executive Summary

Global climate change is expected to have significant impacts upon coastal communities due to the predicted rise in global sea-level and increase in the intensity and frequency of extreme events such as tropical storms, and an increase in the intensity of hurricanes. As witnessed during Hurricane Juan, Halifax Regional Municipality (HRM) **is vulnerable.**

The climate change impacts that HRM can expect to experience include:

- mean annual temperature will increase by 4-5°C by 2100 and annual precipitation will increase by up to 100 mm;
- the magnitude and intensity of tropical storms and hurricanes are predicted to increase so a 1 in 100 year event is now a 1 in 50 year event;
- compounding impacts will be felt, as sea-level rise of up to 80 cm will make coastal communities and infrastructure more vulnerable to erosion and storm surge flooding;
- this, in turn, will lead to increased overwhelming of HRM's infrastructure that is close to or beyond its maximum capacity;
- the increase in mean annual temperatures means warmer winters, which will lead to an increase in the spread of diseases such as West Nile Virus and Lyme disease; and,

- along with mean annual temperature increases, freeze-thaw cycles will increase, stressing our roads and bridge infrastructure.

All of these impacts will have significant financial costs and potential liabilities for all sectors of HRM, including the development sector. These costs extend beyond the direct costs of repair and replacement. They can affect future insurance rates or the ability to obtain insurance; decrease property values; and affect long term perception of community resiliency and safety.

In order to address impacts and reduce economic and social risks, the development industry and HRM need to implement a ***risk management approach*** to address the impacts from climate change in a consistent manner. This Guide provides a framework for users to address climate change risk in planning for new developments, and provides a decision-making tool to assist in the selection of preferred strategies using a systematic and defensible process.

This Guide will assist the developer and HRM staff with:

- assessing the risk associated with climate change on a proposed development activity;
- identifying the significance of the risks; and,
- identifying appropriate adaptation (i.e., risk reduction) measures.

Who Should Use This Guide?

Proponents of all new development and infill need to be aware of the projected impact of climate change on HRM, but the Guide is particularly applicable to:

- development in coastal and low-lying areas;
- development at the urban/forest fringe;
- development with on-site services; and
- rural development.

Why Should We Be Concerned About Climate Change?

Global climate change is expected to have significant impacts upon coastal communities due to projected rise in global sea-level and increase in the intensity and frequency of extreme events, and as witnessed during Hurricane Juan, Halifax Regional Municipality (HRM) is no exception. In fact, impacts to HRM include:

- increase in damage to coastal infrastructure, roads, wharves;
- increased incidence of storm and sanitary sewer overflows;
- increased disruption to critical utilities such as power and telephone lines;
- increase in diseases such as Lyme disease and West Nile virus;
- decreased availiability of ground water for homes and businesses; and
- increased risk of forest fires.

All of these impacts can have significant financial and liability costs for all sectors of HRM, including the development sector. These costs extend beyond the immediate costs of repair and replacement. They can affect long term perceptions about the resiliency and safety of our communities; decrease property values; and increase liabilities.

The question arises then, what can deverlopers and HRM do to minimize the impacts of climate change while at the same time enhancing the economic and social values of our communities?

This document lays out a straightforward guide to assist developers and HRM in asessing climate change risks so that developments are more resilient to climate change.

As HRM moves forward with the implementation of the Regional Municipal Planning Strategy, the Municipality will be developing a Functional Plan dealing with hazards to development. This Functional Plan will include climate change considerations. Implementing this guidance will help developments be more protective of the environment and more resilient to climate change impacts, thereby decreasing long-term risks and the associated costs of such development and increasing the value.

Who Should Use This Guide?

All proponents of new development and infill need to be aware of the projected impact of climate change on HRM, but the Guide is most applicable to:

- development in coastal and low-lying areas;
- development at the urban/forest fringe;
- development with on-site services; and,
- rural development.

The Guide is divided into four modules:

Module 1 provides an overview of climate change
Module 2 describes the predicted impacts on HRM relevant to development projects
Module 3 provides a step-by-step approach to assessing the risk
Module 4 provides a checlist that can be used in the planning and evaluating of development proposals.

Module 1: Climate Change

1.1 Climate System

Climate can be defined as average weather measured over a period of time.

The Earth's climate is affected by the atmosphere, the oceans, sea ice, the land and rivers and lakes (Figure 1-1), the Sun and its output; the Earth's rotation, and the Sun-Earth angle and orbit around the sun.

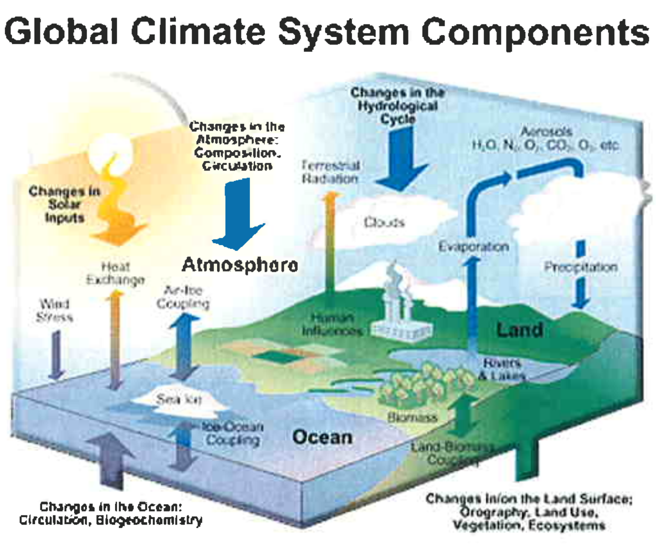


Figure 1-1 Climate System Components

When heat from the sun enters and leaves Earth at the same rate, the climate system stays in balance and the average temperature remains relatively constant. If there is a change in the rate at which heat either enters or leaves the system, or in how that heat is distributed, the balance is upset.

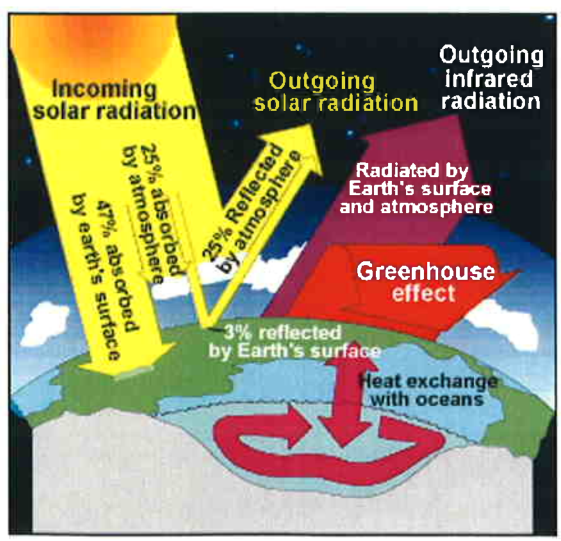


Figure 1-2 Radiation Balance

The Earth's atmosphere contains naturally occurring "Greenhouse Gases" (GHGs) such as water vapour, carbon dioxide, ozone, methane and nitrous oxides, as well as man-made GHGs. These gases trap heat in the Earth's atmosphere. This results in the "greenhouse" effect (Figure 1-2). Without this natural greenhouse effect, the average temperature of Earth's surface would be 33°C colder than the present 15°C.

