Climate Change

Adaptation and Flood Management Strategy

June 2013

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Forward

In April 2010, the Cities of Moncton and Dieppe, and the Town of Riverview were selected to participate in the Regional Adaptation Collaborative (RAC) program, which is a cost-shared federal program developed to identify and reduce risks posed by climate change. Under this program, each region of Canada is developing solutions for region-specific issues related to climate change.

The results of this study, which was completed by AMEC, were presented to Moncton City Council in the fall of 2012. In response, Moncton City Council resolved to undertake a climate change adaptation plan and flood management strategy by June 2013.

While efforts to reduce global warming remain important, there is no doubt that our climate is changing. While the City remains committed to reducing its carbon footprint, there is now both the opportunity and the need to anticipate and adapt to our changing climate as well.

This document was prepared by the City's corporate Climate Change Action Committee (CCAC). The CCAC is committed to working with Moncton City Council, the community at large, and our partners at the regional, provincial and federal levels to better understand the implications of climate change and to take action on adaptation strategies, so that the Moncton community and region will continue on a path of resiliency and prosperity.

Jacques Dubé, City Manager
Chair, Corporate Climate Change Action Committee
June, 2013

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City of Moncton
Climate Change Adaptation Plan and Flood Management Strategy

Forward
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What is Climate Change?

The term 'climate change' refers to "the warming of the earth's atmosphere and oceans, in addition to an increase in the natural variability of the climate". *(Municipal Climate Change Action Plan Guidebook, Canada-Nova Scotia Infrastructure Secretariat, 2011)*

Climate change trends indicate that in the future, we are more likely to experience:

- warmer temperatures
- increasing amounts of precipitation
- greater UV exposure;
- sea level rise (higher tides);
- stronger winds, storm surges
- more frequent storm events; and
- more frequent 'extreme weather events' such as heat waves, droughts, and heavy precipitation in the form of rain, snow or ice storms, coupled with strong winds.

What is Climate Change Adaptation?

Climate change adaptation is about taking actions that will help to reduce the impacts associated with anticipated climate change trends, events and hazards. It is also about taking advantage of new opportunities that may be created as a result of climate change.

1 Introduction

In April 2010, the Cities of Moncton and Dieppe and the Town of Riverview were selected to participate in a Regional Adaptation Collaborative (RAC) program, a cost-shared federal program developed to identify and reduce the impacts posed by climate change[i].

Through this partnership, a technical study, prepared by AMEC Earth and Environmental, was produced to help identify climate change trends and what these trends mean for our region[ii]. The AMEC report recognized that in eastern Canada, a main hazard associated with climate change is the increased risk of higher intensity and more frequent storm events, and increased risk of flooding.

In October, 2012, the results of the RAC project were presented to Moncton City Council. Recognizing its importance, City Council requested that staff develop an action plan and flood management strategy by June 2013, based on the recommendations of the AMEC study.

Since the RAC program was first initiated, communities across Canada have become increasingly engaged in how climate change will impact their community and what steps can be taken to adapt to our changing climate. The importance of adaptation action has been echoed by the federal government, which has indicated that Climate Change Action Plans (CCAPs), which include climate change adaptation strategies, will be required in most provinces to access Gas Tax funding[iii] .

As a result of increased attention to climate change at all levels, there is a growing amount of information and resources available to assist communities in addressing this important issue. With climate change adaptation strategies, communities have the opportunity to reduce risks and strengthen community resiliency and adaptation capacity.

2 Developing Moncton's Climate Change Adaptation Plan

This Plan was developed in order to:

1. Better understand the potential risks related to climate change, particularly with respect to more frequent and intense (or extreme) weather events, in conjunction with higher tides in the future;
2. Consider the potential impacts of climate change on City of Moncton operations, including essential services, infrastructure, facilities and assets;
3. Begin understanding the potential impacts of climate change on the community at large, from a social, cultural, economic and environmental perspective;
4. Identify the types of climate change adaptation strategies and actions that will help to manage and reduce risks associated with climate change; and
5. Identify ways in which to increase the adaptive capacity of the Corporation and the community at large.

While this work focused primarily on the potential impacts and vulnerability with respect to flooding risk, the team also considered other potential climate change hazards including heat wave/drought, forest fire, cold wave, ice storm and severe winter storm conditions.

A Risk Management Approach

Managing the risks of climate change involves understanding how our climate is anticipated to change over time, as well as the probability that a serious climate related event is likely to occur.

The team relied upon two key sources of data:

- The Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick report, prepared by AMEC Earth and Environmental (2011). A key strength of this report is well-researched and documented forecast for a 1:100 year storm in the tri-community area, factoring in climate change trends for rainfall and tide levels.
- New Brunswick Climate Futures data provided by the Atlantic Climate Adaptations Solutions Association (ACASA), http://atlanticadaptation.ca/acasa/.

In the fall of 2012, the City of Moncton purchased rights to use emergency management software developed by the Canadian technology company Sentinel (http://www.sentinelsystems.ca/). This software offers a risk assessment tool that was developed with the participation of Public Safety officials and is used by emergency planners in the development of emergency response plans. In addition to furthering the work of the City's Emergency Preparedness Plan, the team used this tool to scope potential climate change related impacts and to better understand the nature of climate change risk for the City.

The team identified many actions that the City of Moncton can take to reduce risk. These actions were reviewed and further prioritized within a Climate Change Flood Management Action schedule.

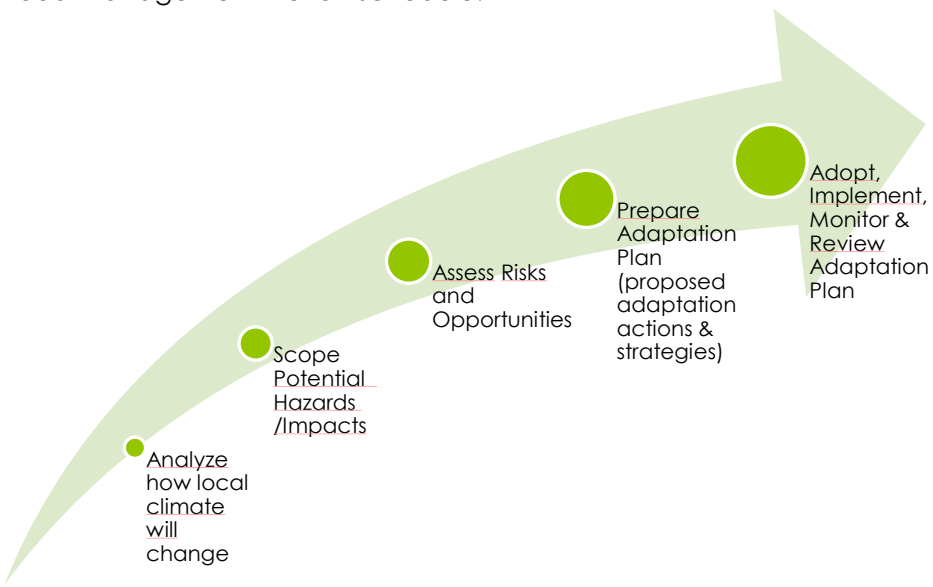


Figure1. Climate Change Adaptation Planning

In developing this plan, the Climate Change Action Committee was conscious of the internal, corporate nature of this exercise. A key short- term recommendation in the Plan is to share the findings of the team's work with a wide range of stakeholder groups and with the community at large, and to engage in a much broader discussion regarding climate change and adaptation strategies at the community level.

Much like the results of the AMEC Study, the results of the team's risk assessment work are not based on certainty and involved having to make a number of assumptions. These assumptions are documented in the Plan, and should be reviewed and updated as new information becomes available through additional research and greater consultation with the community at large.

3 Climate Change Trends

3.1 Temperature and Precipitation

The Atlantic Climate Adaptations Solutions Association (ACASA) has produced projections of future climate scenarios for the Province of New Brunswick using the output from 24 climate models developed by national weather services and research organizations in nine countries across the world. These projections are presented using higher and lower estimates for future greenhouse gas emissions. For the purposes of the team's work, high emissions scenarios were used.

As outlined in Table 1, climate change trends for southern New Brunswick include (but are not limited to):

Temperature:

- Warmer seasonal temperatures and annual mean temperatures
- Increase in extreme heat days
- Decrease in extreme cold days

Precipitation:

- Increase in precipitation levels (rain)
- Increase in precipitation levels of snow in the short and medium term, and a reduction in the long-term.

3.2 Sea Level Rise

While not a climate trend, rising sea level is an important factor that is related to climate change.

Sea level is rising around New Brunswick's coasts, as a result of sea water expansion (from warmer temperatures) and meltwater from land-based glaciers and ice sheets. In many areas, this is compounded by a slow sinking or subsidence of coastal land.

The AMEC Study, prepared on behalf of the tri-community, predicts that over the next century, relative sea level (that is, sea level rise and land subsidence factored together), will gradually increase to a level that is approximately 1 metre higher than what is seen today. Current high tides on the Petitcodiac River of approximately 8 metres are experienced several times each year.

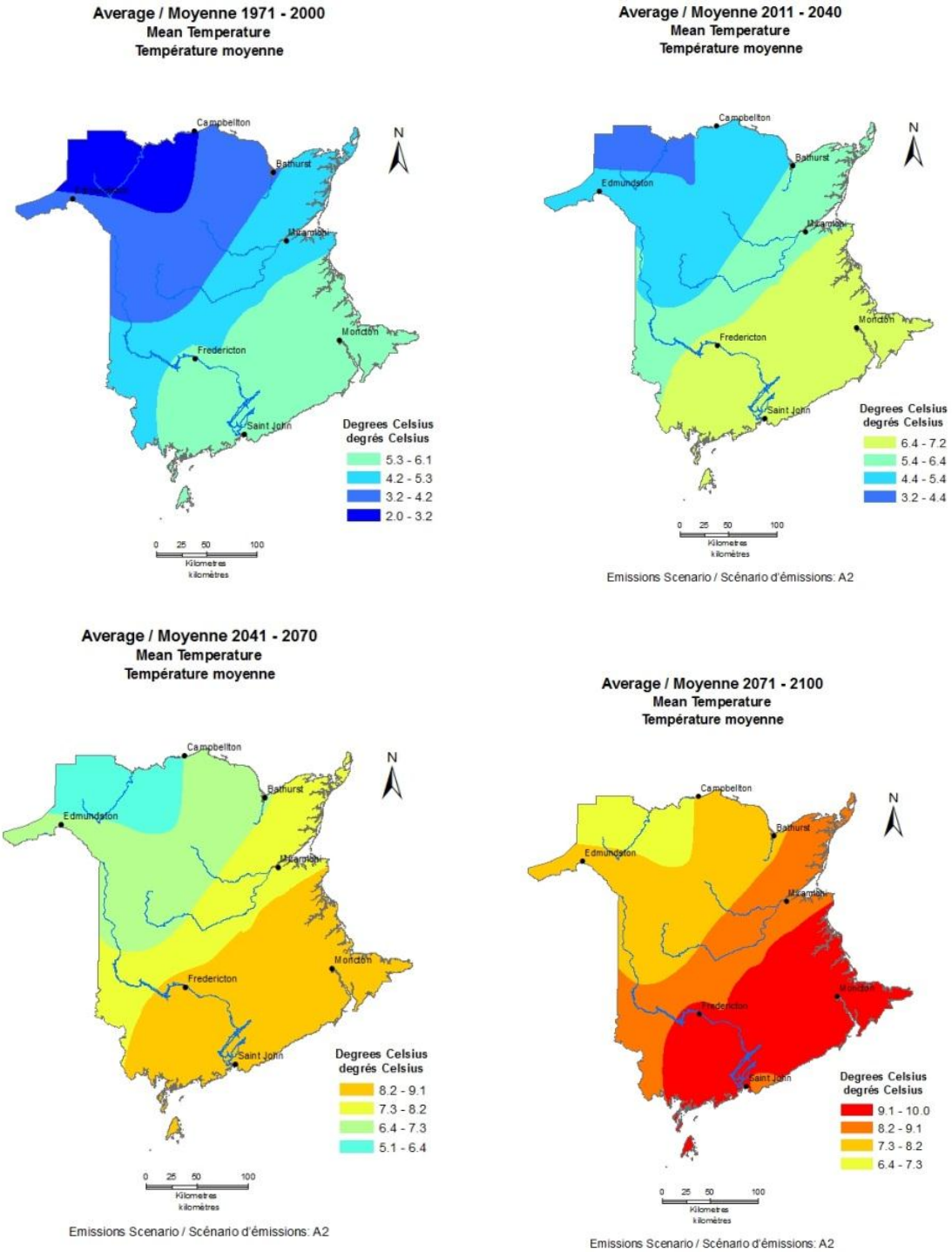
Table 1. New Brunswick Climate Futures (ACASA), 2013 – Southern New Brunswick Climate Change Forecast *(High emissions scenario; temperatures in Celsius; precipitation in millimeters)*

Climate Change Trends	Baseline	Short-term forecast	Medium-term forecast	Long-term forecast
	1971-2000	2011-2040	2041-2070	2071-2100
Mean Temperature Annual	5.3 – 6.1	6.4 - 7.2	8.2 – 9.1	9.1 – 10.0
Mean Temperature Spring	3.8 – 4.6	4.1 – 5.1	5.1 – 6.1	6.8 – 7.4
Mean Temperature Summer	17.3 – 17.8	18.3 – 19.3	18.9 – 19.9	21.1 – 22.0
Annual Number of Days with Maximum Temperature greater than 30 degrees C	4 - 5	8 - 11	10 – 20	26 – 40
Mean Temperature Autumn	7.4 – 8.7	8.1 – 9.1	8.7 – 9.9	11.2 – 12.3
Mean Temperature Winter	-8.5 - -6.4	-7.7 - -5.1	-5.5 - -3.7	-3.7 - -1.9
Annual Number of Days with Maximum Temperature less than -10 degrees C	8 - 14	6 - 12	5 - 9	1 – 3
Annual Total Precipitation	1175 - 1241	1157 - 1217	1180-1231	1231 - 1282
Annual Spring Precipitation	286 - 306	294 – 317	306 – 327	317 - 335
Annual Summer Precipitation	270 – 283	267 – 279	269 - 282	279 - 291
Annual Autumn Precipitation	301 - 325	282 - 309	291 - 309	301 - 325
Annual Winter Precipitation	306 – 348	323 - 373	330 - 366	348 – 380
Total Annual Rain Days	122 - 132	132 - 142	138 - 150	142 - 153
Total Annual Snow Days	45 - 57	51 - 61	53 - 61	39 - 48

Table 2. AMEC Study Results: Anticipated Relative Sea Level Rise over Time

Year	Relative Sea Level Estimate
2025	13 +/- 3 cm
2055	42 +/- 12 cm
2085	80 +/- 28 cm
2100	100 +/- 38 cm

Figure 2. Mean Temperature Scenarios for New Brunswick (ACASA) *By the 2080s, mean temperatures are predicted to increase by around 3-3.5 degrees C. This will mean that northern areas of the province will have a temperature climate similar to that in southern New Brunswick today, while southern areas will become as warm as it is currently is in parts of southern Ontario.*

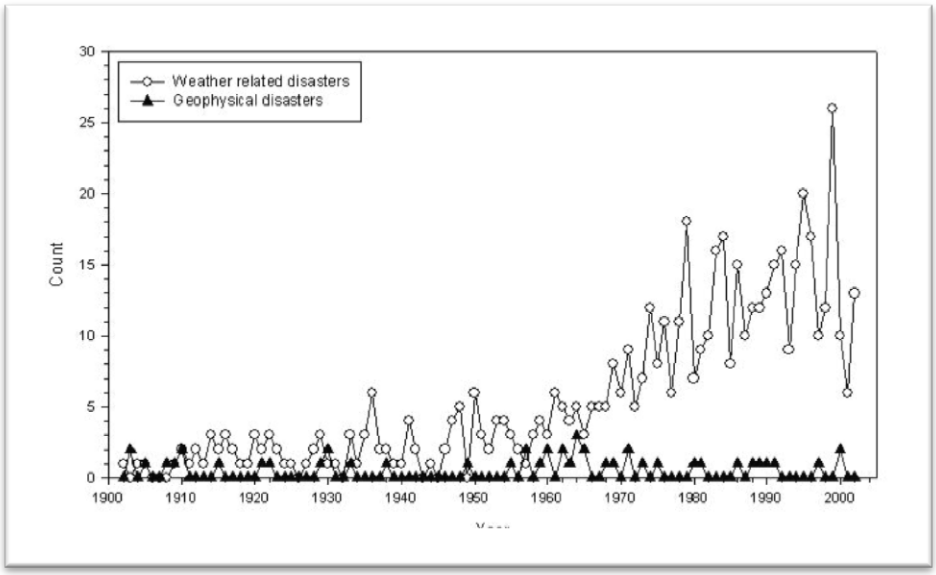


3.3 *Extreme Weather Events*

There is also increasing evidence that Canada is experiencing a greater number of extreme weather events, including heat waves, droughts, storm surges and heavy precipitation.