1.2 A Natural Cycle or Climate Change?

Climate change refers to long-term changes in mean temperature, annual precipitation and weather events such as storm frequency or intensity. Climate change can be as a result of natural and/or man-made causes. Natural changes are generally well understood. For example, dust and ash from volcanic eruption can lower overall temperature by several degrees over a short period of time.

By releasing more GHGs, especially carbon dioxide (CO_2), into the atmosphere through human activity, such as burning of fossil fuels, the natural balance is disrupted. The oceans and the forests absorb CO_2 but at the moment, so much extra CO_2 is being added by human activity that these "carbon sinks" cannot handle the extra amount. The result is warming of our atmosphere.

Scientists have discovered that the addition of ever-increasing GHGs to the atmosphere due to human activity since the Industrial Revolution (approximately 150 years ago) has "warmed" the atmosphere by 0.5 to 1°C. This warming trend can be clearly seen in Figure 1-3.

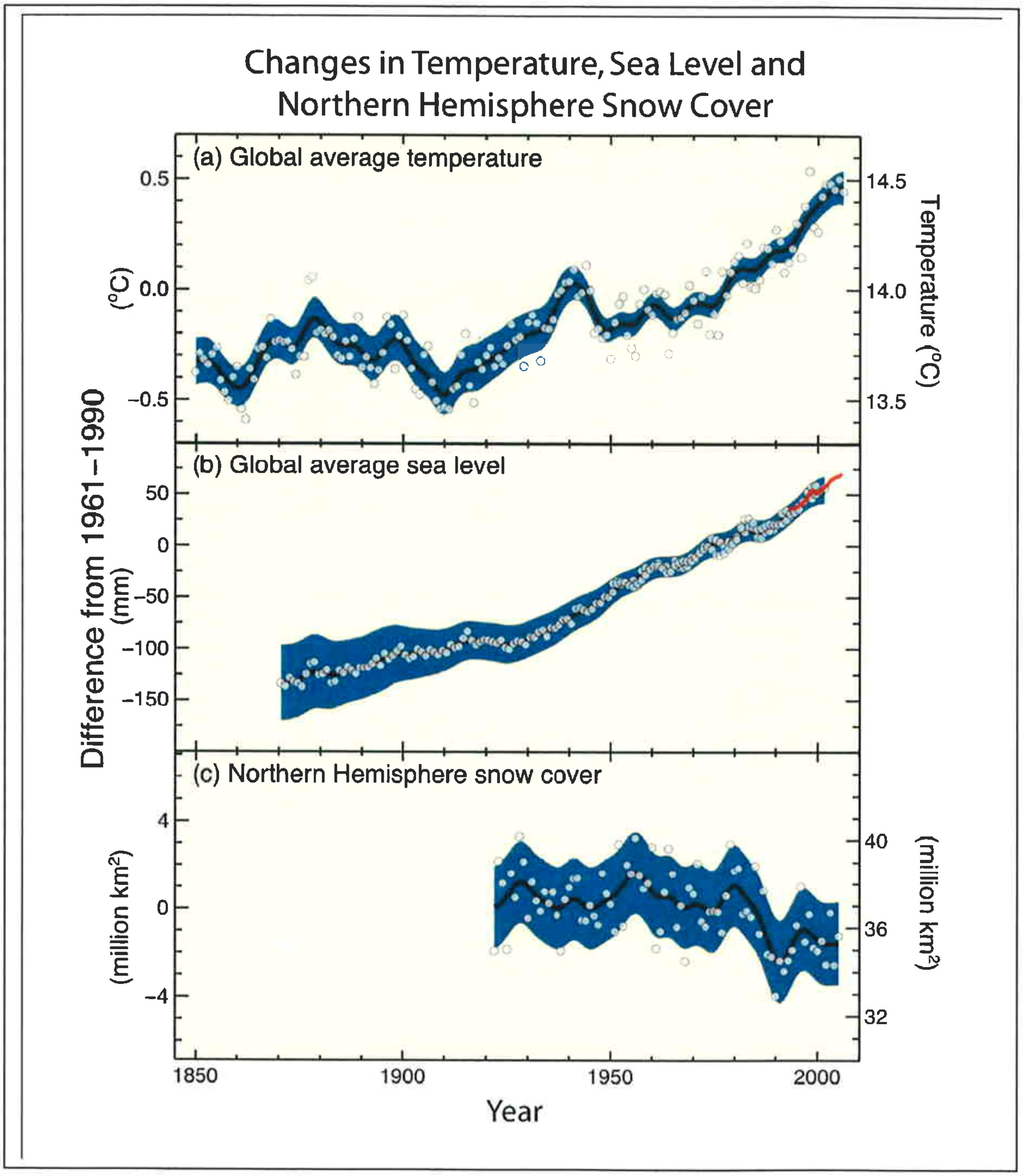


Figure 1-3 Changes in Temperature, Sea Level and Northern Hemisphere Snow Cover

Figure 1-3 taken from the IPCC Summary for Policymakers (February, 2007) shows average surface temperature; average sea-level rise; and northern hemisphere snow cover compared to the 1961-1990 averages. The circles show annual values. The blue shading represents uncertainty intervals in the trends.

It is believed that this impact on our climate, especially over the past 50 years, has resulted in dramatic changes in weather patterns as well as accelerated sea-level rise globally. Climate change impacts are not only a global issue but an issue that has implications for HRM also. These are further detailed in Module 2.

For Nova Scotia, in general, the long term trend in temperatures (from 1895-1998) shows an increase of approximately 0.5°C since 1895 (Figure 1-4).

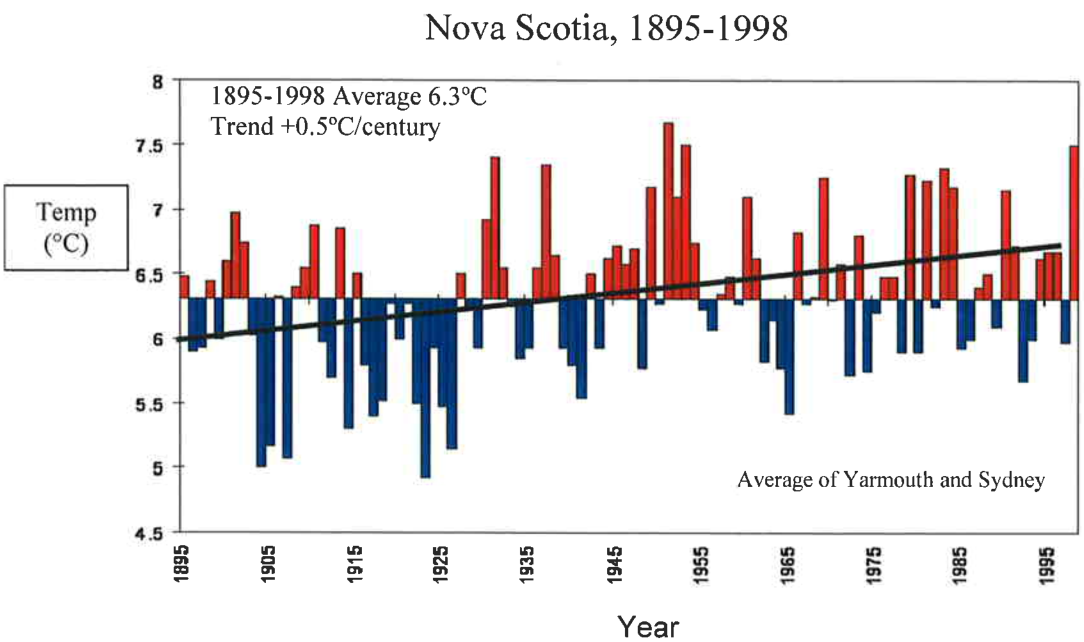


Figure 1-4 Long-Term Temperature Trend – Nova Scotia (Red above average/Blue below average)

For precipitation, the variability across HRM, and between years, makes any trend more difficult to identify at this time. Some areas of Nova Scotia have experienced an increase in total annual precipitation, others less. Snow cover has been generally decreasing.