As detailed in Figure 3, Public Safety Canada has kept records of significant natural disasters for over a century in a Canadian Disasters Database. Since the 1970's, there have been an increasing proportion of weather related disasters (cold waves, droughts, floods, hail/thunderstorms, heat waves, hurricanes/typhoons, avalanches, storms (storm surges, freezing rain, winter storms), tornados and wildfires). A similar increase in frequency however was not noted with respect to geophysical related disasters (earthquakes, landslides and tsunamis).

Figure 3. The Frequency of weather related vs. Geophysical Disasters in Canada
Source: Public Safety Canada (PSC) Canadian Disaster Database (CDD)[iv].



Climate change is expected to affect the frequency, severity and duration of such events. In the future, it is expected that we may experience:

- more extreme heat waves and fewer extreme cold snaps;
- more heavy rains and related storm events (hailstorms, thunderstorms, hurricanes);
- more droughts;
- more intense winter storms;
- more changes in atmospheric circulation which could influence storm tracks and rainfall distribution; and
- large storm surge events.

4 Flood Risk Assessment

4.1 AMEC Study Findings

The AMEC Study was developed to help the Tri-community area to better understand the community's vulnerabilities to flooding, given water related climate change trends (i.e. rising relative sea level, increased precipitation, and greater frequency of extreme storm events with storm surge potential).

There are two types of flooding events which can be experienced in an urban centre. The first type is called a surface or overland flood, where the flood event is noticeable above ground.

The second type of flood event is referred to as a sewer back-up flood event. As in many cities throughout the world, the older portion of the city's sewer system was designed and built as a combined sewer system, meaning that both sanitary sewage and stormwater flow through a single pipe to a treatment facility. Because of the stormwater component in the combined system, cities can experience situations where the combined sewer system will 'back-up', resulting in the potential for basement or underground flooding.

Best practice in flood management is to consider and plan for a 1:100 year flood event. This is an event that has a 1% chance of occurring in any given year, over a hundred year period of time. In preparing for such events, engineers and planners are interested in understanding the potential height or elevation of flooding as a result of such a storm event. As detailed in Table 3, the AMEC Study predicts that the total water level associated with a 1:100 year flood is anticipated to increase over time, as a result of climate change.

In addition to studying 1:100 year flood data, the AMEC Study also considered the potential for a Saxby Gale (1869) type event (a 1:150 + year storm event) to occur again. The Saxby Gale event represented a very rare combination of storm, wind and tidal events, resulting in extreme flood conditions.

Table 3. Projected Water Levels for Selected Planning Horizons (AMEC Study)

Time Horizon	Total Water Level (m)	
	1:100 Year Storm	Saxby Gale
Today	9.25	10.54
Year 2025	9.38	10.67
Year 2055	9.67	10.96
Year 2085	10.05	11.34
Year 2100	**10.25**	**11.54**

4.2 CCAC Flood Scenario Assessments

Based on the findings of the AMEC report, the CCAC team assessed four types or potential flood scenarios for the City of Moncton, as detailed in Table 4.

Table 4. CCAC Flood Assessment Scenario Descriptions

Scenario Name	Flood Elevation (Geodetic)	Description/Significance	Likelihood of occurrence today (Rating by CCAC)
Scenario 1 High-Tide Event (2013)	8 m	Currently, the City experiences an 8 metre high tide, 2-3 times each year. While very little surface flooding will occur under this scenario, should the city experience rainfall at the same time as a high-tide, there is potential for sewer back-up flooding to occur. This scenario does not factor in climate change trends.	Almost certain
Scenario 2 1:100 Year Storm Event (2013)	9.3 m	This scenario considers a 9.3m storm event. This type of event represents the current 1:100 year flood scenario that is used to plan and design the city's major infrastructure. This scenario does not factor in climate change trends.	Likely to Unlikely
Scenario 3 1:100 Year Storm Event (with Climate Change to year 2100)	10.3 m	This scenario considers a 1:100 year storm event factoring in climate change trends to the year 2100. This scenario coincidentally comes close to the elevation of the Saxby Gale flood if it were to reoccur today (10.5 m). Current Zoning provisions require that new habitable floors be constructed to address a 10.2 m potential flood elevation.	Unlikely in 2013 Likely in 2100
Scenario 4 Saxby Gale Event (with Climate Change to year 2100)	11.5 m	This scenario considers the scenario of a Saxby Gale type event occurring in Year 2100 factoring in climate change.	Rare

In assessing vulnerability to flooding, the team considered both:

- the **probability** for a flood event to occur (either sewer-back up flooding or surface flooding); and
- the **severity** of the impacts likely to be experienced as a result of the flood event.

Two main tools were used to assist with its assessment:

1. Each scenario was developed and studied by the CCAC through the use of an integrated GIS (Geographic Information Systems) mapping product, which allowed the team to overlay various flood scenarios on a variety of mapping data layers (transportation, essential infrastructure, civic facilities, parks & open space, land use and zoning layers, etc…).

2. The team used *Sentinel* emergency management software to generate risk profiles for each scenario, based on a detailed assessment of both probability and potential impact.

In assessing the probability of each type of flood scenario, the team considered:

- whether the event occurs regularly in the community or is considered a chronic concern;
- the extent to which the event has been observed in the past (and how far into the past the event took place); and
- the extent to which there is evidence suggesting that the event will take place in the future (and how soon the event is likely to take place).

Through the use of the AMEC Study and the Sentinel approach, a range of potential flood related impacts were studied for each scenario (See Table 5). Considerations included:

- duration of the impact;
- geographical extent of the impact;
- extent to which the community is generally vulnerable or sensitive to the impact;
- magnitude of the impact from a socio-economic standpoint;
- extent to which the impact can be mitigated or reversed; and
- extent to which communication systems are impacted.

A detailed summary of the team exercise is included in Appendix 3.

Table 5. Potential Impacts Related to Flooding Events

Potential impact	Description
Water levels	the effects of rises in water levels rendering parts of the community inaccessible or isolating certain sectors, or causing damage to built infrastructure, business or homes;
Storm surge	effects of storm surges (causing water to pile up higher than the ordinary sea level)
Erosion	erosion of river and stream banks (leading to an undermining of transportation and other built structures);
Fires	fires that might threaten people and/or important installations or critical infrastructure;
Pollution (soil-water)	temporary, long-term or permanent contamination of the soil or water (e.g. hazardous materials);
Water/Sewer Contamination	or when the sewage system gets backs up;
Large Infrastructure	infrastructure such as bridges, dams, power generating stations and electrical transmission towers, etc…
Emergency Services	loss, degradation or reduction in emergency services, including the 911 system, fire, police, ambulance and hospitals.
Essential Services	including power, water, sewage, telecommunications, IT, and potential impacts on health and economy of community
Major Transportation links	airports
Food/Water Security	effects on ability to transport, protect and secure food/water during and after a flood event
Roads or Route Denial	effects on road links and rail system during and after an event
Structures	effects on structures (public and private), both temporary and long-term

Table 6 presents a summary of the risk assessment exercise, and the types of impacts that were deemed to be more important in each scenario. The overall risk profiles for each scenario are illustrated in figure 3.

Scenario 1: High-Tide Event (2013)

This first scenario describes a situation where the City is experiencing 2013 high-tide levels.

As illustrated on Map 1, surface flooding in this scenario is limited to the very low-lying parts of the city (areas below an 8 metre geodetic elevation). Most of this land is undeveloped and as such, the potential effects from surface flooding on structures, property and assets are very limited.

The main risks created by this scenario relate to potential sewer-back up or basement related flooding. Because of the combined nature of the sewage system, there is potential for a sewer-back up event to occur during a rainfall event at high tide. The rainfall event need not be very large for such an effect to be created at high tide. Without proper protection for existing buildings in areas affected by a sewer-back-up, there is increased risk of basement flooding, resulting in potential damage to structures.

While the effects of erosion on the banks of rivers, lakes and streams in Moncton were considered to be relatively low in this scenario, it was noted that erosion is a type of phenomenon which cannot be easily reversed. Monitoring is therefore recommended.

Overall, this scenario received the highest probability rating of all four flood scenarios and the lowest overall severity rating. While the city as a whole may not necessarily feel the impact of this type of scenario, individual homeowners and businesses experiencing a sewer back-up will. It is also important to note that this scenario does not factor in the climate trend for sea level rise. As sea levels rise over time, a greater number of properties in the city will be at risk of overland flooding as well as sewer back-up and related property damage.

The risks associated with sewer-back up can be effectively reduced through the installation of back-water valves.

Map 1

Scenario 1: High-Tide Event (2013)

8 m Flood Elevation

- Surface Flooding
- Affected Streets
- Potential Sewer Back-up
- Waterway
- Municipal Boundary

Trans Canada Highway
McLaughlin Dr
Elmwood Dr
Humphrey's Brook
Wheeler Blvd
Morton Ave
Shediac Rd
Veterans Highway
Hall's Creek
Lewisville Rd
Champlain St
Mountain Rd
Killam Dr
Berry Mills Rd
Vaughan Harvey Blvd
St George St
Jonathan Creek
Wheeler Blvd
Main St
Assomption
Gunningsville Bridge
not affected
Hillsborough Rd
Petitcodiac River
Causeway
not affected
Salisbury Rd
Coverdale Rd

This map was developed on basis of projected tide levels contained in the report by AMEC Earth and & Environmental for the Atlantic Canada Adaptation Solutions Association entitled Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick (the AMEC report). As such, map details are in relation to expected tide levels and flooding elevations located next to the Petitcodiac River and its tributaries, and do not address areas outside the zone of tidal influence.

1 Kilometers

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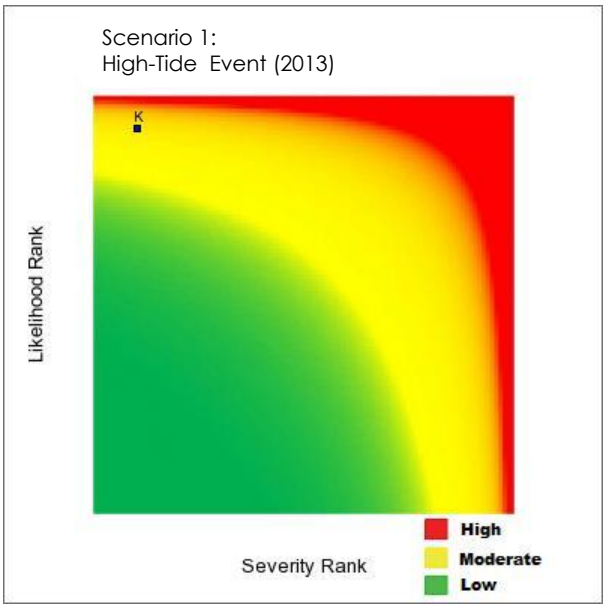
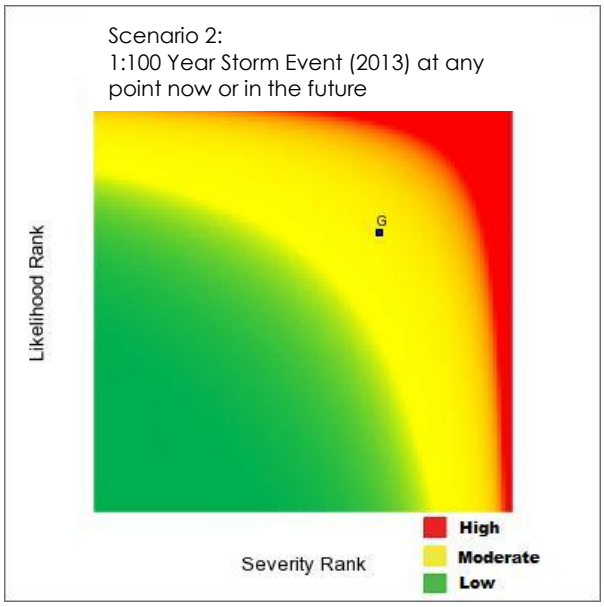
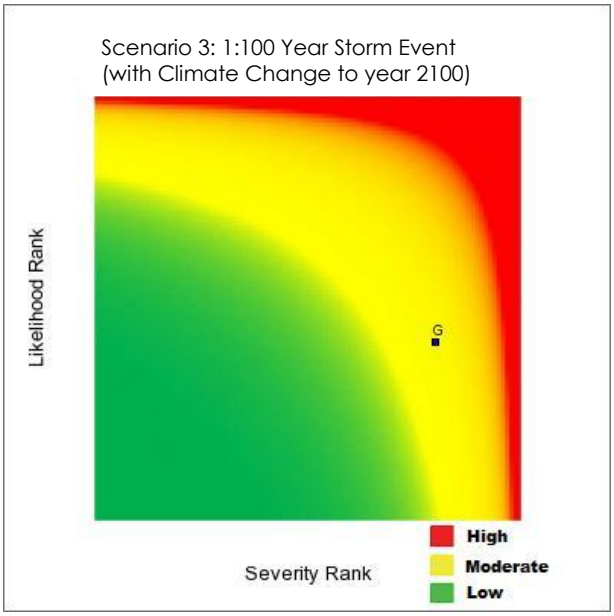
Table 6. Flood Scenario Risk Assessment Results: Summary of Key Impacts

	Scenario 1 High-Tide Event (2013)	**Scenario 2 1:100 Year Storm Event (2013)**	**Scenario 3 1:100 Year Storm Event (with Climate change to year 2100)**	**Scenario 4 Saxby Gale Event in year 2100 (with Climate Change to year 2100)**
Surface Flood Level	8 m	9.3 m	10.3 m	11.5 m
Likelihood of event occurring	Almost certain	Likely to Unlikely	Unlikely	Rare
Potential Impacts Assessed **At least one aspect of impact rated at high severity level**	• Erosion • Surface water levels • Water/sewage contamination • Emergency services • Loss of Essential services • Major transport links (airport) • Structure damage/ failure	• Erosion • **Surface water levels** • **Water/sewage contamination** • Large Infrastructure Failure • **Emergency services** • **Loss of Essential services** • Major transport links (airport) • Food/water supply • Road Closure/Rout denial • **Structure damage/failure**	• Erosion • Fires • **Surface water levels** • **Storm Surge** • Pollution to water and soil • **Water/sewage contamination** • **Large Infrastructure Failure** • **Emergency services** • **Loss of Essential services** • Major transport links (airport) • Food/water supply • **Road Closure/Rout denial** • **Structure damage/failure**	• Erosion • Fires • **Surface water levels** • **Storm Surge** • Pollution to water and soil • **Water/sewage contamination** • **Large Infrastructure Failure** • **Emergency services** • **Loss of Essential services** • Major transport links (airport) • Food/water supply • **Road Closure/Rout denial** • **Structure damage/failure**
Casualties	**None** Fatalities are not possible and evacuations are not required.	**Moderate** Fatalities or injuries are possible. Mandatory evacuation may be implemented.	**Major Casualties** Between 1- 20 fatalities and/or serious injuries are expected. Evacuations are required for a period of a week or more.	**Mass Casualties** Substantial fatalities and injuries or 20 or more. Full evacuation is required for indefinite period of time.