1.3 Projections of Future Climate

Climate modelers use the most advanced physics and mathematics available today to develop complex climate models. Models are first validated against observed climates and climates of the past, and having passed this and other statistical tests, they are used to project future climates based on future levels of GHGs, which are tied to predicted economic growth. Using this approach, modelers have become confident that they can provide a projection of how the climate will respond to continued human influence on the climate system. Figure 1-5 illustrates an experiment where natural and man-made changes were applied to a climate model and compared to the historical record. When both the natural and man-made influences on climate are considered, the climate model shows the changes fairly accurately.

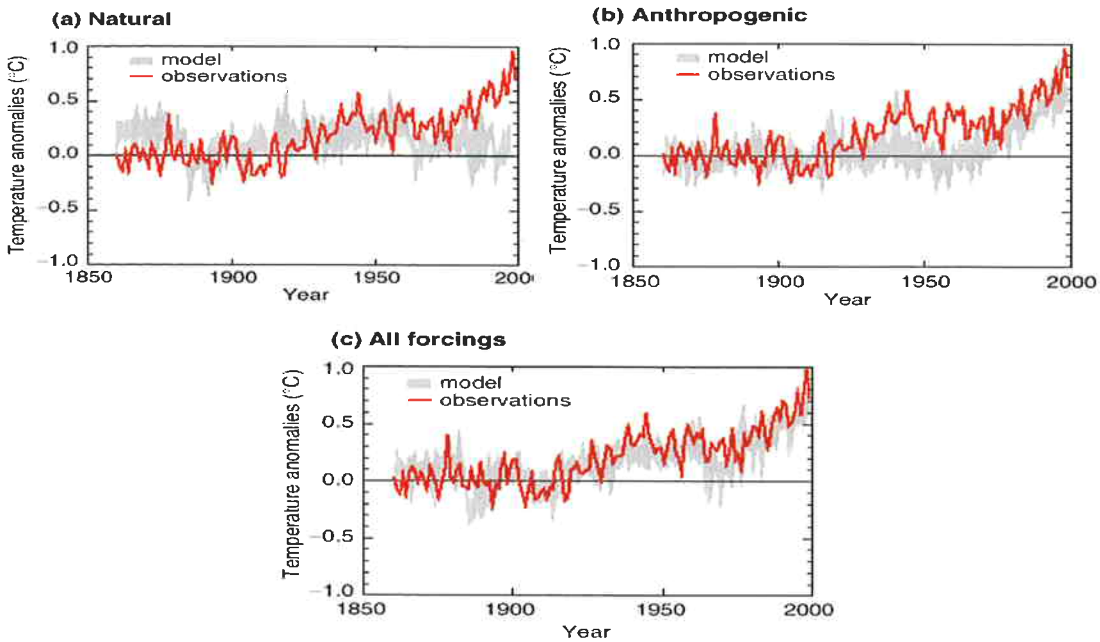


Figure 1-5 Comparison of (a) Natural, (b) Man-made and (c) Combined Temperature Models

The red line represents recorded temperature from 1860 to 2000. The shaded area represents the modelled results: a) natural or no man-made influence; b) man-made influences; c) the combination of both. Note that when both natural and man-made influences are considered in the modelling, the models closely follow recorded temperatures.

General Circulation Models (GCMs) are used to describe how the three main drivers of Earth's climate (i.e., the atmosphere, the oceans and the icecaps) work together to give us our planet's varied climates. Also, they are the only tool available to help us project the impact of changes from future climates. These models, which are generally accepted by the majority of the scientific community, are now providing decision makers around the world with information on anticipated impacts of global climate change, allowing them to develop policies and plans to adapt to the changing climate.

1.4 What are the Likely Impacts from Global Climate Change?

Several United Nations agencies, led by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), established the Intergovernmental Panel on Climate Change (IPCC) in 1988. This Panel summarized the extensive available scientific literature on the state of knowledge of man-made climate change. IPCC has produced three authoritative reports (in 1990, 1995 and 2001) involving several thousand climate scientists and economists from more than 70 countries. A fourth report will be published later this year.

The IPCC identifies what is known, what is only partially known, and the remaining key uncertainties. One uncertainty in projecting future climate lies in estimating the future emissions of GHGs, which depend on future energy sources, as well as economic and population growth rates. At the local or regional scale, research is ongoing to refine the modelling to a smaller scale. The main findings of the upcoming IPCC Report are summarized below.

IPCC Key Messages 2001, 2007

- Warming of the climate system is unequivocal based on observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Strong evidence now exists that warming is attributable to human activities.
- Average Northern Hemisphere temperatures during the second half of the 20th century were *very likely* higher than during any other 50-year period in the last 500 years and *likely* the highest in at least the past 1300 years.
- It is *very likely* that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent.
- For the next two decades a warming of about 0.2°C per decade is projected Even if the concentrations of all greenhouse gases and aerosols kept constant at year 2000 levels, a further warming of about 0.1°C per decade is expected.
- Ranges for global average surface air warming range from 1.1°C to 6.4°C.
- Snow cover is projected to contract.
- Global average sea level rose at an average rate of 1.8 (1.3 to 2.3) mm per year from 1961 to 2003. Sea-level is expected to rise as much 0.8 m in Halifax.
- Coastal communities will be increasingly stressed by climate change impacts interacting with development of and pollution.
- Growth in population and increase in value of infrastructure increase vulnerability to climate change. Losses are protected to increase as the intensity of tropical storms increases.
- Significantly increased precipitation has been observed in eastern parts of North America and the frequency of heavy precipitation events has increased over most land areas.
- There is observational evidence for an increase of intense tropical cyclone activity in the North Atlantic since 1970. This is correlated with increases of tropical sea surface temperatures.
- Based on a range of models, it is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and heavy precipitation.
- Extra-tropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation, and temperature patterns, continuing the broad pattern of observed trends over the last half-century.
- Adaptation is required to reduce vulnerability as the effects of climate change will continue well past the reduction in greenhouse gases.
- Sustainable development can reduce vulnerability by enhancing adaptive capacity and increasing resilience.

Module 2: Climate Change and Halifax Regional Municipality

2.1 Climate-Induced Events in HRM

HRM has experienced a series of weather-related events that have caused considerable social, economic and environmental impacts, including:

- In November 2004, a snow and freezing rain event resulted in a large scale power outage in HRM;
- In February 2004, HRM experienced one of the most severe winter storms (White Juan) in history;
- In the Autumn months of 2003, Nova Scotia experienced four consecutive tropical storms with deleterious impact to marine ecosystems, destabilized watersheds and public works deterioration;
- In September 2003, HRM and Nova Scotia experienced extensive material and environmental damage from Hurricane Juan;
- In March 2003, Nova Scotia experienced infrastructure losses resulting from torrential rains, resulting in flash floods and excessive loads on existing sewer, transportation and dike infrastructure - HRM infrastructure was similarly impacted; and,
- In January 2003, HRM experienced a rapid ice storm, resulting in felled trees on streets and buildings, and black-outs from downed power lines. Non-budgeted debris removal and infrastructure repair costs were considerable.

Costs to HRM and its residents from these events were significant. Although not broken down by municipality or sector, these events are estimated to have caused in excess of $25,000,000 in damages in HRM.

2.2 Impacts of Climate Change in HRM

Temperature and precipitation changes have been modeled by Environment Canada. Results show that mean annual temperature will increase by 4-5°C by 2100 and annual precipitation amounts will increase by up to 7% or 100 mm.

In addition, flash floods, tropical storms and hurricanes, storm surge and anticipated droughts will continue to challenge the sustainability and public security of HRM's residents and businesses.

Climate change impacts predicted for HRM include:

- Increase in the magnitude and intensity of precipitation/ temperature levels and extreme events (e.g., floods, storms), and increase in the intensity of hurricanes affecting HRM.

- Increase in incidence of vector-borne diseases, such as West Nile virus.
- Increasing vulnerability of communities and infrastructure in coastal areas within HRM to erosion, flooding, sea-level rise, extreme events and associated storm surges.
- Increased maintenance requirements for HRM's parklands and green spaces due to drought, flood waters and infestation of pests, such as the brown spruce long-horn beetle.

Details on projected impacts specific to HRM can be found at:
www.halifax.ca/climate/index.html

BECAUSE OF CONSIDERABLE COASTAL RISK FROM CLIMATE VARIABILITY AND EXTREMES, HRM RESIDENTS AND BUSINESSES WILL NOT BE ABLE TO ADEQUATELY RESPOND TO THESE THREATS WITHOUT INCORPORATING RISK MANAGEMENT, CLIMATE CHANGE ADAPTATION, AND EMERGENCY PREPAREDNESS AND RESPONSE CONSIDERATIONS INTO DAILY ACTIVITIES AND COMMUNITY PLANS.

The following tables provide an outline of the anticipated climate change impacts on the socio-economic sectors in HRM relevant to land development.

Sector	Example Impacts
Communities, Infrastructure and Transportation	
a) Impact on Infrastructure	• Possible intensified damage and disruption to coastal infrastructure, essential services and communications from extreme events, sea level rise and storm surge flooding. • Possible increased overflow incidents from storm sewers and combined sanitary systems unable to deal with more frequent, high-intensity rainfall and storms. • Changes in distribution and range of river and coastal ice, compounded by break-up and extreme events, will likely increase damage to river and coastal infrastructure. • Buried municipal infrastructure in coastal areas at risk of being inundated or damaged by sea-level rise. • Possible increased damage and disruption to vulnerable critical services, utilities and other infrastructure, including power outages and disruption of communications, due to extreme events.
b) Impacts on Built Infrastructure	• Possible increased incidents of structural failures. • Projected increased insurance costs associated with damage to vulnerable infrastructure and buildings or loss of insurance in future.
c) Impact on Land Use Planning	• Increased uncertainty in human settlement patterns and urban planning due to climate variability, sea-level rise and impacts from extreme events. Much of the coastline in HRM is sensitive to the effects of sea-level rise combined with extreme events. • Indications are that some low-lying communities in HRM will be flooded more frequently and the floods will become more severe. • Anticipated increased economic and social costs associated with adaptation by vulnerable coastal communities.
d) Impact on Transportation Infrastructure, Operations and Maintenance	• Projected increase in the frequency and unpredictability of break up of ice on rivers, and flooding with associated change in patterns of damage to property, highways, and bridges. • Anticipated increased costs for road maintenance related to pavement softening and traffic-related rutting. • Potential for increased cracking and deterioration of pavements related to frost action and increase in number of freeze-thaw cycles.

Sector	Example Impacts
	• Anticipated increased costs for road construction and maintenance.
e) Change in Recreational Activities	• Projected sea level rise highly likely to reduce, or modify, or eliminate existing recreational beaches. • Potential direct and indirect effects on tourism through beach loss, impacted infrastructure, and ecosystem degradation.
Coastal Zones	
a) Change in Natural Erosion, Migration, and Deposition Patterns (incl. Beach Dunes)	• Rising sea level likely to expose coastlines to increase damage from wave action, and intensify rates of erosion. • Potential for increased variability in shore-line dynamics with potential changes in shoreline advance or erosion, and resultant impact on distribution of beaches.
b) Changes in Current Flooding Patterns	• Sea level will rise in Atlantic Canada over the next century with the result that storm surges in HRM are likely to inundate areas never before flooded. • Sea-level rise and storm surge likely to result in the inundation of low-lying coastal lands. • Potential increases in the extent and location of marine pollution associated with stormwater run-off.
Human Health	
a) Change in Use and Capacity of Public Health System	• Persistance of foreign diseases will likely increase; • Stress and over-loading of the capacity of public health system, from the cumulative effects of extreme events, introduction of foreign diseases, and break-down in essential services such as electrical power and communications during or following extreme events.
b) Change in Incidence, Distribution and Severity of Vector (animal, bird, insect) and Flood Borne Disease	• Incidents and distribution of vector-borne diseases (e.g., Lyme disease, West Nile virus) and flood borne diseases will likely increase as a result of changes in temperature, precipitation, and extreme events.
c) Change in Respiratory Disorders	• Possible increased incidents and distribution of respiratory disorders associated with increases in temperature and air pollution (strong connection between higher daily temperatures and the potential for smog).
d) Change in Illness, Stress, Injury and Casualty Rates	• Health impact of thermal extremes (death and illness in vulnerable sectors of the community including the elderly, frail and ill); • Incidents of health impacts associated with extreme weather events and other natural hazards (deaths, injuries, infectious diseases, stress-related disorders,

Sector	Example Impacts
	adverse health effects associated with social disruption, environmentally-forced migration). Extreme events such as heat waves are projected to be more numerous in HRM.
e) Change in Eye and Skin Disorders	• Increased incidents of disruption to the immune system and increased incidents of skin cancer and cataracts in the eyes due to changes in levels of ultra-violet radiation.
f) Change in General Public Health by Food-Borne Diseases	• Possible increased incidence of food-poisoning and intestinal tract ailments associated with spoiled food in summer temperatures. • Seafood affected by increased levels of pollution associated with run-off events of increased severity. • Anticipated increased incidence in toxic algae blooms from change in sea level, temperature, and sediment in precipitation runoff.
Water Resources	
a) Change in Surface Water Supply and Quality	• Potential for increased variability in the quality and quantity of water resources. • Possible increased variability in water supply, affecting energy production (hydropower), domestic and industrial water supplies, agriculture production and pollution events and extent. • Anticipated increases in both intense rain events and sea level rise places HRM at risk for reductions in surface water quality from run-off, flooding, pollution, evaporation, decreased flow. • Potential for cumulative effect of increased consumptive use of water linked to regions with significant growth in population.
b) Change in Ground Water Supply and Quality	• Potential for increased incidents and distribution of environmental and water contamination primarily related to agricultural run-off (i.e., manure) and water management (e.g., well-head and water quality management). • Changes in temperature and precipitation likely to alter recharge to groundwater aquifers, causing shifts in water table levels in unconfined aquifers. • Possible increased incidents of salt-water intrusion in coastal aquifers affecting potable and agricultural groundwater supplies. • Potential for increased incidents of aquatic pollution associated with runoff and flooding. •