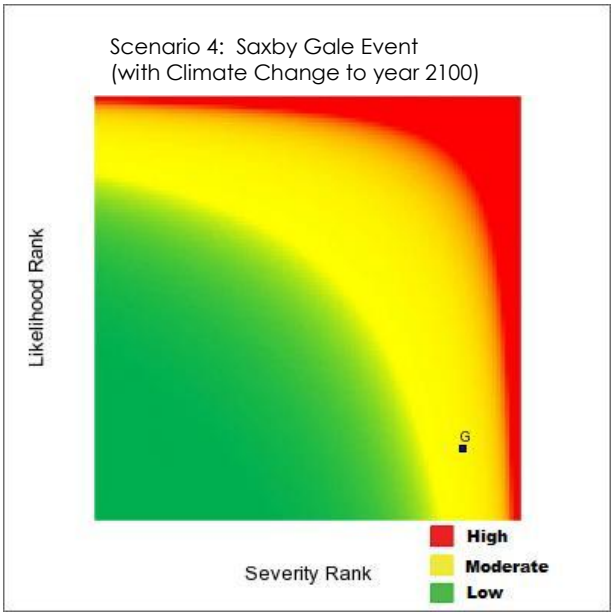


Figure 3. Flood Risk Assessment Profiles (Sentinel), completed by CCAC team, April, 2013

Scenarios 2 and 3: The 1 in 100 Year Flood (today and with climate change to the year 2100)

Scenarios 2 and 3 both examine the case of the 1:100 year flood. Scenario 2 represents the present 1:100 year storm scenario, without factoring in climate change. Scenario 3 portrays a picture of the same type of storm but under conditions that have factored in climate change trends to the year 2100.

Scenario 2 Findings

In scenario 2, the potential flood water elevation level is 9.3 metres, which represents an additional 1.3 metres above the current approximate level of high-tide on the Petitcodiac River today (maximum annual high-tide elevation in 2013 is approximately 8 metres).

As detailed on Map 2, surface flooding would occur in parts of the city located at or below the 9.3 m geodetic elevation level, including lands closest to the river and along the Hall's creek tributary. While the geographic extent of surface flooding is not large, a variety of existing land uses are impacted, including low-lying residential and commercial development, and parks and open spaces. While the elevation of water levels may not necessarily be life-threatening, structures with floor elevations at or below a 9.3 geodetic elevation will experience surface water damage. From a sewer-back-up issue perspective, a greater number of structures are potentially impacted in this scenario, when compared to the first scenario.

Important sections of the tri-community road system used to navigate within the city are compromised during a potential flood of this scale. These sections include portions of Vaughn Harvey Boulevard, Assomption Boulevard, Main Street east by Halls Creek, the Main Street west traffic circle, Lewisville and considerable sections of Wheeler Boulevard, including the Wheeler Boulevard traffic circle. Flooding along the Wheeler Boulevard area has the potential to act as a physical barrier between the east and west sections of the city if the crossings of Connaught Avenue and Church Street are not reviewed in more detail. Access points to adjoining communities may also be compromised.

A flood event of this magnitude triggers the need for emergency response operations. In addressing issues of public health and safety, emergency response providers will have to address a wide range of potential issues, including (but not limited to) any failures or loss of major infrastructure, and essential services (power, water supply, sewage systems, telecommunications and IT).

As illustrated in Figure 3, while not as probable as Scenario 1, this scenario is expected to occur and the potential impacts may be severe. Currently,

Map 2

Scenario 2: 1:100 Year Storm Event (2013)

9.3 m Flood Elevation

- Surface Flooding
- Affected Streets
- Potential Sewer Back-up
- Waterway
- Municipal Boundary

Trans Canada Highway
McLaughlin Dr
Elmwood Dr
Humphrey's Brook
Wheeler Blvd
Morton Ave
Shediac Rd
Veterans Highway
Hall's Creek
Lewisville Rd
Champlain St
Mountain Rd
Killam Dr
Berry Mills Rd
Vaughan Harvey Blvd
St George St
Jonathan Creek
Wheeler Blvd
Main St
Assomption
Gunningsville Bridge
not affected
Hillsborough Rd
Petitcodiac River
Causeway
not affected
Salisbury Rd
Coverdale Rd

This map was developed on basis of projected tide levels contained in the report by AMEC Earth and & Environmental for the Atlantic Canada Adaptation Solutions Association entitled Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick (the AMEC report). As such, map details are in relation to expected tide levels and flooding elevations located next to the Petitcodiac River and its tributaries, and do not address areas outside the zone of tidal influence.

1 Kilometers

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new city infrastructure is planned with this major storm scenario in mind. More vulnerable, are the city's established buildings, infrastructure and assets that were built many years ago, under different specifications and standards.

Scenario 3 Findings

Scenario 3 considers a 1 in 100 year flood scenario, based on a potential flood elevation level of 10.3 metres. In keeping with the AMEC Study, this scenario represents a 1:100 year storm, factoring in climate change trends to the year 2100. In the year 2100, the normal high tide level is predicted to be approximately 9 metres.

In this scenario, the extent of the city's geography affected remains concentrated on lands closest to the river and the Hall's Creek tributary. Potential flood related issues that would be experienced in a 9.3 metre flood event would continue to be experienced in this scenario, however the magnitude of the impacts are predicted to be more severe.

The 10.3 metre event coincidentally is very close to the same flood elevation that is associated with the Saxby Gale event if it were to happen again today (elevation would be 10.5 m). While the Saxby Gale flood was indeed a rare occurrence, the City currently requires that new structures be designed with habitable floors and structured parking above 10.2 metres. This is the scenario that the CCAC team has also identified as the basis for the City's emergency response planning activities.

<u>Scenarios 4: A Saxby Gale event (with climate change to the year 2100)</u>

The last and least probable scenario that the team assessed was that of a Saxby Gale level storm, factoring in climate change conditions. This is the most severe of the water level predictions identified in the AMEC Study.

The probability of such an event occurring today is the lowest of all four scenarios (considered rare) however the impacts of such an event are the most severe. The duration, geographic extent and magnitude of the impacts (physically, socially, economically) under this type of storm scenario, could be extremely significant.

Conclusions

The completion of the scenario risk assessment identified in what ways the city is most vulnerable to a flood event. These key risks point to a need to address most critically:

- emergency response needs during a flood event;
- upgrading of city infrastructure, where financially feasible, in order to reduce the potential impacts of a flood event for the

Map 3

Scenario 3: 1:100 Year Storm Event (with Climate Change to year 2100)

10.3 m Flood Elevation

- Surface Flooding
- Affected Streets
- Potential Sewer Back-up
- Waterway
- Municipal Boundary

Trans Canada Highway
McLaughlin Dr
Elmwood Dr
Humphrey's Brook
Wheeler Blvd
Morton Ave
Shediac Rd
Veterans Highway
Hall's Creek
Lewisville Rd
Champlain St
Mountain Rd
Killam Dr
Berry Mills Rd
Vaughan Harvey Blvd
St George St
Jonathan Creek
Wheeler Blvd
Main St
Assomption
Gunningsville Bridge not affected
Hillsborough Rd
Petitcodiac River
Salisbury Rd
Coverdale Rd

This map was developed on basis of projected tide levels contained in the report by AMEC Earth and & Environmental for the Atlantic Canada Adaptation Solutions Association entitled Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick (the AMEC report). As such, map details are in relation to expected tide levels and flooding elevations located next to the Petitcodiac River and its tributaries, and do not address areas outside the zone of tidal influence.

1 Kilometers

MONCTON

Map 4

Scenario 4: Saxby Gale Event (with Climate Change to year 2100)

11.5 m Flood Elevation

- Surface Flooding
- Affected Streets
- Potential Sewer Back-up
- Waterway
- Municipal Boundary

Trans Canada Highway
McLaughlin Dr
Elmwood Dr
Humphrey's Brook
Wheeler Blvd
Morton Ave
Shediac Rd
Veterans Highway
Hall's Creek
Lewisville Rd
Champlain St
Mountain Rd
Killam Dr
Berry Mills Rd
Vaughan Harvey Blvd
St George St
Jonathan Creek
Wheeler Blvd
Main St
Assomption
Gunningsville Bridge
not affected
Hillsborough Rd
Petitcodiac River
Salisbury Rd
Coverdale Rd

This map was developed on basis of projected tide levels contained in the report by AMEC Earth and & Environmental for the Atlantic Canada Adaptation Solutions Association entitled Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick (the AMEC report). As such, map details are in relation to expected tide levels and flooding elevations located next to the Petitcodiac River and its tributaries, and do not address areas outside the zone of tidal influence.

1 Kilometers

MONCTON

- community and to protect the integrity of the city's system of infrastructure and assets
- reducing potential impacts on existing private and public buildings, structures and assets and mitigating potential impacts for new constructions in flood risk areas;
- reducing potential impacts related to sewer-back-ups, including property damage; and
- financial and other options or strategies for restoration/recovery of private and public infrastructure, structures and assets following a major flood event.

The completion of the risk assessment also pointed to the need for the City to reach out to the key stakeholders and the community at large in education, consultation and partnerships.

4.3 Proposed Strategy for Reducing Flood Risk

A comprehensive flood management strategy and action plan is proposed to provide a strategic approach to flood risk reduction. The strategy is based on the completion of the following key steps:

1. *Completion of Major Storm/Hurricane/Flood Emergency Response Plan*

   While the City currently has in place an All Hazards Emergency Measures Plan, there is a need to develop a hazard specific plan to address the type of flooding scenarios examined by the CCAC, and in particular the 10.5 metre flood scenario. It is anticipated that such a plan will be developed by the summer of 2013.

   In support of this hazard specific plan , there is a need to carry out more detailed investigations in regards to the vulnerability of essential services, major infrastructure and the overall transportation system.

   While initial consultation with key stakeholders has begun, further consultation activities will play an important role in finalizing the plan. Once in place, it will be important to communicate the plan to the community at large.

2. *Community Engagement (Education, Consultation and Partnerships)*

   There are a number of important ways in which community education, consultation and partnerships can assist to reduce and address the potential impacts of flooding. Important stakeholders include:
   - The City of Dieppe and Town of Riverview
   - Provincial agencies
   - External essential service providers

- Downtown and neighbourhood organizations (social, cultural, economic and environmental)
- Targeted landowners in flood risk areas
- The community at large

Given the relative newness of the AMEC Study results and available climate change information, community engagement is seen as a top priority, only second to the development of an EMO Plan. It is important to begin discussions with our partners in the community in order to refine and improve upon the overall adaptation strategy.

3. Research, Planning and Priority Setting

The team identified an important need to carry out further research and planning activities in order to verify and confirm potential risks and establish clearer priorities and direction for land use and infrastructure in flood prone parts of the city. Studies include:

- An Urban Forest Management Plan to strengthen overall health and resiliency of City's Urban Forest;
- Heritage and civic properties assessment in flood prone areas;
- Best practice stormwater and flood plain management;
- Development of a city-wide stormwater strategy through the completion of Sewer System Review/Master Plan Studies and Area Structure Plans (e.g. Neighbourhood Plans); and
- Further assessment of potential infrastructure at risk.

4. Adaptation Policies and Regulations

Updating policies and regulations to reflect climate change trends is an important component of the proposed strategy. A number of policy proposals will be presented to City Council in 2013 in conjunction with the Plan Moncton project. Proposed changes include:

- zero-net stormwater policies and regulations that help to reduce stormwater run-off volumes;
- new minimum floor elevation requirements for habitable space and structured parking associated with new buildings (an increase in elevation from 10.2 m to 10.5 m);
- additional landscaping provisions which will assist in containing storm-water run-off (e.g. parking lot design, street trees);and
- increased development setbacks from watercourses to 30 metres (Zoning By-law amendment).

Further to the adoption of zero-net policies, it is recommended that stormwater design standards and specifications be updated in 2013 to reflect the 10.5 metre flood scenario, as recommended by the AMEC study.

The strategy also calls for the development of further municipal plan policy and zoning regulation to help guide future land use decisions in flood prone areas. Such regulation will first require considerable research and community consultation prior to finalization.

5. Physical Adaptation

Both the City and the community have a role to play in physical adaptation.

With the adoption of updated regulations to reflect climate change, the City is able to ensure that new infrastructure is designed to address a 10.5 metre flood scenario, as recommended by the AMEC Study. Based on the completion of more detailed studies, higher priority climate change related infrastructure upgrades will also be completed.

Adaptation measures which property owners/developers will be asked to participate in include the construction of new habitable floor levels and indoor parking at flood resistant elevations (10.5 m).

For existing structures with floor elevations below 10.5 metres, until such time as the City has adopted further floodplain policy and regulation, owners are permitted to renovate and add on to an existing structure at an elevation that is at least the same habitable floor level as what is currently in place. To ensure that property owners are well-informed in regards to potential flood risk at the building permit stage, it is proposed that an acknowledgement form be used explaining the potential for flood risk under 10.5 metres.

While no specific regulation is in place, developers will also be encouraged to locate essential services (e.g. electrical boxes) at elevations above 10.5 metres.

Another important physical adaptation is the installation of back-water valves. Mandatory for all new construction, the challenge for the City will be to encourage the installation of these valves in existing homes. To serve as an incentive, the City should continue to offer a back-water valve rebate to existing home owners.

6. Monitoring

Climate change trends will continue to evolve over time. There is a continual need to update and reflect on any environmental changes being seen on the ground.

Monitoring of existing infrastructure and facilities and assets relative to climate change is also recommended.

7. Funding

   Funding climate change adaptation is a key consideration. Recommendations include:

   - A yearly assessment of external Climate Change adaptation funding options;
   - Continued funding of the back-water valve replacement program (100 valves per year);
   - Capital budget adjustment to anticipate increased stormwater management requirements (i.e. implementation of zero-net policy & increased maintenance of stormwater infrastructure such as ponds);and
   - Yearly adjustments to proposed capital budget for Climate Change Adaptation related items, based on recommendation of Climate Change Action Committee and available external grants.

8. Oversight & Ongoing Updates

   The establishment of the Climate Change Action Committee ensures that climate change effects are considered by every department of the City. It is recommended that this Committee remain in place to provide oversight and further direction to the implementation of the flood management strategy, including yearly updates and reporting to City Council and the community at large.

4.4 Addressing Flood Risk Outside the Scope of the AMEC Study

The flood scenario assessments and mapping contained in this report were developed on the basis of projected tide levels contained in the report by AMEC Earth and & Environmental for the Atlantic Canada Adaptation Solutions Association entitled *Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick (the* AMEC report).

As such, the comments, flooding scenario assessment and mapping contained in this report are based on the expected tide levels and flooding elevations predicted in the AMEC report. While the flood risk assessments scenarios and mapping contained in this report are more detailed for the areas located next to the Petitcodiac River and its tributaries, a detailed study of risk assessment outside the zone of tidal influence does not form part of this report.

To minimize the impacts of potential flooding generally, all Moncton residents and businesses are encouraged to protect their homes and properties by reviewing and implementing best practices outlined in the following documents contained on the City of Moncton website:

- The Homeowner's guide to Flood Protection; and
- Protect you home from basement flooding (City of Moncton Backwater Valve Incentive and Grant Programs).

5 Assessment of Other Climate Change Trends

While a main interest in the development of this report was to consider the potential impacts of climate change on flood risk in the city of Moncton, the CCAC team also considered that climate change trends may also have other implications for the City, in both the positive and negative sense of the word.

The purpose of this section is to begin to scope a variety of possible benefits and challenges that other aspects of climate change may bring. In the course of further community consultation and discussion, it is hoped that the ideas presented here will be further refined and developed into additional action plan considerations for the City.

5.1 Warmer Average Temperatures & Extreme Heat Days

Climate change is anticipated to bring warmer average temperatures to our region in the future. It is anticipated that our region will likely experience the kind of heat that is more typically experienced in southern Ontario today (ACASA, 2013). A key factor related to warmer temperatures is an increase in the number of extreme heat days.

As outlined in Table 8, there are both potential benefits and challenges associated with a warmer city. Warmer weather may create new opportunities for tourism and recreation in our region and offer an easier winter perhaps for retirees. However, warmer average weather is also associated with more heat days (above 30 degrees Celsius).

In other parts of the country such as Ontario, communities are paying close attention to the ways in which municipalities can help their community to remain liveable during hotter summer periods. Cities such as Windsor are studying the 'heat island effect' that is created as a result of hard asphalt surfaces (e.g. roads, parking lots, rooftops) to better understand how to reduce this particular effect. Other cities are revisiting how buildings and homes are designed to offer cooler spaces, both inside and out. Demand for electricity may rise during summer months, so any design features which naturally cool buildings and outdoor spaces will be greatly appreciated.