Sector	Example Impacts
c) Affect on Aquatic Life from Precipitation	• Potential increase in surface water temperatures affecting trout and salmon habitat. • Potential decrease in groundwater flows resulting in higher water temperature and poorer water quality of surface waters.
Forests	
a) Change in Soil Erosion Potential	• Increased soil erosion and run-off as a result of changes in temperature, precipitation and wind likely to impact habitat, wildlife, and sediment in storm run-off.
b) Change in Forest Fire Potential	• Anticipated increase incidents and range of forest fires due to changes in temperature and precipitation bringing about extended hot dry conditions.
c) Change in Sustainable Forest and Wildlife Habitat	• Potential for increased variability in forest structure, composition, productivity, and regeneration as a result of changes in temperature, precipitation and wind. Warmer and more humid climate could increase the numbers of local and exotic forest pests.
d) Change in Pest Populations	• Potential for increased variability in incidents and locations of pests, and on the pest cycle, and rate of infestation. For example, the Gypsy Moth has rarely caused more than trace defoliation in Atlantic Canada. However, it likes hardwood foliage and is potentially a risk to these species. Winter temperature increase is a critical limitation to development and survival of this moth, as eggs are killed on prolonged exposure to temperatures at or below -9°C, (exposure at -23°C for even short periods is lethal). • Possible increased risk of invasive species, especially as winter temperatures rise. Potential changes in range and distribution of invasive species. Changes in precipitation and temperature significantly affect the impacts from invasive species.
Environment	
a) Change in Abundance and Distribution of Wildlife Populations	• Possible changes in the distribution, range and number of birds and other wildlife depend on habitat affected by climate change. Up to a certain point, living organisms can adapt to natural stresses such as new climatic conditions. More resistant species may survive, others will have to migrate if they can, whereas still others will disappear and be replaced by different species that are better adapted to the new conditions. Wildlife is sensitive to climate variations. Mild winters will enhance the reproductive capacities of some species, leading to a gradual northward expansion of their populations.

Sector	Example Impacts
	• Anticipated changes in biodiversity. • Projected increased stress on native species due to invasion/migration of alien species without natural controls.
b) Change in Abundance and Distribution of Isolated Populations and Ecosystems	• Projected increased stress on isolated wildlife populations and ecosystems, such as protected areas that are ecosystem "islands", which will likely threaten the sustainability of the species or ecosystem.

c) Change in the Migration of Species (i.e., Coastal Water-Fowl)	• Anticipated changes in river flow - earlier break-up, stronger spring flows, and reduced summer flow could:
	  • alter the migration patterns of species, particularly waterfowl due to changes in coastal wetlands from temperature, precipitation, season, and sea level.
	  • further threaten certain endangered species (for example ducks and aquatic species).

Module 3: Assessing the Risks from Climate Change

3.1 Overview

The complexity of assessing a course of action where there are uncertainties about the needs, or actions necessary to adapt to climate change requires the use of an approach decision makers can follow in a consistent manner. A risk management process, therefore, provides a framework for managing the selection of adaptation strategies for those aspects that create or increase a risk to HRM, its citizens, infrastructure, economies and environment.

The process also provides a decision-making tool that assists in the selection of preferred alternatives using a systematic and defensible process.

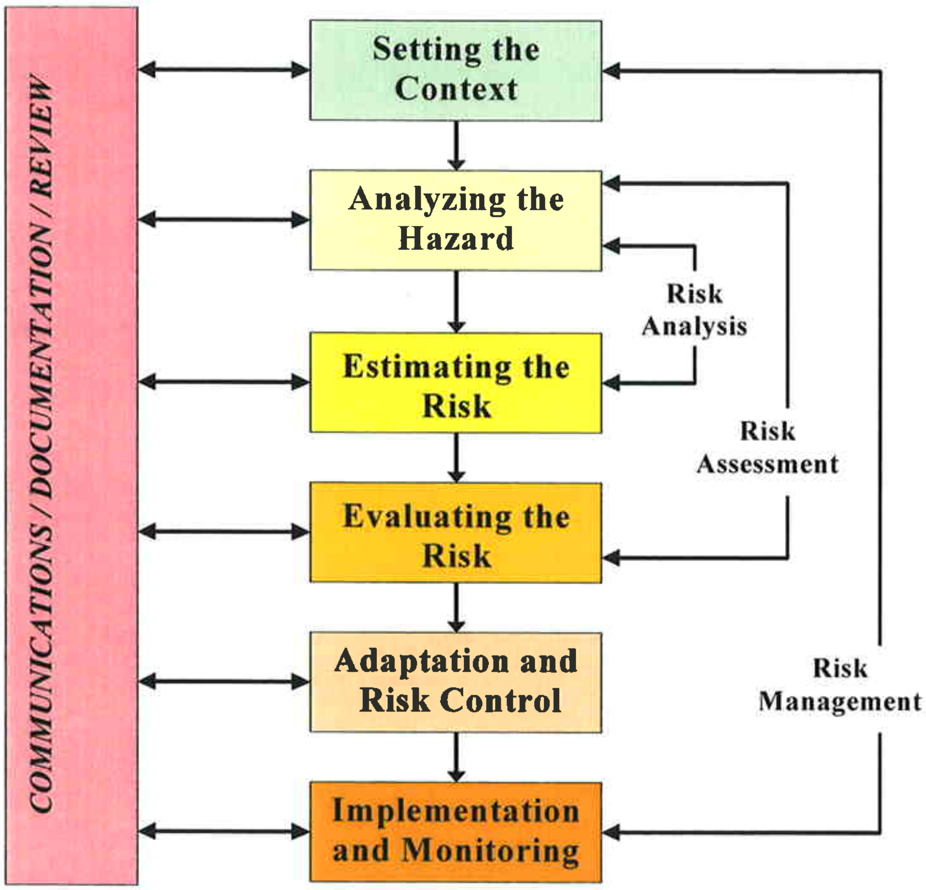
A risk management approach will assist the developer and HRM staff in:

a. undertaking an assessment of the risk associated with climate change that may affect a proposed development activity;
b. identifying the significance of such risks; and,
c. identifying appropriate adaptation (i.e., risk reduction) measures.

3.2 Approach

This guide adopts a methodology based on the Canadian Standards Association's *Risk Management: Guidelines for Decision-Makers (CAN/CSA-Q850-97)* and the *Caribbean Risk Management Guidelines for Climate Change Adaptation Decision Making,* and consist of the steps shown in Figure 3-1.

Figure 3-1 Steps in the Climate Change Risk Management Process



3.2.1 Step 1 – Setting The Context (Define Project And Alternatives)

- **Objective:** Clearly describe proposed project, identify alternatives to project and approaches to implementation.

- **Information needs:**
  - Project information: plan(s), design(s), costs, expected benefits.
  - Project scope: spatial and temporal boundaries.
  - Site information: location, environment, hazards, development and social setting.

- **Process:** Prepare project description and information on the site(s) identified, as per requirements of HRM planning department, with natural hazard-related information added, as necessary.

- **Responsibility:** Developer

3.2.2 Step 2 - Analyzing The Hazard

- **Objective:** Preliminary identification of significant climate change hazards and hazard impacts to inform estimation and evaluation (Steps 3 and 4).

- **Information needs:**
  - Prevalent climate change hazards in project's zone of influence—frequency, distribution and magnitude. Climate scenarios (***See Module 2***)
  - Characteristics of the project—the site, structures and processes (from Step 1).
  - Determine the vulnerability of the project.

- **Process:**
  - Using existing information (Module 2) and expert knowledge (Environment Canada, Consultants), estimate frequency or probability of hazard events (initial hazard identification).
  - Estimate severity of impacts on the project components and zone of influence (initial assessment of vulnerability).

- **Responsibility:** Developer with advice from professionals with climate expertise.

3.2.3 Step 3 – Estimating The Risk

a) Estimating Frequency or Probability of an Event

- **Objective:**

Determine the relative frequency with which the various risk scenarios can be expected to occur over a given period of time.

- **Information Needs:**

Typically this can be based on historical data and climate change projections available from a number of sources including Environment Canada; scientific studies and research papers.

- **Process:**

Such data should indicate how often particular risk scenarios have occurred in the past and this is used together with climate scenarios developed by Environment Canada, to determine probable risk scenarios arising from future climate.

The "Frequency or Probability Rating" shown below in Table 1 and the "Risk Assessment Matrix" following in Table 2 can be used to define the magnitude of potential risks.

Table 1: Frequency/Probability Rating

Hazard	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
Hazards from risk scenario (deal with each separately)	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

b) Estimating Severity of the Impacts

- **Objective:**

Determine the potential health, property damage, environmental and financial impacts of risk scenarios.

- **Process:**

Develop an impact severity rating scale appropriate to the risk scenarios such as the table shown below:

Table 2: Impact Rating Matrix

Impact Degree	Social factors				Economic factors			Environmental factors			
	Displace-ment	Health	Loss of Livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air	Water	Land	Eco-systems
Very low											
Low											
Moderate											
Major											
Extreme											

- **Responsibility:** Developer with advice from Environment Canada and risk specialists.

3.2.4 Step 4 – Evaluating The Risk

- **Objective:** Fully assess and characterise significant risk scenarios, their potential impact on the project and potential effects on those hazards introduced by the project.

- **Information needs:**
  - Baseline data;
  - Hazard studies and maps indicating past incidence (the past record may inform the process but the user should consult climate change scenarios);
  - Factors influencing hazard occurrence; and
  - Climate change scenarios.

- **Process:**
  - Establish baseline;
  - Predict impacts;
  - Evaluate management, mitigation and adaptation options;
  - Select preferred alternative; and
  - Determine feasibility.

- **Responsibility**: Developer to undertake assessment, including detailed vulnerability assessment (Quantitative Analysis), where data allows, otherwise complete a qualitative analysis using specialists (natural hazards, engineering, social), as appropriate.

Example of the evaluation that should be undertaken during this stage in the process:

- Is there a water resource management program – including infrastructure – that will be significantly impacted by changes in rainfall patterns, increased evaporation, and reductions in ecosystem resilience brought about by climate change?
- Is any greenbelt or nearby agriculture likely to be significantly impacted by changes in rainfall patterns, reductions in ecosystem resilience brought about by climate change, or changes in incidents in agricultural pests and diseases resulting from climate change?
- Is any pollution prevention program likely to be significantly impacted by reductions in ecosystem resilience brought about by climate change?
- Is any coastal infrastructure to be significantly impacted by sea-level rise, increased storm events, or flooding?
- What are the social, human health, ecological and economic impacts associated with damage to any coastal infrastructure resulting from sea-level rise, increased storm events, or flooding?

As an example, in order to evaluate potential flood hazard resulting from climate change, the developer needs to determine:

- What are the likely climate change scenarios for flooding?
- Which areas are likely to be affected by flooding?
- How often will the floodplain be covered by water?
- How long will the floodplain be covered by water?
- At what time of year can flooding be expected?

- Where are the floodplain and flood-prone areas are?
- Can the development be re-designed or relocated to avoid any flooding risk?

3.2.5 Step 5 – Adaptation And Risk Control

<u>Adaptation Planning and Management</u>

According to the Intergovernmental Panel on Climate Change (IPCC), "adaptation is defined as: *Any adjustment - whether positive, reactive, or anticipatory - that can respond to anticipated or actual consequences associated with climate change. It thus implicitly recognizes that future climate change will occur and must be accommodated in policy. It is concerned with responses to both the adverse and positive effects of climate change* (IPCC, 1996, *p. 831).*

There are various ways to classify adaptation strategies. First, depending on the timing, goal, and motive of its implementation, adaptation can be either *reactive* or *planned.* Reactive adaptation occurs after the initial impacts of climate change are apparent, while planned adaptation takes place before impacts are apparent. Second, adaptation may be considered to be *incremental* or *deliberate.* Incremental adaptation occurs without a decision-maker; for example, individuals increasing the use of air conditioning due to gradually increasing summer temperatures. While deliberate adaptation arises from informed and strategic actions. Deliberate adaptation is the result of a strategic policy decision based on the awareness that conditions have changed or are about to change, and that action is needed.

The suitability of a particular adaptation strategy or plan depends on local conditions, priorities and choices. Adaptation involves preparing institutional structures (policies, laws, organizational capacity), developing expertise, implementing appropriate management mechanisms, and building knowledge. These are relative slow processes that require adequate capacity building at all levels; but to be effective, there should be no delay in their initiation. Planning for climate change greatly reduces the potential cost of reactive adaptation responses at a later date when resources and other constraints limit the range of adaptation options available. The long lead time associated with climate change response requires planned adaptive strategies to explicitly confront the large uncertainties relating to the nature, scope and intensity of climate change impacts.

Rather than viewed as an impediment or cost issue, adaptation measures should be viewed as actions that will result in benefits independent of climate change. What does adaptation look like in practice?

- Adaptation proceeds in a rational fashion;
- Adaptation is not a response, but instead is a portfolio of responses;
- Adaptation is a shared responsibility between developers and HRM; and
- Adaptation links the needs of today with the expected challenges of tomorrow.

Environmental management plans are generally not developed as part of the development planning process in HRM at the current time; however, a ***Climate Change Adaptation Plan*** should be developed as part of the development plan submission to address significant impacts from climate change that will affect the project (including project activities and project area of influence). The plan should define adaptation measures that will be established to address climate change impacts relevant to the development as identified in the previous steps. Key elements to be considered in the development of a ***Climate Change Adaptation Plan*** are provided in Module 4.

Adaptation planning and management regimes have been broken down into four principal types of strategy for adapting to the effects of climate change, namely:

Strategy 1 - Prevention Of Loss, Tolerating Loss (Enhancing The Resilience Of Natural Systems), And Spreading/Sharing Loss

- ***Prevention of loss*** involves pro-active actions to reduce the susceptibility of a development to the impacts of climate.
- ***Tolerating loss*** (includes enhancing the resilience of natural systems) involves situations where adverse impacts are accepted in the short term because they can be absorbed by natural systems without long term damage.
- ***Spreading or sharing*** loss involves actions which distribute the burden of impact over a larger region or population beyond those directly affected by the climatic event. For example, certain adaptation actions may be undertaken directly by HRM.

Strategy 2 - Changing Use or Activity

- ***Changing use or activity*** involves a switch of activity or land use to adjust to the adverse as well as the positive consequences of climate change.

Strategy 3 - Relocation

- ***Relocation*** involves situations where the preservation of a development is considered more important than its location, and the development is moved to areas that are more suitable under the changed climate, or the development is reconfigured to be less susceptible to climate change.