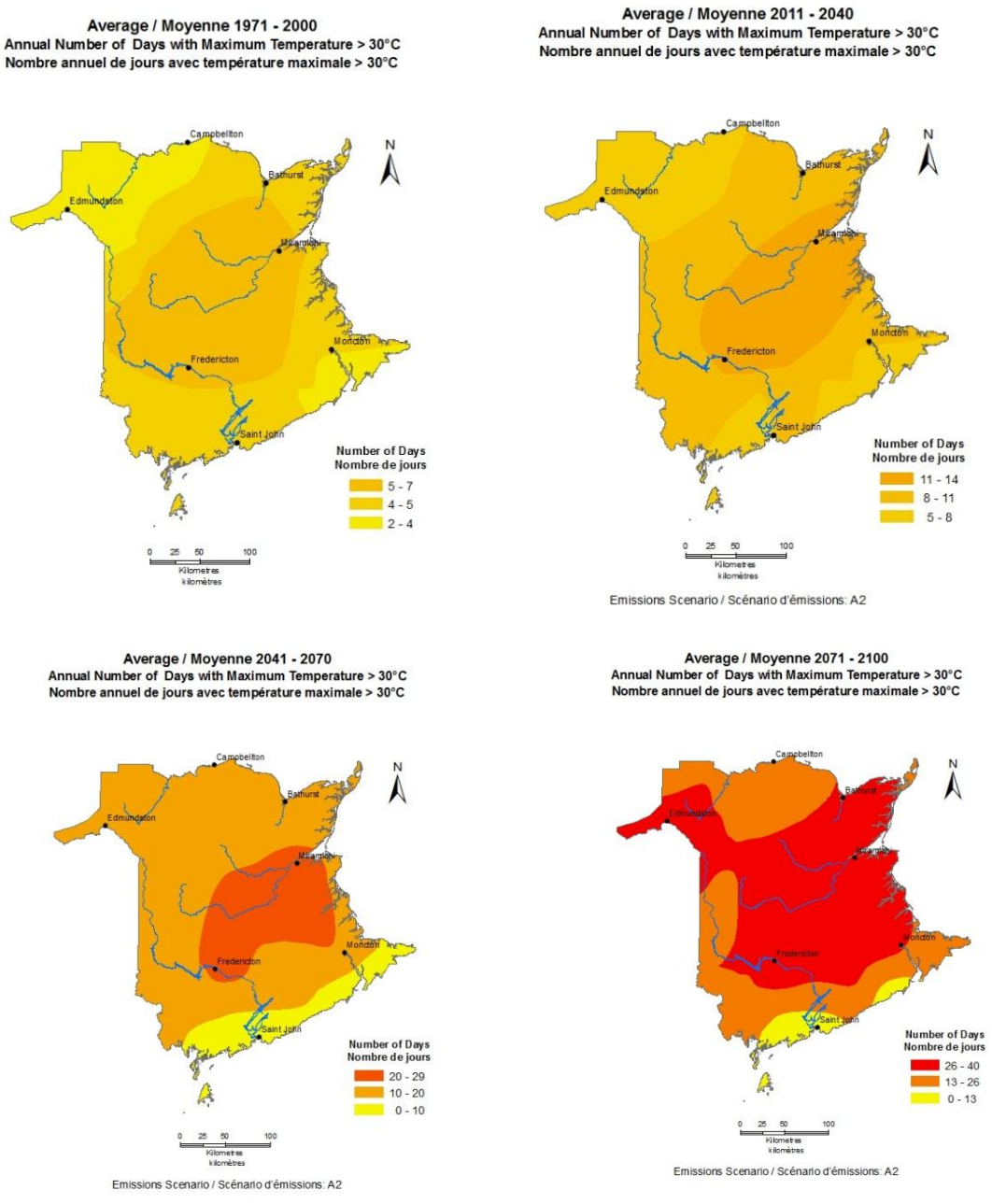
Table 8. Potential Implications of a Warmer Climate for the City of Moncton (CCAC, 2013)

Potential Benefits & Opportunities	Potential Challenges
• NB may become a more attractive destination for tourists and retirees • Longer growing seasons • Longer construction seasons • Reduced demand for electricity during winter months	• Increased demand for cooling systems/air conditioning in buildings • Increased demand for electricity during summer months • Increased demand for shade & outdoor protection from sun and heat • Increased demand for drinking water in public spaces • Increased occurrence of heat stress & management of health impacts • Increased demand for water for personal consumption and irrigation purposes • Water-based bacteria (from rising surface water temperatures) affecting recreational use of lakes • Increased risk for forest fires

Heat stress will likely play a more important role in summer health management issues. Municipalities can play an important role by helping to ensure access to water in public spaces, and by designing public places with shade in mind.

Rising temperatures also may mean a potential rise in water temperatures and changes to water quality, local habitat and vegetation. Many cities are factoring climate change into their urban forest management and urban landscaping plans to reduce future water consumption requirements and ensure the long-term health of the urban forest and landscape.

Figure 4. Annual Number of Days with Maximum Temperature greater than 30 degrees C *is the average number of days per year when the temperature exceeds this threshold. Also known as hot days. The number of hot days increases everywhere in the future climate scenarios. The increase is dramatic by the latter part of the century. By this time most central areas of the province will have more days over 30 degrees C than locations in extreme southwestern Ontario (such as Windsor) do today.*



5.2 Other Extreme Weather Events

Through the use of the Sentinel software, the CCAC considered the general vulnerability of the City to following types of extreme weather events:

- *Heat Wave/Drought*
- *Forest Fires*
- *Cold Wave*
- *Ice Storm*
- *Severe Winter Storm*

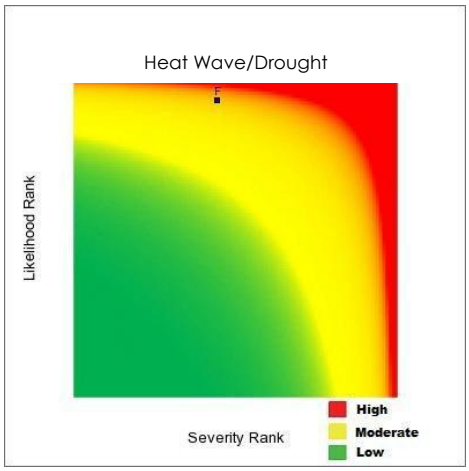
As outlined in Table 9, while the probability of each of these events occurring is likely or almost certain, the scope of potential impacts are more limited than in the case a flood hazard. Nevertheless, the results remind us that events such as heat waves will likely occur more frequently in the future.

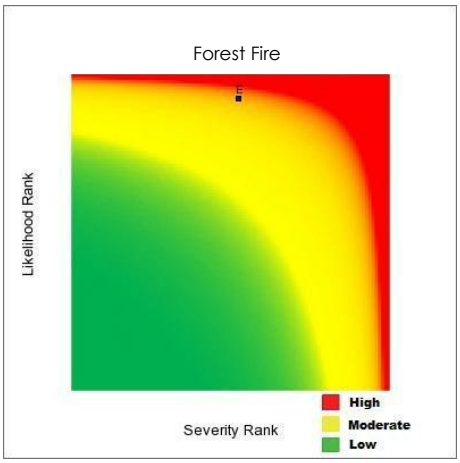
From an emergency services perspective, such exercises are an important opportunity to consider and test the All Hazards Plan that the City now has in place to ensure that it will respond well to these types of scenarios. More hazard specific planning to any one of these events may be useful to complete in the future.

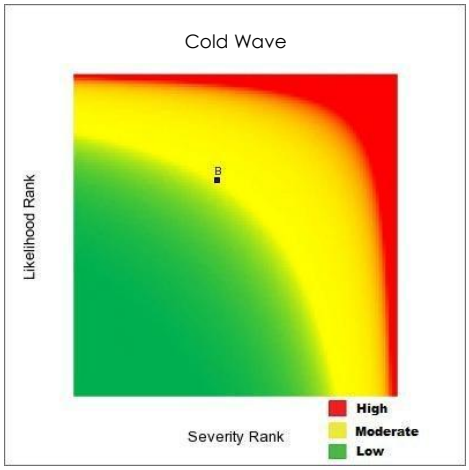
Table 9. Climate Change Risk Assessment Results: Summary of Key Impacts

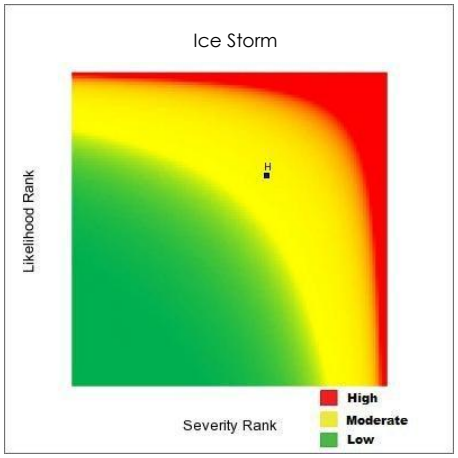
	Heat Wave/ Drought	**Forest Fire**	**Cold Wave**	**Ice Storm**	**Severe Winter Storm**
Likelihood of event occurring	Almost certain-Likely	Almost certain-likely	Likely	Likely	Almost certain
Potential Impacts Assessed At least one aspect of impact rated at medium severity level **At least one aspect of impact rated at high severity level**	Fires Loss of animal habitat **Pollution/ Air Impacts** Degradation/ loss of emergency services Loss of essential services	Fires Loss of animal habitat Pollution/ Air Impacts **Degradation/ loss of emergency services** Loss of essential services Road closure/route denial Structure failure	**Loss of essential services (e.g. power**)	**Degradation/ loss of emergency services** **Loss of essential services (e.g. power)** Road Closure/Route Denial Structure failure	**Degradation/ loss of emergency services** Loss of essential services Road Closure/ Route Denial Structure failure
Casualties	Low	Moderate	Low	Low	Low

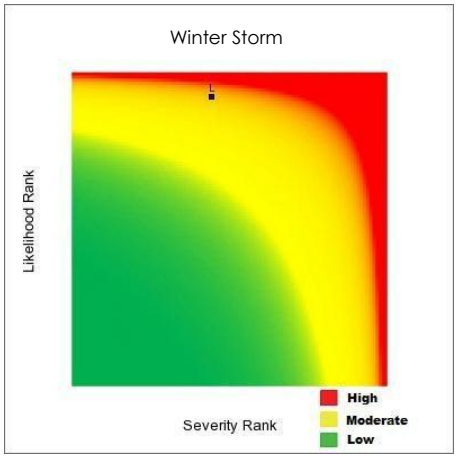
Figure 5 Other Hazard Assessment Profiles (Sentinel), completed by CCAC team, April, 2013











6 Conclusions/Recommendations

The City of Moncton has taken a significant step in preparing this corporate climate change adaptation plan. Of particular importance is the proposed flood management strategy, which provides a course of action for the City to embark on, in order to help reduce potential impacts in the city. Factoring in climate change trends in flood management will help to ensure that measures carried out today will more properly address flood management needs well into the future.

This report highlights the need for the City to reach out to key stakeholders and the community at large, with respect to flood management, as well as in respect to climate change generally. There is a need to continue to scope, confirm and update the ideas presented in this document, as our understanding of climate change develops over the coming years.

Appendix 1
Glossary

Adaptation: any activity that reduces the negative impact of climate change, while taking advantage of new opportunities that may be presented as a result of climate change.

Adaptive Capacity: The collective of capabilities, resources and institutions of a country or region to implement effective adaptation measures.

Climate Change: Any long-term change in the "average weather" that a given region experiences. Average weather may include average temperature, precipitation and wind patterns. It involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years. These changes can be caused by dynamic processes on Earth (ocean processes, volcanoes), external forces including variations in sunlight intensity, and more recently by human activities.

Climate Change Mitigation: Implementing policies and/or introducing technological change and substitution that reduce greenhouse gas emissions and enhance sinks.

Climate Scenario: A plausible and often simplified representation of the future climate, based on a consistent set of climatological relationships and assumptions, typically constructed for explicit use as input to climate change impact models. A "climate change scenario" is the difference between a climate scenario and the current climate.

Extreme Weather Event: An extreme weather event refers to meteorological conditions that are rare for a particular place and/or time, such as an intense storm or heat wave. An extreme climate event is an unusual average over time of a number of weather events, for example heavy rainfall over a season resulting in floods.

Greenhouse Effect: Greenhouse gases effectively absorb thermal infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus, greenhouse gases trap heat within the surface-troposphere system. This is called the greenhouse effect.

Greenhouse Gases (GHGs): Gases present in the atmosphere which reduce the Earth's loss of heat into space and therefore contribute to increases in global temperatures through the 'greenhouse effect'. Greenhouse gases are essential in maintaining the temperature of the Earth, however, an excess of greenhouse gases can raise the temperature of the planet. Greenhouse gases include carbon dioxide (CO2), methane (CH4), nitrous oxide (N20), sulfur hexafluoride (SF6), perflurocarbons (PCF's) and hydrofluorocarbons (HFC's).

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

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Retrofitting: Retrofitting means to install new or modified parts or equipment, or undertake structural modifications, to existing infrastructure that were either not available or not considered necessary at the time of construction. The purpose of retrofitting in the context of climate change is generally to ensure that existing infrastructure meets new design specifications that may be required under altered climate conditions.

Risk: A combination of the likelihood (probability of occurrence) and the consequences of an adverse event (e.g. climate-related hazard).

Risk management: A systematic approach to setting the best course of action under uncertainty, by applying management policies, procedures and practices to the tasks of analysing, evaluating, controlling and communicating about risk issues.

Sea level rise: An increase in the mean level of the ocean. Seal levels can rise at a global level through an increase in the volume of the world's oceans or at a local level due to ocean rise or land level subsidence.

Storm surge: Generally used to refer to a temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place. Negative storm surges also occur and can present significant problems for navigation.

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

Weather: The state of the atmosphere at a given time and place, in terms of temperature, air pressure, humidity, wind, cloudiness and precipitation. The term weather is used mostly for conditions over short periods of time.

Appendix 2
Climate Change Adaptation and Flood Management Strategy:
Action Plan Schedule

City of Moncton Climate Change Adaptation and Flood Management Strategy: Action Plan Schedule

Please Note: The following schedule is meant to be reviewed and updated from time to time. Target dates for completion and anticipated costs are estimates only and are subject to further discussion via the regular budget approval process.