Strategy 4 - Restoration

- ***Restoration*** aims to restore a development to its original condition following damage or modification due to climate.

The ***Climate Change Adaptation Plan*** should cover "planned adaptation" management mechanisms (principally changes to the design or building standards) and identify where possible, natural responses to climate change occurring in the ecosystem associated with the development. Examples of adaptation to climate change are provided in the following chart.

Types of Adaptation to Climate Change		
	Anticipatory or Planned	**Reactive**
Natural Systems		○ Changes in length of growing season ○ Changes in ecosystem composition ○ Wetland migration
Human Systems **Private**	○ Purchase of insurance ○ Construction above storm surge levels	○ Changes in farm practices ○ Changes in insurance premiums ○ Purchase of air-conditioning
Public	○ Early-warning systems ○ New building codes, design standards ○ Incentives for relocation	○ Compensatory payments, subsidies ○ Enforcement of building codes ○ Beach nourishment

An additional tool to facilitate assessing the impacts of climate change on a development project is an environmental impact assessment process. Although environmental impact assessments are not generally required for development projects, it provides a stepwise approach to assessing the impacts of the environment, such as climate change, on projects. An example of incorporating climate change considerations through an environmental impact assessment approach is provided in Appendix A.

The ***Climate Change Adaptation Plan*** should be consistent with the climate change policies or plans adopted by HRM and the province of Nova Scotia. ***The Climate Change Adaptation Plan should be developed in consultation and collaboration with HRM's Community Development Department.***

3.2.6 Step 6 – Implementation And Monitoring

- **Objective:** A development design, which incorporates necessary management, mitigation and adaptation measures necessary to address identified climate change hazard vulnerabilities and risks. Appropriate monitoring programmes.

- **Process:**
  - Detailed report outlining development proposal finalized with the results of the hazard and vulnerability assessments.
  - Identified management, mitigation and adaptation measures incorporated into development design and description.
  - Climate Change monitoring program developed and incorporated.

- **Responsibility:** Developer prepares final report, which includes necessary management, mitigation and adaptation measures, and submits to HRM for planning approval.

The Developer should develop a ***Climate Change Monitoring Program*** that is established as part of the ***Climate Change Adaptation Plan***. Such a program should be designed to monitor:

The results from the monitoring program will assist in the development of a database that can be used to provide advice to future development and refine adaptation measures. HRM should develop a Climate Change Monitoring Program that will track across HRM:

- climate patterns affecting the development area; and,
- climate change impacts on key social, economic and environmental indicators.

Module 4: Development and Building Checklist

The following checklist, aimed at developers and builders in HRM, was adapted from the London (UK) Climate Change Partnership.

The following checklist can assist in developing an appropriate **Climate Change Adaptation Plan** for the proposed development:

For Development

- ❑ Construct any new development or infrastructure away from any areas that are at risk from sea-level rise, storm surge, coastal erosion or flooding.
- ❑ Development design shall address flood risk to lands downstream of the development to reduce new flood risks.
- ❑ Development design shall address risks associated with climate change impacts on coastal development, including a sea-level rise of 70 cm for Halifax by 2100, compounded with storm surge of 2.9 m (above chart datum), occurring during any maximum seasonal high tide.
- ❑ Any infrastructure needed to support the development (roads, bridges, utilities, sewage) shall be located and designed to meet projected risks associated with climate change as identified during ***Steps 2-4.***
- ❑ Stormwater design shall consider potential effects of increased storm events. Data on return periods are available from Environment Canada or at: (*www.halifax.ca/climate/index.html)*
- ❑ Minimize areas of ponding (except for ponds required for stormwater control and treatment) in site layout and grading, and if any natural ponds occur in proposed development area, maintain drainage to and from the features.
- ❑ Maximize areas for natural vegetation within the development area, over and above HRM's required Parkland Dedication requirement to enhance natural climate change resiliancy.
- ❑ Maximize retention of trees on lots.
- ❑ If development is unserviced, then provide appropriate measures to address any changes in water quality or quantity that may result from climate change impacts and any assessment undertaken during ***Steps 1-4*** of the groundwater resource.

- Maximize local sourcing of construction and landscaping materials to reduce transport and thereby reduce impacts from emissions.

- Make residents aware of early warning systems and alarms as appropriate, and establish measures to familiarize the community in the proposed development area.

- Design an Evacuation Response Plan and map-out the Evacuation Route, highlighting Safe-Zones and Danger-Zones for any identified emergency (flood, storm, hurricane).

- Bury all utility lines to prevent damage and interruption with essential services during a hurricane or storm.

- Remove only dead, damaged or dying trees in any development area and replant with new trees.

- Protect water catchment areas, including any stream or river that flows through or near the development.

- When establishing any green belts or undertaking landscaping associated with any development:
  - use natural fertilizers to reduce pollution of coastal areas, rivers and streams, thereby increasing the resilience of such ecosystems to stresses from climate change; and
  - only plant local varieties of trees, shrubs and flowers to reduce incidents of invasive pests and exotic species that may be more tolerant to changing climate regimes.

For Buildings in any Development:

- When undertaking renovations or construction for a development, relocate existing buildings or infrastructure away from areas that are at risk from sea-level rise, storm surge, coastal erosion or flooding.

- When building a new housing development, bury electrical and telephone cables underground.

- Install containers to capture rainwater.

- Design facilities for the recycling of water – grey water from sinks can be used in gardens.

- Install emergency power packs/equipment for use in times of power outages from ice or tropical storms.

- Design the internal building layout to support ventilation and cooling.

- ❑ Design buildings to maintain comfortable internal temperatures during times of increased outdoor temperatures, such as through the use of heat exchange/groundwater pump systems.

- ❑ Incorporate passive features for temperature control such as window overhangs/awnings, shutters, reflective glass, and thermal mass.

- ❑ Utilize waste heat from ventilation systems as an energy source.

- ❑ Power cooling and heating systems from local renewable energy sources where possible.

- ❑ Maximize energy efficiency in electrical, heating and cooling systems.

- ❑ Construct "green roofs" to reduce heat build up in urban areas.

- ❑ Select cladding materials that are able to cope with increased winds.

- ❑ Design drainage systems and entrance thresholds to cope with increased stormwater run-off.

- ❑ Employ water-efficient fixtures such as low flow toilets and showerheads, waterless urinals.

- ❑ Promote the construction of new homes and buildings according to energy efficient and environmentally sustainable standards such as the ENERGY STAR level of energy performance, the R-2000 Standard for residential construction, or the EnerGuide 80 rating (Natural Resources Canada).

- ❑ Develop and promote energy upgrade packages for new construction based on Natural Resources Canada's EnerGuide for New Houses service.

- ❑ If supplying appliances, provide ENERGY STAR qualified appliances.

For Buildings and Development

- ❑ Prepare final report, which includes necessary management, mitigation and adaptation measures.

- ❑ Submit to HRM for planning approval with completed checklist.

Appendix A
Incorporating Climate Change in Environmental Impact Assessments in HRM

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Incorporating Climate Change in Environmental Impact Assessments in HRM

In the last three years, guidance documents have been prepared to address the incorporation of climate change in the environmental impact assessment (EIA) process as the EIA process is recognized as a key planning tool for projects that may negatively affect or be affected by the environment.