Flood Management Strategy Component	Flood Management Actions	Target Date for Completion								Estimated Cost	Funding Source	Comments	Lead Dept.	Supporting Dept.
		2013	2014	2015	2016	2017	2018	2028 (within 15 Years)	2038 (within 30 Years)					
Major Storm/ Hurricane/ Flood Emergency Response Plan	Draft EMO Plan	x								Staff time	Absorbed		Fire	
	Consult EMO stakeholders to review flood scenarios and identity potential impacts and ways of reducing flood risk: *Public Works, Police, Ambulance, Red Cross Hospitals, NBEMO, Department of Transportation, Department of Supply & Services, City of Dieppe, Town of Riverview, Moncton Airport Authority, CN, GMSC, Utility Providers (power, telephone, etc..), Food suppliers/distributors*	x	x							Staff time	Absorbed		Fire	Engineering & Environmental Services, Urban Planning
	EMO Plan Implementation	x								Staff time	Absorbed		Fire	
	Develop overall infrastructure strategy to support EMO Plan, including diversion of traffic (including Codiac Transpo) during event and post-event recovery action items.	x	x							Staff time	Absorbed		Engineering & Environmental Services	Fire, Codiac Transpo
	Use transportation model created through Sustainable Transportation Plan to run flooding scenarios in order to prioritize street upgrades that will help to reduce impacts during flood events				x					Staff time	Absorbed		Engineering & Environmental Services	
	Development strategy for ensuring adequate fuel supply for essential services during storm event	x	x							Staff time	Absorbed		Fire	
	Develop monitoring/action plan for post-storm Parks & Leisure Infrastructure, Structures & Assets		x							Staff time	Absorbed		Parks & Leisure Services	
	Upkeep/Maintenance of EMO Plan (Yearly Updates)		x	x	x	x	x			Staff time	Absorbed		Fire	
Community Engagement (Education, Consultation and Partnerships)	Climate Change website development & maintenance	x	x	x	x	x	x	x	x	Staff time	Absorbed		Communications	Engineering & Environmental Services
	Voluntary flood protection options for homes and buildings – Brochure Update	x								Printing only	Absorbed	Action Complete	Building Inspection	Communications

Flood Management Strategy Component	Flood Management Actions	Target Date for Completion								Estimated Cost	Funding Source	Comments	Lead Dept.	Supporting Dept.
		2013	2014	2015	2016	2017	2018	2028 (within 15 Years)	2038 (within 30 Years)					
	Public consultation regarding emergency preparedness for a major storm/flood event		x							Staff time	Absorbed		Fire	Communications
	Inform public about sewer-back-up risks & available options for reducing risk		x	x	x	x	x	x	x	Staff time	Absorbed		Engineering & Environmental Services	Building Inspections, Legal, Communications
	Communication program with property owners/businesses associated with hazardous materials in flood prone areas		x							Staff time	Absorbed		Fire	Communications Engineering & Environmental Services
	Education on need to protect stream banks with healthy riparian buffer areas	x	x	x	x	x	x	x	x	Staff time	Absorbed		Parks & Leisure Services	Communications Engineering & Environmental Services
	Ongoing consultation and assistance to development industry stakeholders in making informed investment decisions within floodprone areas	x	x	x	x	x	x	x	x	Staff time	Absorbed		Economic Development	
Community Engagement (Education, Consultation and Partnerships	Review flood scenarios with Department of Transportation to identify any potential Provincial infrastructure at risk (e.g. bridges) that are located in the City of Moncton and identify proposed actions	x	x							Staff time	Absorbed		Engineering & Environmental Services, Fire	
	Review flood scenarios with Department of Supply & Services to identify Provincial facilities (located in the City of Moncton) at risk and proposed actions	x	x							Staff time	Absorbed		Engineering & Environmental Services, Fire	
	Review flood scenarios with GMSC to identify any potential infrastructure at risk and proposed actions		x							Staff time	Absorbed		Engineering & Environmental Services, Fire	
	Meet with cities of Dieppe and Riverview to review results of flood risk analysis for Moncton and exchange insights regarding flood risk management	x								Staff time	Absorbed		Climate Change Action Committee	
	Meet with utility providers (telephone, gas, power) to identify utilities at risk (including electrical substations) and proposed actions	x	x							Staff time	Absorbed		Engineering & Environmental Services, Fire	
Research, Planning & Priority Setting	Develop Urban Forest Management Plan to identify risks and strengthen overall health and resiliency of City's Urban Forest			x						$250,000	Operating Budget Level 3	Issue RFP for consultant to assess tree infrastructure	Parks & Leisure Services	Engineering & Environmental Services (Urban Forester)
	Assess risks to Heritage properties in flood prone and develop adaptation strategies if required						x			Staff time	Absorbed		Building Inspection (Heritage Officer)	Urban Planning
	Assess risks to civic facilities in flood prone and develop adaptation strategies if required	x	x							Staff time	Absorbed		Parks & Leisure Services	Building Inspection

Flood Management Strategy Component	Flood Management Actions	Target Date for Completion								Estimated Cost	Funding Source	Comments	Lead Dept.	Supporting Dept.
		2013	2014	2015	2016	2017	2018	2028 (within 15 Years)	2038 (within 30 Years)					
Research, Planning & Priority Setting	Research and propose best practices for floodplain management			X						7,500$	Operating Budget Level 3	Potentially work with local universities / student research	Urban Planning	Engineering & Environmental Services
	Research best practices for stormwater management		X	X	X	X	X			Part neighbour-hood /area structure plans	Absorbed		Engineering & Environmental Services	Urban Planning, Strategic Initiatives
	Research best practices in flood EMO management		X	X						Staff time	Absorbed		Fire	
	Address stormwater management through the completion of Area Structure Plans (e.g. Neighbourhood Plans)		X	X	X	X	X			150,000 $ per year Looking at creating partnership with developers / landowners to cost share	Operating Budget Level 3.	3 plans in the next 5 years: - Shediac Road Area - Lands North of Wheeler - Existing residential areas in proximity to Downtown	Urban Planning	Engineering & Environmental Services, Strategic Initiatives
	Completion of SSRMP (Sewer System Review & Master Plan) Studies		X		X		X			$ 6 million	Capital Budget	6 more MIGS left @$1 million each	Engineering & Environmental Services	
	Consult with Department of Environment to confirm nature of potential environmental impacts associated with flood scenarios; identify any additional required actions, including any proposed actions to reduce any potential risks associated with the old land fill site.			X						Staff time	Absorbed		Engineering & Environmental Services	
	Inventory location of wells, verify with Province and confirm is any well is at risk for water contamination as a result of a flooding event				X					Staff time	Absorbed		Engineering & Environmental Services	
	Assess potential impacts (if any) on Turtle Creek dam and water treatment plant			X						Staff time	Absorbed		Engineering & Environmental Services	
	Develop short, medium & long range solutions for sewer back-ups			X						Staff time	Absorbed		Engineering & Environmental Services	
	Inventory, survey and assess location and condition of pumping stations and develop short-term, medium-term and long-term strategy to adapt to 1:100 year Climate Change Storm scenario (10.5m)			X						Staff time	Absorbed		Engineering & Environmental Services	

Flood Management Strategy Component	Flood Management Actions	Target Date for Completion								Estimated Cost	Funding Source	Comments	Lead Dept.	Supporting Dept.
		2013	2014	2015	2016	2017	2018	2028 (within 15 Years)	2038 (within 30 Years)					
Research, Planning & Priority Setting	Use transportation model created through Sustainable Transportation Plan to run flooding scenarios in order to prioritize street upgrades that will help to reduce impacts during flood events				**X**	**X**				$100,000	Operating Budget Level 3		Engineering & Environmental Services	
	Plan new transportation, infrastructure and essential services to meet 1:100 year Climate Change Storm scenario (10.5m)							**X**	**X**	Staff time	Absorbed		Engineering & Environmental Services	
	Research regarding external funding options for climate change adaptation	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Staff time	Absorbed		Finance	Climate Change Action Committee (all Depts.)
Adaptation Policies & Regulations	Adopt zero-net stormwater policies and regulations in order to reduce the quantity of stormwater run-off - PlanMoncton	**X**	**X**							$15,000	Operating Budget Level 3	Communi-cation strategy and "how to" guide to help developers understand zero-net	Urban Planning	Engineering & Environmental Services, Corporate Communications
	Update Design Criteria Manual to address rainfall intensities for year 2100	**X**								Staff time	Absorbed		Engineering & Environmental Services	
	Update design criteria and specifications for new infrastructure design to reflect data based on 1:100 year Climate Change Storm scenario (10.5m)	**X**								Staff time	Absorbed		Engineering & Environmental Services	
	Adopt new minimum floor elevation requirements for habitable space and structured parking associated with new buildings (Zoning By-law amendment) - PlanMoncton	**X**								Staff time	Absorbed		Urban Planning	
	Adopt additional landscaping provisions in the Zoning By-law which will assist in containing storm-water run-off (e.g. parking lot design, street trees)	**X**								Staff time	Absorbed		Urban Planning	
	Adopt increased development setbacks from watercourses to 30 metres (Zoning By-law amendment) – PlanMoncton	**X**								Staff time	Absorbed		Urban Planning	
	Adopt further Municipal Plan floodplain policies & Zoning-By-law regulations through continued best practice research and community consultation.				**X**	**X**				25,000$ (over 2 years)	Operating Budget Level 3		Urban Planning	Corporate Communications
	Develop/adopt LfPP (Land for public purposes) policies to prevent parks and trails from being situated in higher risk areas				**X**	**X**							Urban Planning	Parks & Leisure Services

Flood Management Strategy Component	Flood Management Actions	Target Date for Completion								Estimated Cost	Funding Source	Comments	Lead Dept.	Supporting Dept.
		2013	2014	2015	2016	2017	2018	2028 (within 15 Years)	2038 (within 30 Years)					
Adaptation Policies & Regulations	Reassessment of standards & regulations as required						X			Staff time	Absorbed		Climate Change Action Committee	
Physical Adaptation Measures (City)	Adjust design criteria, where appropriate, to ensure potential climate change impacts (1:100 year Climate Change Storm scenario (10.5m)) are considered for new road construction		X	X	X	X	X	X	X	Staff time	Absorbed	In conjunction with ongoing capital works program	Engineering & Environmental Services	
	Adjust design criteria to ensure that potential climate change impacts are considered in construction of new sewer infrastructure		X	X	X	X	X	X	X	Staff time	Absorbed	In conjunction with ongoing capital works program	Engineering & Environmental Services	
	Raise elevations of mechanical & electrical equipment in existing pumping stations to address 1:100 year Climate Change Storm scenario (10.5m)							X		Staff time	Absorbed	In conjunction with ongoing capital works program	Engineering & Environmental Services	
	Consider locating and constructing new trails at higher elevations to meet 1:100 year Climate Change Storm Model (10.5m)		X	X						Staff time	Absorbed	In conjunction with ongoing capital works program	Parks & Leisure Services	
	Consider climate change impacts during the redesign/construction of existing street infrastructure identified as a priority (following the completion of transportation modelling assessment)								X	Staff time	Absorbed	In conjunction with ongoing capital works program	Engineering & Environmental Services	
	Consider climate change impacts during the redesign/construction of other infrastructure		X	X	X	X	X	X	X	Staff time	Absorbed	In conjunction with ongoing capital works program	Engineering & Environmental Services	
	Intensive tree planting program		X	X	X	X	X	X	X	$100,000 per year	Operating Budget Level 3	Based on planting of 900-1000 trees per year (in addition to existing planting program)	Parks & Leisure Services	
Physical Adaptation Measures (Community)	New buildings constructed with habitable floors and structured parking above 10.5m	X	X	X	X	X	X	X	X	No Cost			Urban Planning; Building Inspection	
	Ensure proper installation of Back-water valves	X	X	X	X	X	X	X	X	Staff time	Absorbed	All new buildings	Building Inspection	

Flood Management Strategy Component	Flood Management Actions	Target Date for Completion								Estimated Cost	Funding Source	Comments	Lead Dept.	Supporting Dept.
		2013	2014	2015	2016	2017	2018	2028 (within 15 Years)	2038 (within 30 Years)					
Physical Adaptation Measures (Community)	Inform public of properties situated on sites with a geodetic elevation of less than 10.5 of potential flood risks through the use of a acknowledgement form (to be implemented at time of building permit application). Provide suggestions for voluntary flood adaptation measures, including mechanical and electrical systems located above 10.5m	X	X	X	X	X	X	X	X	Staff time	Absorbed		Urban Planning, Building Inspection, Legal	
Climate Change Environmental Monitoring	Review of Climate Change Trends	X	X	X	X	X	X	X	X	Staff time	Absorbed	Ongoing every year	Engineering & Environmental Services	
	Review erosion rates along river, streams and lakes, especially in areas where erosion may compromise the stability of existing roads, culverts or buildings	X	X	X	X	X	X	X	X	Staff time	Absorbed	Ongoing every year	Engineering & Environmental Services	
	Monitor water quality associated with old land fill site	X	X	X	X	X	X	X	X	Staff time	Absorbed	Ongoing every year	Engineering & Environmental Services	
	Monitor/inventory hazardous material sites									Staff time	Absorbed		Fire	Engineering & Environmental Services
Monitoring & Maintenance of Infrastructure	Ongoing review, maintenance & monitoring of water distribution system	X	X	X	X	X	X	X	X	Staff time	Absorbed		Engineering & Environmental Services	
	Maintain folded all-way stop-signs at signalized intersections	X	X	X	X	X	X	X	X	Staff time	Absorbed		Engineering & Environmental Services	
Funding	Yearly assessment of external Climate Change adaptation funding options	X	X	X	X	X	X	X	X	Staff time	Absorbed		Finance	Climate Change Action Committee (All Depts.)
	Back-water valve installment program, including the continued development and promotion of this program	X	X	X	X	X	X	X	X	$265,000 (2013-2018) ($15,000 in 2013, $50,000 in subsequent years)	General Utility 50/50 Operating budget	$15,000 budgeted in 2013, after which no funds are budgeted As per 100 valves per year with a $500 rebate.	Engineering & Environmental Services	Building Inspection, Finance
	Adjust capital budgets to anticipate increased stormwater management requirements (i.e. implementation of zero-net policy & increased maintenance of stormwater infrastructure such as ponds)	X	X	X	X	X	X	X	X	Staff time	Absorbed		Engineering & Environmental Services	Finance

Flood Management Strategy Component	Flood Management Actions	Target Date for Completion								Estimated Cost	Funding Source	Comments	Lead Dept.	Supporting Dept.
		2013	2014	2015	2016	2017	2018	2028 (within 15 Years)	2038 (within 30 Years)					
Funding	Yearly adjustments to proposed capital budget for Climate Change Adaptation related items, based on recommendation of Climate Change Action Committee and available external grants	X	X	X	X	X	X	X	X	Staff time	Absorbed		Finance & Climate Change Action Committee	
Oversight & Ongoing Updates of CCAP	Bi-yearly meetings of Climate Change Action Committee *(Spring/fall)*	X	X	X	X	X	X	X	X	Staff time	Absorbed		Climate Change Action Committee	
	Yearly Reporting to City Council on Climate Change Adaptation Activities & Updates to the CCAP *(in conjunction with Capital Budget presentation - November)*	X	X	X	X	X	X	X	X	Staff time	Absorbed		Climate Change Action Committee	
	Yearly tri-community meetings to discuss Climate Change Adaptation	X	X	X	X	X	X	X	X	Staff time	Absorbed		Climate Change Action Committee	
	Yearly Community update regarding Climate Change Adaptation		X	X	X	X	X	X	X	Staff time	Absorbed		Climate Change Action Committee	

Appendix 3: Detailed Flood Risk Assessment

SCENARIOS	8.0 M FLOOD (3 times a yr. today)	9.3 M FLOOD AND STORM EVENT (1:100 yr. storm today without climate change)	10.3 M FLOOD AND STORM EVENT (1:100 yr. storm with Climate Change impacts to year 2100 or Saxby Gale storm today without climate change factored in)	11.5 M FLOOD AND STORM EVENT (1:100 yr. storm with Climate Change impacts to year 2100 & Saxby Gale event)
LIKELYHOOD OF OCCURRING TODAY	**Almost certain** Occurs regularly in this region or community and is considered a chronic concern. Effect is observed at least once every 10 years. At least one occurrence of this threat is expected in the next 10 years. Evidence suggests that at least once occurrence of this threat is expected in the next 10 years. This type of event can occur 3 times a year in Moncton today. *Lewisville in front of Taylor Ford; Botsford Street; traffic circle at Wheeler (only marsh areas, not roads)* *No or little disruption to community life.*	**Likely -Unlikely** Last known occurrence of this threat was between 101 and 1000 years ago (Saxby Gale). Not expected in the next 10 years but is likely to occur in the next 50 years. Evidence suggests that this threat is not expected in the next 10 years but is likely to occur in the next 50 years. *AMEC Study results NYC events – trend is for storms to move northward*	**Unlikely** Last known occurrence of this threat was between 101 and 1000 years ago (Saxby Gale). Not expected in the next 50 years but is likely to occur in the next 100 years. Evidence suggests that this threat is not expected in the next 50 years but is likely to occur in the next 100 years.	**Unlikely - Rare** There has never been an observed or recorded occurrence of this threat in more than 1000 years or the effect has not been detected. Not expected in the next 100 years but is likely to occur in the next 1000 years. Evidence suggests that this threat is not expected in the next 100 years but is likely to occur in the next 1000 years.
CASUALTIES	**No casualties** Fatalities are not possible, evacuations are not required.	**Moderate casualties** Fatalities or injuries are possible. Evacuation not required but voluntary. Mandatory evacuation may be implemented. Hurricane Yuan experience as a guide.	**Major Causalities** Between 1 and 20 fatalities and/or serious injuries are expected. Evacuations are required for a period of a week or more.	**Mass Casualties** Substantial fatalities and injuries of 20 or more. Full evaluation is required for indefinite period of time.

IMPACTS: EROSION

Erosion is a geomorphological phenomenon which can lead to undermining of transportation and other built structures

Potential impacts noted by TAG:	Proposed solutions to reduce potential impacts:
1. Trail network along riverbank and key streams potentially impacted 2. Riprap is in place along riverbanks which helps to mitigate but will need to be strengthened over time 3. Valuable roads could be undermined by erosion due to culvert crossings (e.g. St. George Blvd., Milner Rd., Westbrook Circle, Salisbury Road) 4. Stability of buildings (public and private) can be undermined by erosion activity along riverbank as well as banks adjacent to Wheeler corridor (Bathurst Street area) 5. Risks associated with erosion rise over time	1. Wider setbacks from streams and buildings (Zoning By-law) – proposed 30m setback in proposed Zoning By-law. 2. Construction and location of new trails to factor in potential for erosion 3. Construction and reconstruction of roads to factor in potential for erosion in vulnerable locations 4. Erosion monitoring program of erosion rates along riverbank and areas at risk 5. Develop communications program to educate public on need to retain banks in good conditions (i.e. leave vegetation intact, etc…)

Scenario	8m	9.3m	10.3m	11.5m
Duration	**Low** Effect causes disruption to normal community life for several weeks or less.	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.	**High** Effect causes disruption to normal community life for more than a year.
Geographic Extent	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.
Regional Sensitivity	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**Low** Effect has the potential to cause localized socio-economic impacts.	**Medium** Effect has potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**Medium** Effect has potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Medium** Moderate disruption, denial or corruption of ICT and/or communications over portions of region or community where service is restored within 7 days.

IMPACTS: FIRES Fires threatening people and/or important installations or critical infrastructures.				
Potential impacts noted by TAG: 1. Home fires during periods of power outages			Proposed solutions to reduce potential impacts: 1. Develop communications program to educate public on how to minimize fire risks during flood events	
Scenario	**8m**	**9.3m**	**10.3m**	**11.5m**
Duration	**NA**	**NA**	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.
Geographic Extent	**NA**	**NA**	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.
Regional Sensitivity	**NA**	**NA**	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.
Magnitude	**NA**	**NA**	**Low** Effect has the potential to cause localized socio-economic impacts.	**Low** Effect has the potential to cause localized socio-economic impacts.
Reversibility	**NA**	**NA**	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.
Communications	**NA**	**NA**	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: FLOODING (Surface Flooding)

The effects of rises in water levels rendering parts of the community inaccessible or isolating certain sectors. Damage to built infrastructure, business and dwellings is common.

Potential impacts noted by TAG:

1. Areas within the 8-11.5 m zone with development on the ground or land use opportunities in place ; Lewisville Rd area, area east of Botsford to river Downtown - parking lots, superstore area, Vision lands
2. Existing development – Backwater valve issues; potential flooding at 1st floor or possible second floor levels - property damage…
3. While impacts grow with each scenario, the biggest difference in impacts is experienced between 8m and 9.3m scenario. Depending on the location of a building / property and its use, the impact could be severe.
4. Future development - areas within the 8-11.5 m zone with land use opportunities in place ; Lewisville Rd area, area east of Botsford, Downtown - parking lots, superstore area,Vision lands
5. Potential damage or limited access to areas of high public value
    a. East End Boys & Girls Club pool;
    b. sportsfields,
    c. riverfront,
    d. Heritage properties (95 Foundry, 40 Waterloo, 1 Factory and a few properties located on Main Street)
    e. Centennial Park beach ; Most properties are located on higher elevations (10 to 12m) which would correspond to a 1:100 recurring period in the year 2100
    f. tree canopy
    g. Rabbit Brook Trail,
    h. Hall's Creek Trail,
    i. Crowley Farm Rd.;
    j. Salisbury RD Nature Park;
    k. Mapleton Park
    l. Main Plaza area (east Main Street near Jones Lake)
6. Damage to existing tree cover during storm events - without a tree management program in place, additional risk is created for damage to trees
7. Increased costs for stormwater management
8. Community sensitivity - affects development decisions and risk management decisions for landowners in flood prone areas

Proposed solutions to reduce potential impacts:

EMO

1. EMO Plan - Engineering to work closely with the EMO team to address infrastructure flood related issues

Parks

2. Mapping of urban tree canopy and data management system for public trees (GIS) ; urban forest management plan; Monitor, structurally prune or remove trees at risk as required
3. Develop a monitoring/ action plan for post storm parks & leisure infrastructure failure
4. Place new park and trail infrastructure at higher elevations
5. Develop LFPP (Land for Public Purposes) planning policies to prevent trails from being situated in at risk locations

Zero net – reducing quantity of run-off

6. Additional landscaping/tree planting provisions (e.g. parking lot design)
7. Implementation of zero net policy – (Municipal Plan, Zoning By-law, Development Standards)

Land Use in Flood prone areas:

8. Proposed 10.5m minimum habitable floor elevation in proposed Zoning By-law.
9. Resources (Urban Planning) - Developing new Municipal Plan policies and zoning overlay regulation resources Need to develop a strategy on how to "handle" lands in the most at risk areas;
10. Further review of how other jurisdiction are using overlay zoning; Need to better understand the legal / financial implications
    a. Existing buildings/uses and non-conformity
    b. Urban design issues in the downtown
    c. Land owner consultation
    d. Draft new provisions for flood overlay zone
    e. Inform land owners of potential risk / mitigate flood risk for new development.
11. Heritage properties to be addressed under the overlay zoning regulations…may need to create specific policies for heritage properties - may need to consult with heritage staff and heritage board

Infrastructure design:

12. Design new infrastructure using recommended elevations and IDF curves - New IDF curves to form basis of future design - Update design criteria manual and subdivision guidelines
13. Retrofitting of existing sewer system - If completed in a systematic, planned advance manner, the impact is likely minor. If completed as a reaction, the costs are likely moderate or severe
14. As the City implements climate adaptation measures and/or policies such as zero net increase (which means retention ponds). The City will need to increase operating budgets and or capital budget to operate and eventually rebuild these facilities. - Spread potential costs over several years via setting up of reserves, establishing borrowing authority over several years and implementing infrastructure changes required as new construction is performed now rather than retrofit in the future of same areas.
15. Consider what other cities have done to address the stormwater management, identify the priorities and related risks and inform stakeholders of such risks
16. Allow for higher flood elevations in future planning of transportation and essential services
17. Discuss climate change impacts within context of Transportation Master Plan

Public Engagement/Communication

18. Economic development staff to stay informed of future environmental risks associated with downtown development; Communicate and share current information with developers as proposals are received for development in flood zone areas; Continue to liaise with other City departments as a resource and channel of communication for the development community;
19. Inform land owners of potential risk / mitigate flood risk for new development – waiver form – public consultation processes in conjunction with development of new floodplain policy-by-laws.

IMPACTS: FLOODING (Surface Flooding) The effects of rises in water levels rendering parts of the community inaccessible or isolating certain sectors. Damage to built infrastructure, business and dwellings is common.				
Risk Assessment Scenarios	**8m**	**9.3m**	**10.3m**	**11.5m**
Duration	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.	**High** Effect causes disruption to normal community life for more than 1 year.	**High** Effect causes disruption to normal community life for more than 1 year.
Geographic Extent	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	**High** Effect occurs over an extensive area within your region or community. The effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. The effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**Low** Effect has the potential to cause localized socio-economic impacts.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: POLLUTION/WATER/SOIL IMPACTS Temporary, long-term or permanent contamination of the soil and/or water.	
Potential impacts noted by TAG: 1. Gas stations within 9.3m – design standards help to mitigate risk 2. Land fill site protected by riprap and filtrated by wetland – loss of wetland will result in more direct seepage into river 3. Water/combined sewer pollution is assumed to be diluted 4. Pollution will travel down river, however pollution/debris will also be deposited from areas downstream as well. 5. Buildings with chemical storage within surface flood risk areas 6. Should verify if any transformers can be flooded as these may contain oil which may escape in environment causing concerns 7. Older Substations and transformer pads used less environmentally friendly oils	Proposed solutions to reduce potential impacts: 1. Consultation with DoE to confirm nature of environmental impacts and any proposed actions which can help mitigate impacts 2. Ongoing monitoring of water quality levels associated with landfill site – Study this area in greater detail 3. Ensure hazardous materials are stored in a safe location - Ongoing monitoring and inventory of hazardous material sites, with priority to locations within flood prone areas - Identify storage areas and make modifications if necessary 4. Provide additional funding for the backwater valve replacement program 5. Communication program with property owners/businesses dealing with hazardous materials in vulnerable areas 6. Consult with NB Power to regarding potential impacts related to rupturing of transformer pads and potential release of hazardous oils

Scenario	8m	9.3m	10.3m	11.5m
Duration	**NA**	**NA**	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.
Geographic Extent	**NA**	**NA**	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.
Regional Sensitivity	**NA**	**NA**	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.
Magnitude	**NA**	**NA**	**Low** Effect has the potential to cause localized socio-economic impacts.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.
Reversibility	**NA**	**NA**	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.
Communications	**NA**	**NA**	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Storm Surge Storm surge is an offshore rise of water typically associated with a tropical cyclone. Storm surge is caused primarily by high winds pushing on the ocean's surface. The wind causes the water to pile up higher than the ordinary sea level.				
Potential Impacts Noted by TAG 1. Same types of impacts as flooding			Proposed solutions to reduce potential impacts 2. Same solutions as in flooding	
Scenario	**8m**	**9.3m**	**10.3m**	**10.5m**
Duration	**NA**	**NA**	**High** Effect causes disruption to normal community life for more than 1 year.	**High** Effect causes disruption to normal community life for more than 1 year.
Geographic Extent	**NA**	**NA**	**High** Effect occurs over an extensive area within your region or community. The effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. The effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**NA**	**NA**	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**NA**	**NA**	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**NA**	**NA**	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**NA**	**NA**	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Water/Sewage Contamination

The contamination of water supplies by the sewage or when the sewage system backs up.

Potential impacts noted by TAG:

1. Urban water supply – no serious impacts noted; only potential issue could be a water main break – distribution issues, as opposed to issues with reservoir/treatment plant functionality – dam built to 1:100 yr. flood.
2. Areas where the wells are located and elevations are below 10.5m are vulnerable by salt water intrusion or surface water intrusion
3. Sewer back up are the key issue for basements under elevation 10.5m (in 8m storm); 11.5m (in 9.3m storm); 12.5 (in 10.3m storm) and 13.5(in 11.5m storm)
4. Without a backwater valve, basements are vulnerable to sewer back-up impacts; important to keep in mind that 8m regular high tide today is 9m in the future
5. Downtown is vulnerable as well as system will surcharge, so combined flows will exit manhole (particularly during rain event) – the fix for this is not readily available.
6. Issue is not just mess to clean-up but also fact that toilets are not functional until system is restored. Means that businesses, restaurants, homes, facilities are not fully functional during the event.
7. U de M affected in 9.3m scenario in terms of access to facilities, functionality, then clean-up required.
8. High sensitivity due to nature of combined system
9. Clean up can take months, because of the extent of damage created

Proposed solutions to mitigate potential impacts

1. Add known well locations to maps , verify that all wells are identified with Province;
2. Confirm whether any particular well locations are at risk and if so, what type of mitigative measures may assist;
3. Ongoing maintenance/monitoring of water distribution system;
4. Confirmation of structural strength of any bridges that support water distribution lines (with DoT);
5. Assess risks associated with sewer back-ups and develop adaptive measures short medium and long range strategies;
6. Review locations for proposed combined sewer overflow pumping stations – share info with GMSC;
7. Raise elevations of mechanical and electrical equipment in pumping stations above projected flood level (10.5 m)

Scenario	8m	9.3m	10.3m	11.5m
Duration	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.	**Medium** Effect causes disruption to normal community life for several months.	**High** Effect causes disruption to normal community life for more than 1 year.
Geographic Extent	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	**High** Effect occurs over an extensive area within your region or community. The effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Infrastructure Failure

The destruction of bridges, dams, power generating stations and electric transmission towers etc…

Potential impacts noted by TAG:	Proposed solutions to mitigate potential impacts:
1. Turtle Creek dam should have no issues 2. Gunningsville bridge – should have no issues 3. Causeway – water lapping the road at 9.3m – at 10.5 m flood, access is lost, worst case scenario is that causeway is washed out and takes several years to rebuild 4. There is a need to meet with DOT to confirm potential impacts for bridges 5. Airport needs to be consulted in regards to radar beacon at U de M 6. Power company needs to be consulted regarding electrical substations)Downtown & Donald Avenue) 7. If any infrastructure fails, recovery period can be long. 8. Longer recovery periods mean longer ongoing transportation rerouting etc…impacting distribution of people and goods throughout the city.	1. Review each flood scenario with DOT to confirm any potential impacts and proposed mitigation measure 2. Involve Riverview/DOT in review of potential impacts on the causeway 3. Involve Airport Authority in review of each flood scenario, including assessment of radar beacon at U de M. 4. Consult with power companies in regards to potential impacts on electrical substations and potential mitigative measures - Need to have infrastructure identified (NB power Pad mounts) as well as id buildings at risk with located between elevation 7.0m and 10.5m

Scenario	8m	9.3m	10.3m	11.5m
Duration	**NA**	**Medium** Effect causes disruption to normal community life for several months.	**High** Effect causes disruption to normal community life for more than 1 year.	**High** Effect causes disruption to normal community life for more than 1 year.
Geographic Extent	**NA**	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	**High** Effect occurs over an extensive area within your region or community. The effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. The effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**NA**	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**NA**	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**NA**	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**NA**	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Medium** Moderate disruption, denial or corruption of ICT and/or communications over portions of region or community where service is restored within 7 days.	**High** Disruption, denial or corruption of ICT and/or communications over significant areas of region or community where service is not fully restored within at least 7 days.

IMPACTS: Loss/Degradation/Reduction of Emergency Services Emergency services consist of the 911 system as well as fire, police, ambulance and hospital emergency rooms	
Potential Impacts noted by TAG: 1. Transportation blocks reduce response time 2. Lewisville/SunnyBrae more cut-off, harder to service 3. 2 EMO bldgs. vulnerable (close to flood locations) 4. 911 in located in Dieppe Fire Station – back-up centre is Moncton DT police station	Proposed solutions to mitigate potential impacts 1. Prepare Hurricane/Major Flood Response Plan Definitions, Protection of City Infrastructure, Warning System/ Advisories, Safety during Storm, Check Lists for Responders and Operational Departments, Evacuation, Recovery, Communication Plan 2. Consultation with key stakeholders: Group 1: EMO groups: Police, Ambulance, Red Cross, Hospitals, NBEMO Group 2: City of Dieppe and Town of Riverview - as well as LSD areas surrounding the urban centres - Group 3: citizens in flood zones; all citizens to lesser extent Group 4: Media 3. GIS maps to assist in planning 2. Meeting with major stakeholders 4. Research Major Storm Plans in Canada 5. Public communication program around EMO preparedness

Scenario	8m	9.3m	10.3m	11.5m
Duration	**Low** Effect causes disruption to normal community life for several weeks or less.	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.	**High** Effect causes disruption to normal community life for more than 1 year.
Geographic Extent	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**Low** Effect has the potential to cause localized socio-economic impacts.	**Low** Effect has the potential to cause localized socio-economic impacts.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Medium** Moderate disruption, denial or corruption of ICT and/or communications over portions of region or community where service is restored within 7 days.	**High** Disruption, denial or corruption of ICT and/or communications over significant areas of region or community where service is not fully restored within at least 7 days.

IMPACTS: Loss of Essential Services

Essential services include power, water, sewage, telecommunications and IT. The loss of power may result in health (lack of dialysis machines, heart monitors etc…) and economic (loss of food and medication that requires refrigeration) consequences.