As deliverables of the Climate SMART project, the guidance documents were tested on a project in HRM that had required an EIA. Based on the findings of the test, a tool or guide was to be developed that would assist in the incorporation of climate change in EIAs of projects within the municipality. The Climate SMART team was provided with an EIA completed for the development of a marina associated with a proposed development in the HRM.

Requirements for EIA of projects that would occur within HRM fall under provincial jurisdiction through the *Environmental Assessment Regulations NS Reg 44/2003* or federal jurisdiction through the *Canadian Environmental Assessment Act*. HRM has no EIA process as part of its approval process. In fact, few municipal activities trigger an EIA under the current legislation, unless federal funding or federal approvals are required, such as the Harbour Solutions Project. One area of activity that is not addressed in either the provincial or federal EIA regulations is land development. While these activities can tangentially require an EIA through coastal infrastructure or rate of water withdrawl, the scope of EIA is specific to the trigger. In the example presented here, a proposed marina associated with a proposed development required an EIA due to the requirement for federal approvals under the *Navigable Waters Protection Act* and the *Fisheries Act*. The remainder of the development was not subject to an EIA.

The following tables provide a summary of the review of the EIA completed for the marina against three guidance documents:

- Guide to the Integration of Climate Change Adaptation into the Environmental Impact Assessment (EIA) Process (CARICOM, SPREP, CIDA, 2004);
- Practitioner's Guide: Incorporating Climate Change into the Environmental Assessment Process (Climadapt, 2003); and
- Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners (CEAA, 2003).

The review noted a number of opportunities where climate change could have been included in the assessment for completeness. These include: basic discussion of climate change considerations related to the project; identification of climate change during issues scoping; and consideration of sea-level rise and storm surge in the project design. These findings are summarized in the following framework, together with recommended opportunities to include climate change.

Review of An Environmental Screening Assessment for a Marina Against Incorporating Climate Change Into Environmental Assessment Documents					
Environmental Assessment Step	**Guide to the Integration of Climate Change Adaptation into the Environmental Impact Assessment (EIA) Process (CARICOM, SPREP, CIDA, 2004)**	**Practitioner's Guide: Incorporating Climate Change into the Environmental Assessment Process (Climadapt, 2003)**	**Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners (CEAA, 2003)**	**[1]Environmental Assessment of Marina in HRM**	**Opportunity to Include Climate Change**
Project Description	As a companion step, undertake a climate change vulnerability assessment. Document via an initial screening.	Assess project to determine if climate change is relevant and if so, how best to address in EA.	Not addressed.	No reference to indicate climate change or sea-level rise was included as part of project design.	Climate change, in particular the effects of sea-level rise and storm surge on marina and outfall associated with the treatment plant, should be considered as part of design considerations. In addition, determine if there is potential for salt water intrusion, if on-site water supply is needed.
Scoping	Identify critical issues to be addressed in EA. Assess information needs regarding hazards and vulnerabilities.	Determine how climate change needs to be incorporated into project design, ecological, socio-economic and physical factors.	Address general considerations and readily accessible information. Provide rationale for impacts or no impact.	Climate change not referenced or raised by others during the scoping process.	Issues scoping can 'flag' whether climate change will have an impact on the resources potentially affected by the project and on the project itself.
Identification of Valued Environmental Components (VECs)	Critical issues identified in previous step.	In general, what is considered a VEC without climate change remains a VEC. Potential for additional VECs to be identified based on ecological sensitivity.	Not addressed.	VECs unlikely to change with consideration of climate change.	Not applicable.
Assessment of Impacts	Using project and environmental baseline, assess hazard mapping, factors influencing hazards, detailed vulnerability assessment	Assessment of impacts must extend beyond lifespan of project to include potential effects of climate change on remaining project elements.	Assess impacts on environment from climate change impacts on the project.	No reference to climate change impacts on either the VECs or the project.	Impact assessment can refer to existing information on climate change impacts on marine environment and structures as well as potential vulnerabilities identified in the scoping step.

[1] EIAs are not required for development projects in HRM. The EIA reviewed is an environmental screening of proposed marine works associated with the proposed development in HRM.

Review of An Environmental Screening Assessment for a Marina Against Incorporating Climate Change Into Environmental Assessment Documents					
Environmental Assessment Step	**Guide to the Integration of Climate Change Adaptation into the Environmental Impact Assessment (EIA) Process (CARICOM, SPREP, CIDA, 2004)**	**Practitioner's Guide: Incorporating Climate Change into the Environmental Assessment Process (Climadapt, 2003)**	**Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners (CEAA, 2003)**	**[1]Environmental Assessment of Marina in HRM**	**Opportunity to Include Climate Change**
Identify Mitigation Options	Develop an environmental management plan that includes: (a) measures to manage climate change risks, or; (b) climate change adaptation plan.	Include mitigate measures addressing climate change impacts, including adaptation responses.	Develop impacts management plan. Emphasis on reducing project vulnerability but also addresses broadly reducing risks associated with climate change.	Climate change not considered in discussion of mitigation measures.	Mitigation measures related to potential climate change impacts such as sea-level rise should be included in the discussion. Although not required for the land-based development, a discussion of likelihood of salt water intrusion could be identified and discussed.
Identification of Significant Residual Impacts	Not specifically addressed but incorporated into Assessment of Impacts above.	Apply significance not only to effects from the project but environmental effects on the project. Important that climate change and ecological or social experts be involved in assessment of residual impacts.	Not addressed.	Residual impacts do not include climate change.	Opportunity to include climate change depends on the impacts that may not be mitigatible. For this project, it is likely that impacts resulting from climate change could be mitigated through project design.
Assess Cumulative Effects	Include assessment of projected climate change on project effects and the effects of other foreseeable projects.	Assessment of cumulative effects should be considered if climate change is relevant to the project.	Not addressed.	Cumulative effects not considered.	The cumulative effects assessment section should include discussion of environmental impacts related to climate change and whether they act cumulatively or not with effects from other projects or proposed projects.
Effects of the Environment on the Project	Inherent in the steps described above.	Apply same measures of significance to effects of the environment on the project as used in Impact and Residual Impact Assessment sections described above.	Inherent in steps described above.	Effects of the environment on the project not discussed.	Sea-level rise and storm surge are examples of effects of the environment on the project related to climate change that can be described in this section.
Develop Monitoring Program	Monitor actual impacts and climate.	In addition to monitoring requirements identified during the environmental assessment, also include climate monitoring for	Monitor project and effectiveness of mitigation. Implement remedial measures as required.	Climate change, in particular sea-level rise, not noted.	Sea-level rise and salt water intrusion can be monitored and a monitoring plan should be developed.

Review of An Environmental Screening Assessment for a Marina Against Incorporating Climate Change Into Environmental Assessment Documents					
Environmental Assessment Step	**Guide to the Integration of Climate Change Adaptation into the Environmental Impact Assessment (EIA) Process (CARICOM, SPREP, CIDA, 2004)**	**Practitioner's Guide: Incorporating Climate Change into the Environmental Assessment Process (Climadapt, 2003)**	**Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners (CEAA, 2003)**	**[1]Environmental Assessment of Marina in HRM**	**Opportunity to Include Climate Change**
		aspects that are sensitive to climate change.			
Final Report	Report includes final design, vulnerability and risks, mitigation and adaptation measures, monitoring programs.	Final report not to over-emphasize deficiencies in climate change related data if the omission is not associated with significant impacts.	Not addressed.	Overall climate change is not addressed in the report.	Several areas where climate change can be addressed are noted in the previous sections above.