Potential Impacts noted by TAG:	Proposed solutions to mitigate potential impacts
1. Moncton one of the cities further away from a generation station 2. Electrical substation downtown & Sunny Brae 3. Power outages likely – but should not take too long to resolve 4. Without power, impacts food supply and ability to access fuel (gas stations) – may need to prioritize use of fuel for essential services. 5. Underground power – Westmorland – could be affected 6. Risk rises with severity of flood 7. Staff are not experts in communication systems 8. Low lift pumping station; Highfield pumping station; sewer systems, City owned buildings at geodetic 10.5 or lower - Failure could cause sewer back up for properties with geodetic up to m13.5m. Overland flooding risk up to 10.5m. In the case of Highfield pumping station failure would cause city wide issues (properties under 13.5 m geodetic)	1. Discussions with food stores and distribution centres to review potential flood scenarios and systems in place to address potential shortages during events 2. Consult with power authority re potential impacts on electrical substations during an event, and potential impacts related to underground power system 3. Consultation with communications experts (e.g. Bell Aliant) regarding potential impacts and possible actions to mitigate 4. Assess risks to loss of pumping stations and develop adaptive measures short medium and long range - May need to pick up survey on individual sites and review record drawings(i.e. Highfield pumping station and other City owned facilities) to understand where things will fit short, medium or long term adaptive measures category

Scenario	8m	9.3m	10.3m	11.5m
Duration	**Low** Effect causes disruption to normal community life for several weeks or less.	**Low** Effect causes disruption to normal community life for several weeks or less.	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.
Geographic Extent	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**Low** Effect has the potential to cause localized socio-economic impacts.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Medium** Moderate disruption, denial or corruption of ICT and/or communications over portions of region or community where service is restored within 7 days.	**Medium** Moderate disruption, denial or corruption of ICT and/or communications over portions of region or community where service is restored within 7 days.	**High** Disruption, denial or corruption of ICT and/or communications over significant area of region or community were service is not fully restored within at least 7 days.

IMPACTS: Loss of Transportation Links Includes loss of structures and facilities such as airports and ports as well as loss or blockage of shipping channels.				
Potential Impacts noted by TAG: 1. Airport links should only experience short term issues from storm activity			Proposed solutions to mitigate potential impacts 1. Consultation with Airport Authority to confirm potential impacts and proposed actions to mitigate risk	
Scenario	**8m**	**9.3m**	**10.3m**	**11.5m**
Duration	**Low** Effect causes disruption to normal community life for several weeks or less.	**Low** Effect causes disruption to normal community life for several weeks or less.	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.
Geographic Extent	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.
Regional Sensitivity	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**Low** The nature of this region or community's economy, culture or environment do NOT make it particularly sensitive or vulnerable to this effect.	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.
Magnitude	**Low** Effect has the potential to cause localized socio-economic impacts.	**Low** Effect has the potential to cause localized socio-economic impacts.	**Low** Effect has the potential to cause localized socio-economic impacts.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.
Reversibility	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.
Communications	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Medium** Moderate disruption, denial or corruption of ICT and/or communications over portions of region or community where service is restored within 7 days.

IMPACTS: Loss and Reduction of Food and Water Supply May result in inability to transport the food into the area, the contamination of food/water so that it is inedible or the inability to produce food.	
Potential Impacts noted by TAG: 1. Typically communities are within 3 days of running out of food 2. Moncton benefits from being a food transportation hub – however, if event is Atlantic based, then competing with other areas for food delivery (orders may be issued in this regard) 3. No major concerns expected with respect to water supply 4. Superstore in Riverview, Sobey's DT and potentially Sobey's at Champlain mall could be in accessible in case of an event 5. TransCanada Highway not vulnerable	Proposed solutions to mitigate potential impacts 1. Discussions with food stores and distribution centres to review potential flood scenarios and systems in place to address potential shortages during events

Scenario	8m	9.3m	10.3m	11.5m
Duration	**NA**	**Low** Effect causes disruption to normal community life for several weeks or less.	**Low** Effect causes disruption to normal community life for several weeks or less.	**Medium** Effect causes disruption to normal community life for several months.
Geographic Extent	**NA**	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**NA**	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**NA**	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.
Reversibility	**NA**	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.
Communications	**NA**	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Road Closure/Route Denial

Includes the closure of routes (roads, rail, etc…) by permanent means such as having been destroyed or for extended periods of time .

Potential Impacts noted by TAG

- Impact severity rises with severity of flooding
- CN links should only experience short term issues from storm activity
- Codiac Transit services could be delayed significantly during storm activities
- Land freight transport should experience short term issues from storm activities
- **Traffic signals:**

Freeway:

a. Wheeler at Botsford St / Lewisville Rd (9.5)

Arterial Roads

b. Main St @ Super Store/Chateau Moncton (9.5)
c. Main St @ Route 15 (9.5)
d. Elmwood at Lewisville Rd (9.5)
e. Morton Ave. @ Université/Crawley Farm Rd. (9.5)
f. Assomption Blvd @ Westmorland St. (9.5)
g. Assomption Blvd @ Lutz St. (9.5)
h. Assomption Blvd @ Foundry (9.5)
i. Lewisville Rd at Shediac Rd. (10.5)
j. Assomption at Vaughan Harvey Blvd 11.5

Traffic Signal malfunctioning or not working. Risk of possible collisions if traffic continues utilizing the streets. Fire department will lose functionality of controlling signals and will need to reduce speed through intersections. Any flooding beyond elevation noted, the probability of traffic signals not functioning is very high. The impact could be severe if traffic continues to utilize the intersections; however, if intersections are not accessible, impacts are minor.

Freeways:

a. Wheeler Blvd - from Main Street including east traffic circle to approximately 400m beyond Connaught Ave. (9.5)
b. Wheeler Blvd - 200 m section between Connaught Ave and Mapleton Rd. (10.5)
c. 1) Wheeler Blvd - 300 m section between Connaught Ave and Mapleton Rd. (11.5)

This entire section of Wheeler Blvd. will not be accessible for all type of vehicles during a flooding event noted by elevation. The impact could be very severe for emergency services. East side of Moncton and Dieppe will not be easily accessible from central Moncton. Presently Wheeler carries approximately 30,000 vehicles per day. Diverting this amount of traffic to other surrounding streets in Moncton will cause significant delays or event grid locks.

d. Wheeler Blvd - West traffic Circle.; West Traffic Circle will not be accessible for all type of vehicles during a 9.25 m flooding event. Riverview and Salisbury Rd will not be accessible from the traffic circle. (9.5)

Arterials:

a. Main Street between King Street and Dieppe(9.5)
b. Assomption Blvd between Main St. and Albert Street(9.5)
c. Vaughan Harvey Blvd between Assomption Blvd to intersection into Sobeys. (9.5) *Assomption and Vaughan Harvey generate on average 40,000 vehicles per day and traffic using these streets will be diverted to Albert Street and Foundry Street. These streets are not designed to accommodate an extra 40,000 vehicles per day. These streets would become grid lock.*
d. Morton Ave. at the intersection of Crawley Farm Rd / Université (9.5) *Morton Ave. generates on average 20,000. Traffic would be diverted to other street and could increase delays significantly.*
e. Botsford St. at Wheeler Blvd / Lewisville Rd. interesction. (9.5) *Botsford and Lewisville Rd generate on average 13,000 vehicles per day and traffic will require another location to access east Moncton.*
f. Lewisville Rd. from Wheeler to Germaine St. *Lewisville Rd, generates on average 20,000 vehicles per day and traffic using this street will be diverted elsewhere while creating more congestion.* (9.5)
g. Lewisville Rd from Germain to Pleasant and Shediac Rd to Dieppe (10.5) *Lewisville Rd, generates on average 20,000 vehicles per day and traffic using this street will be diverted elsewhere while creating more congestion.*
h. Main Street from Hillcrest to MacWilliams. (10.5) *Main Street generates on average 15,000 vehicles per day and would need to be diverted thru west end, residential street.*
i. Various sections of Assomption Blvd. (10.5)
j. Section of Vaughan Harvey Blvd near Assomption Blvd. north side (10.5) *Assomption and Vaughan Harvey generate on average 40,000 vehicles per day and traffic using these street will be diverted to Albert Street and Foundry Street. These streets are not designed to accommodate an extra 40,000 vehicles per day. These streets would become grid lock.*
k. Main St. from Alma to Church St.10.5 *Main Street between Alma and Church St. generates on average 13,000 Vehicles per day*

Proposed solutions to mitigate potential impacts:

1. Consultation with CN and VIA Rail to confirm any potential impacts and proposed actions to mitigate
2. Codiac Transpo to review potential impacts and mitigation actions.
3. Consultation with Atlantic Trucking Association to confirm impacts and proposed actions to mitigate risk
4. Maintain existing folded all-way stops in order to control traffic during impact. Could raise controller cabinets to elevation 11.5. Down side would be accessing cabinets for maintenance. Cost to raise each cabinet would be approximately $20,000.
5. Raising/retrofitting:
   a. Nothing can be done to mitigate impacts on Wheeler, other than to raise Wheeler or realign it to avoid the area. To raise or divert Wheeler could cost close to 1/2 a billion dollars.
   b. Change the West Traffic Circle to overhead interchange.
   c. Main Street - Nothing can be done for this street. Raising Main in certain parts est. $45 million
   d. Vaughan Harvey Blvd - Consider building a bridge over CN Rail in the future approximate cost of $20 Million.
   e. Morton Ave. - Build overpass to access east Moncton. Consider building a bridge for Morton Ave over Université Ave/Crawley Farm Rd. approximate cost of $15 million.
   f. Botsford St. and Lewisville Rd. consider abandoning both streets.
   g. Raise Donald Ave and abandon Clement Cormier and Lutz St. Raising Donald Ave would cost approximately $2 million.
   h. Raise the intersection of Lewisville Rd at Shediac Rd. Cost to raise Lewisville Rd would be approximately $2 million , approximately $10 million at 10.5m flood scenario
   i. Assomption and Vaughan Harvey would need to be raised. $30 million for each street
   j. Raise Foundry Street - Cost to raise Foundry Street would be

l. Morton Ave. east of Université10.5 Morton Ave. generates on average 20,000. *Traffic would be diverted to other street and could increase delays significantly.*
m. Lewisville Rd at Shediac Rd (11.5)
n. Main Street from Botsford to Robinson(11.5) *Main Street generates on average 15,000 vehicles per day and would need to be diverted to Queen St* 11.5
o. Various sections of Assomption Blvd. (11.5)
p. Section of Vaughan Harvey Blvd near Assomption Blvd. north side (11.5) Assomption and Vaughan Harvey generate on average 40,000 vehicles per day and traffic using these will access Moncton or Riverview during a 11.5 flooding event.
q. Morton Ave. east of Université (11.5) Morton Ave. generates on average 20,000. Traffic would be diverted to other street and could increase delays significantly.

All streets described will not be accessible for all type of vehicles during flooding event noted. The impact could be very severe for accessing local businesses for emergency services.

Collectors

a. Donald Ave. at Clement Cormier Str. (9.5) *Donald Ave. generates on average 7,500 vehicles per day; therefore this traffic would be diverted to residential streets*
b. Clement Cormier St. from Braeside Dr. to Donald Ave. (9.5) Clement Cormier St. generates on average 2,000 vehicles per day. *This will have minimal impact on traffic patterns, but will eliminate an access point to the University.*
c. Lutz St. from Assomption Ave. to 200 m north of Record St. (9.5) *Lutz Street generates on average 3,000 vehicles per day and will have minimal impact.*
d. Foundry Street (10.5) *Depending strategy Foundry could have a severe impact. If it is used to divert traffic from Assomption and Vaughan Harvey it will need to be raised.*

All streets described will not be accessible for all type of vehicles during flooding event noted. The impact is moderate to severe as these streets do provide an important role in moving traffic.

Arterial Sidewalks:

a. Main Street between King Street and Dieppe (*9.5m)*
b. Assomption Blvd between Main St. and Albert Street *(9.5m)*
c. Vaughan Harvey Blvd between Assomption Blvd to intersection into Sobeys. (*9.5m)*
d. Morton Ave. at the intersection of Crawley Farm Rd / Université (*9.5m*)
e. Botsford St. at Wheeler Blvd / Lewisville Rd. interesction. *(9.5m)*
f. Lewisville Rd. from Wheeler to Germaine St. *(9.5m)*
g. Lewisville Rd from Germain to Pleasant and Shediac Rd to Dieppe (10.5)
h. Main Street from Hillcrest to MacWilliams. (10.5)
i. Lewisville Rd at Shediac Rd (11.5m)
j. Main Street from Botsford to Robinson (11.5m)
k. Various sections of Assomption Blvd. (11.5m)
l. Section of Vaughan Harvey Blvd near Assomption Blvd. north side (11.5m)

Collector sidewalks:

a. Donald Ave. at Clement Cormier Str. (*9.5m)*
b. Clement Cormier St. from Braeside Dr. to Donald Ave. *(9.5m)*
c. Lutz St. from Assomption Ave. to 200 m north of Record St. *(9.5m)*
d. Foundry Street

All sidewalks on these streets would not be accessible for pedestrians during a 9.25 event - Minor; however, citizens will expect sidewalk infrastructure for transportation purposes.

Codiac Transit:

1. Primary transit hub at Champlain Place would no longer be accessible; primary hub on Main St. would be compromised;
2. Transit service availability/hours would be greatly impacted
3. Transit users with limited mobility options are greatly affected, not only with respect to transportation (persons with lower incomes & seniors likely to be more affected because of added vulnerability)
4. Demand on fleet employees during evaluations will reduce overall level of service
5. Required re-routing will result in much longer route paths, will require additional fleet/operators and will result in overall reduced level of service compared to pre-flooding.
6. Should extreme weather event trigger a high contagious disease (i.e. SARS) or major security threat, EMO may determine to no longer permit public gathering places and therefore transit would be closed.

approximately $2 million.
k. Accommodate sidewalk infrastructure upgrades with street recommendations (cost already factored in).

6. May want to use the new Transportation Model to run scenarios of street impact with Wheeler not being accessible. The Model is being developed for the Transportation Plan. The City should have the model to run scenarios by summer of 2014. To study alternative transportation scenarios though modeling would be approximately $100,000.

7. Diverting traffic during storm events:
   a. Assomption and Vaughan Harvey could be diverted to Albert Street; however, with current traffic volumes, this option would become unmanageable. Close Main Street m Botsford to Robinson, and from Church to Alma

Codiac Transpo:

1. Codiac Transpo to assist with the development of flood/major storm emergency response plan. Issues to address include, but are not limited to:
   a. Communication shortfalls – two way radio operations, cellular operations from employee to employee to enable operations
   b. Create employee preparedness toolkit/provide expectations
   c. Create new temporary transit hubs in Moncton
   d. Create new temporary transit hub in Dieppe to connect Dieppe to Moncton transit routes and U de M
   e. Employee security
   f. Determine if Provincial or private fleets are available for evacuation assistance
   g. Determine evacuation plan for residents requiring wheelchair accessible bus
   h. Diesel fuel supply confirmation
   i. Collection of transit fares to continue during an extreme event? (During ice storm, transit picked up anyone for concern re potential health risks)

IMPACTS: Road Closure/Route Denial Includes the closure of routes (roads, rail, etc…) by permanent means such as having been destroyed or for extended periods of time				
Scenario	**8m**	**9.3m**	**10.3m**	**11.5m**
Duration	**NA**	**Low** Effect causes disruption to normal community life for several weeks or less.	**High** Effect causes disruption to normal community life for more than 1 year.	**High** Effect causes disruption to normal community life for more than 1 year.
Geographic Extent	**NA**	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**NA**	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**NA**	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**Medium** Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic disruption.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**NA**	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** Negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government restoration efforts.
Communications	**NA**	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Structure Failure or Loss With respect to buildings, means the destruction, collapse or loss of use of the structure for an extended period of time, or permanently.				
Potential Impacts noted by TAG: 1. Homes with water become inhabitable in short term; variation in damages depending on location of building and type of flooding (surface vs. basement) 2. Impacts are localized, but overall extent of damage will have impact on community as a whole. 3. Key public facilities at risk (list): • downtown police station; • 2 fire stations; • access to courthouse; • public library (blue cross) • East End Boys & Girls Club pool; 4. Recovery period a key factor – likely owners will be allowed to rebuild in some areas, but chances are not without financial risk (therefore relocation discussions are likely at that time) 5. Residential owners less 'resourced' to recovery than businesses, based on experiences in other cities 6. Downtown businesses will be impacted, development decisions will need to weigh in on risks and provide adaptive solutions to proceed. 7. Champlain mall area also poses risk to regional economy			Proposed solutions to mitigate potential impacts: 1. Proposed 10.5m minimum habitable floor elevation in proposed Zoning By-law. 2. Resources (Urban Planning) - Developing new Municipal Plan policies and Zoning Overlay regulation Resources (senior management) Need to develop a strategy on how to "handle" lands in the most at risk areas. 3. Further review of how other jurisdiction are using overlay zoning. 4. Inform land owners of potential risk / mitigate flood risk for new development. – waiver form 5. Heritage properties to be addressed under the overlay zoning regulations…may need to create specific policies for heritage properties - may need to consult with heritage staff and heritage board	
Scenario	**8m**	**9.3m**	**10.3m**	**11.5m**
Duration	**Low** Effect causes disruption to normal community life for several weeks or less.	**High** Effect causes disruption to normal community life for more than 1 year.	**High** Effect causes disruption to normal community life for more than 1 year.	**High** Effect causes disruption to normal community life for more than 1 year.
Geographic Extent	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Low** Effect occurs over a localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	**Medium** Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	**High** Effect occurs over an extensive area within your region or community. This effect is considered to have an area of influence extending over a large geographic area, perhaps beyond the community or region.
Regional Sensitivity	**Medium** The nature of this region or community's economy, culture or environment make it moderately sensitive or vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Magnitude	**Low** Effect has the potential to cause localized socio-economic impacts.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.	**High** Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability.
Reversibility	**Low** Negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	**Medium** Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.	**High** The nature of this region of community's economy, culture or environment make it atypically sensitive or vulnerable to this effect. Some regional characteristics could exacerbate the negative consequences of the effect.
Communications	**Low -** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low -** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low -** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	**Low -** Short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

Appendix 4
Detailed Risk Assessment – Other Hazards

HEAT WAVE and FOREST FIRES

SCENARIOS http://www.acasamaps.com/index.html	*Annual Number of Days with Maximum Temperature greater than 30 degrees C is the average number of days per year when the temperature exceeds this threshold. Also known as hot days.* *Moncton estimates:* *2011-2040=8-11 days* *2041-2070=10-20 days* *2071-2100=26-40 days* *The number of hot days increases everywhere in the future climate scenarios. The increase is dramatic by the latter part of the century. By this time most central areas of the province will have more days over 30 degrees C than locations in extreme southwestern Ontario (such as Windsor) do today.*	
Scenario	**HEAT WAVE**	**FOREST FIRE**
LIKELYHOOD OF OCCURRING TODAY	Almost Certain - Likely	
CASUALTIES	Low	Moderate
IMPACTS: FIRES Fires threatening people and/or important installations or critical infrastructures.		
Potential Impacts	High heat and drought conditions may lead to fires within city limits. Moncton is surrounded by industrial parks – a fire in those areas could have a significant impact damage to natural features and structures – probability unclear – would have to research this - likely to more an issue in large parks and towards periphery of the city - Drought events can trigger higher risks for fires - impact could be severe if the extent of the fire was large and/or uncontrolled, but again difficult to assess	
Proposed Solutions	Monitoring of weather/environmental indicators for drought ; adoption of EMO procedures for forest fire situations to reduce opportunities for uncontrolled fires; Forest management planning to take into account of potential for drought events - review of this potential fire issue by Heather Hawker to confirm information	
Duration	Medium – effect causes disruption to normal community life for several months	
Geographic Extent	Low – effects occurs over localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	
Regional Sensitivity	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Magnitude	Medium – Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic impacts	
Reversibility	Low – negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	
Communications	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	

IMPACTS: LOSS OF ANIMAL HABITAT		
Potential Impacts	Increased need for irrigation; Dryer weather, dying vegetation; More stress/failures among tree plantings; Watercourses and wetlands drying up; Increased potential for algae in lakes/ponds - Jones Lake, Centennial Pond, Irishtown Nature Park, Mapleton Park, McLaughlin Reservoir and Turtle Creek Reservoir - reduced water quality affecting flora/fauna and reducing opportunities for community recreational activities – affects Greater Moncton residents, fish and wildlife	
Proposed Solutions	Use different type of vegetation - move away from grass when possible – zeroscape; carry out studies to understand what types of vegetation may work best in future	
Scenario	**HEAT WAVE**	**FOREST FIRE**
Duration	Low – effect causes disruption to normal community life for several weeks or less	Medium – effect causes disruption to normal community life for several months
Geographic Extent	Low – effects occurs over localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	
Regional Sensitivity	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Magnitude	Low – Effect has potential to cause localized socio-economic impacts	
Reversibility	Low – negative impacts revert within one year without restoration efforts. The community will return to pre-effect state without any intervention.	High – negative impacts caused by this effect are irreversible or only reversible over an extended period of time with major government efforts
Communica-tions	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	
IMPACTS: POLLUTION/AIR IMPACTS Temporary, long-term or permanent contamination of the air.		
Potential Impacts	Public health implications – heat stroke; Greater demand for shade and water generally	
Scenario	**HEAT WAVE**	**FOREST FIRE**
Duration	Low – effect causes disruption to normal community life for several weeks or less	
Geographic Extent	High – Effect occurs over an extensive are within the community.	Medium – Effect occurs over a portion of the community or region.
Regional Sensitivity	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Magnitude	Low – Effect has potential to cause localized socio-economic impacts	
Reversibility	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Communica-tions	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	
IMPACTS: Loss/Degradation/Reduction of Emergency Services Emergency services consist of the 911 system as well as fire, police, ambulance and hospital emergency		
Scenario	**HEAT WAVE**	**FOREST FIRE**
Duration	Low – effect causes disruption to normal community life for several weeks or less	
Geographic Extent	Low – effects occurs over localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	High - Effect occurs over an extensive are within the community
Regional Sensitivity	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	Medium – The nature of this region or community's economy, culture, or environment make it vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.
Magnitude	Low – Effect has potential to cause localized socio-economic impacts	Medium – Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic impacts
Reversibility	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Communica-tions	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	Medium – moderate disruption, denial or corruption of ICT and or communications over portions of region or community where service is restored within 7 days.

IMPACTS: Loss of Essential Services Essential services include power, water, sewage, telecommunications and IT. The loss of power may result in health (lack of dialysis machines, heart monitors etc…) and economic (loss of food and medication that requires refrigeration) consequences.		
Potential Impacts	1. Reduced water recharge/watertable; 2. Increased water temp. Higher water temperatures may increase the amount of e coli, blue green algae and other pathogens. 3. Drier summers could draw down water in wells and wells could go dry - Wells with issues may need to connect to City Water or dig well deeper 4. Increased demand for summer electricity (increased potential for brown-outs) 5. Longer construction season (positive)	
Proposed Solutions	1. Review Water Master Plan to factor in climate change estimates; Review need for additional studies to monitor water temp./quality at water reservoirs 2. Add known well locations to maps , verify that all wells are identified with Province 3. Consultation with NB power to understand potential impacts and proposed actions 4. Additional study to identify all infrastructure at risks not just asphalt	
Scenario	**HEAT WAVE**	**FOREST FIRE**
Duration	Low – effect causes disruption to normal community life for several weeks or less	
Geographic Extent	Medium – Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	
Regional Sensitivity	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	Medium – The nature of this region or community's economy, culture, or environment make it vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.
Magnitude	Low – Effect has potential to cause localized socio-economic impacts	Medium – Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic impacts
Reversibility	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Communica-tions	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	Medium – moderate disruption, denial or corruption of ICT and or communications over portions of region or community where service is restored within 7 days.
IMPACTS: Road Closure/Route Denial Includes the closure of routes (roads, rail, etc…) by permanent means such as having been destroyed or for extended periods of time due to heavy snowfall, flooding or blockage by illegal strikes/demonstrations.		
Potential impacts	1. More rapid deterioration of infrastructure 2. May create issues with asphalt as higher temperatures and degree days occur more frequently – affects public streets, parking lots driveways, private streets 3. To address asphalt issues, use different binders (binders with higher temperature limit)	
Scenario	**HEAT WAVE**	**FOREST FIRE**
Duration	NA	Low – effect causes disruption to normal community life for several weeks or less
Geographic Extent	NA	Low – effects occurs over localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.
Regional Sensitivity	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect
Magnitude	NA	Low – Effect has potential to cause localized socio-economic impacts
Reversibility	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect
Communica-tion	NA	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Structure Failure or Loss With respect to buildings, means the destruction, collapse or loss of use of the structure for an extended period of time, or permanently.		
Potential Impacts	Longer construction season (positive); negative potential fire may damage structures	
Proposed Solutions		
Scenario	**HEAT WAVE**	**FOREST FIRE**
Duration	NA	Medium – effect causes disruption to normal community life for several months
Geographic Extent	NA	Low – effects occurs over localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.
Regional Sensitivity	NA	Medium – The nature of this region or community's economy, culture, or environment make it vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.
Magnitude	NA	Low – Effect has potential to cause localized socio-economic impacts
Reversibility	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect
Communications	NA	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

COLD WAVE, ICE STORM and SEVERE WINTER STORM

SCENARIOS http://www.acasamaps.com/index.html	*Moncton estimates for cold days (below minus 10 degrees Celsius):* *2011-2040: 6-12days* *2041-2070: 5-9 days* *2071-2100: 3-6 days* Days with a maximum temperature below -10 degrees C become increasingly rare towards 2100. *Winter total precipitation is the average total of rainfall and snowfall for the months of December, January and February. Winter precipitation is expected to increase in all areas.* *Moncton estimates:* *2011-2040: 323-373mm* *2041-2070: 330-366mm* *2071-2100: 348-380mm* *Annual Total Snow Days is the average number of days per year with at least 0.2 cm of snowfall.* *Moncton estimates:* *2011-2040: 51-61days* *2041-2070: 53-61 days* *2071-2100: 39-48 days* *Days with snow show relatively little change in future scenarios, decreasing slightly in the north and remaining similar in the south. Temperature change across the freezing point can directly affect materials and infrastructure (e.g. paint, road surfaces). There are also indirect effects. More freeze-thaw cycles can require increased use of road salt, for example. Increased freeze-thaw activity in winter can be harmful for plants and wildlife by breaking dormancy and increasing the damage caused by subsequent cold spells. The full range of impacts is hard to predict, but effects are likely on the maple syrup industry, forest management, and road maintenance and weight restriction periods.*		
Scenario	**COLD WAVE**	**ICE STORM**	**SEVERE WINTER STORM**
LIKELYHOOD OF OCCURRING TODAY	Likely	Likely	Almost Certain
CASUALTIES	Low		
IMPACTS: Loss/Degradation/Reduction of Emergency Services Emergency services consist of the 911 system as well as fire, police, ambulance and hospital emergency			
Scenario	**COLD WAVE**	**ICE STORM**	**SEVERE WINTER STORM**
Duration	NA	Low – effect causes disruption to normal community life for several weeks or less	
Geographic Extent	NA	High - Effect occurs over an extensive are within the community	
Regional Sensitivity	NA	Medium – The nature of this region or community's economy, culture, or environment make it vulnerable to this effect. Some regional characteristics are vulnerable but do not exacerbate the effect.	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect
Magnitude	NA	High – Effect has the potential to impact the local population as a whole and triggering major socio-economic change that is outside the range of normal variability	Medium – Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic impacts
Reversibility	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Communications	NA	Medium – moderate disruption, denial or corruption of ICT and or communications over portions of region or community where service is restored within 7 days.	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Loss of Essential Services Essential services include power, water, sewage, telecommunications and IT. The loss of power may result in health (lack of dialysis machines, heart monitors etc…) and economic (loss of food and medication that requires refrigeration) consequences.			
Potential Impacts	High than average demand on the grid; ice storm may cause loss of power;		
Scenario	**COLD WAVE**	**ICE STORM**	**SEVERE WINTER STORM**
Duration	Low – effect causes disruption to normal community life for several weeks or less		
Geographic Extent	High - Effect occurs over an extensive are within the community		Medium – Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.
Regional Sensitivity	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	High – The nature of the region or community's economy culture or environment make it atypically sensitive to this effect. Some regional characteristics could exacerbate the negative consequence of the effect.	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect
Magnitude	Low – Effect has potential to cause localized socio-economic impacts	Medium – Effect has the potential to impact a portion of the local population and could trigger detectable socio-economic impacts	Low – Effect has potential to cause localized socio-economic impacts
Reversibility	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	Medium - Negative impacts caused by this effect can be reversed within 2 years with some government restoration efforts or over a longer period of time without government intervention.	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect
Communications	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	High – Disruption, denial or corruption of ICT and or communications over significant areas of region or community where service is not fully restored within at least 7 days	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.

IMPACTS: Road Closure/Route Denial Includes the closure of routes (roads, rail, etc…) by permanent means such as having been destroyed or for extended periods of time due to heavy snowfall, flooding or blockage by illegal strikes/demonstrations.			
Potential impacts	Trees and branches falling and blocking access; temporary closures due to heavy snow		
Scenario	**COLD WAVE**	**ICE STORM**	**SEVERE WINTER STORM**
Duration	NA	Low – effect causes disruption to normal community life for several weeks or less	
Geographic Extent	NA	Medium – Effect occurs over a portion of the region or community. The effect is considered to have an area of influence which is limited to a portion of the geographic area.	
Regional Sensitivity	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Magnitude	NA	Low – Effect has potential to cause localized socio-economic impacts	
Reversibility	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Communicat ion	NA	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	

IMPACTS: Structure Failure or Loss With respect to buildings, means the destruction, collapse or loss of use of the structure for an extended period of time, or permanently.			
Potential Impacts	Falling trees – minor damages; some buildings lose roof (load issues);		
Scenario	**COLD WAVE**	**ICE STORM**	**SEVERE WINTER STORM**
Duration	NA	Low – effect causes disruption to normal community life for several weeks or less	
Geographic Extent	NA	Low – effects occurs over localized area within the region or community. Effect is considered to have an area of influence which is limited to the footprint of the effect or its immediate vicinity.	
Regional Sensitivity	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Magnitude	NA	Low – Effect has potential to cause localized socio-economic impacts	
Reversibility	NA	Low – The nature of this region or community's economy, culture or environment do not make it particularly sensitive or vulnerable to this effect	
Communica-tions	NA	Low – short term or no disruption of ICT and/or communications or disruption over isolated, non-sensitive areas.	

REFERENCES

[i] The Atlantic Climate Adaptation Solutions Association (ACASA) , established by the Atlantic Provinces (New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador) and with the Government of Canada, has assisted in managing the Atlantic RAC projects. Additional information on ACASA and the RAC program can be found at http://atlanticadaptation.ca/.

[ii] Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick, prepared by AMEC Earth Environmental for the Atlantic Canada Adaptation Solutions Association, December 21, 2011. A Final Summary Report was completed in September, 2012. http://atlanticadaptation.ca/sites/discoveryspace.upei.ca.acasa/files/Adaptation_Measures_Greater_Moncton-2011.pdf

[iii] The Province of New Brunswick is currently not required to prepare a Climate Change Action Plan in order to receive Gas Tax funding. For more details on Gas Tax funding: http://www.infrastructure.gc.ca/regions/nb/nb-prof-eng.html. In the Province of Nova Scotia, municipalities are required to prepare Climate Change Action Plans by December 31, 2013 in order to receive Gas Tax Funding in 2014: See http://www.nsinfrastructure.ca/pages/Municipal-Climate-Change-Action-Plan-Guidebook1.aspx

[iv] *Note: Weather related disasters from the CDD include: cold waves, droughts, floods, hail/thunderstorms, heat waves, hurricanes/typhoons, avalanches, storms (storm surges, freezing rain, winter storms), tornados and wildfires. Geophysical disasters from the CDD include e earthquakes, landslides and tsunamis. Disclaimer: Where there has been no finding of fact by a court of law in criminal, civil or administrative proceeding, the facts set out in this database are alleged facts. The Canadian Disaster Database continues to be a work in progress. While entries are checked, and every effort is made to use reliable sources, the data presented here may contain errors and/or duplications. As a consequence, revisions to the database are ongoing.*

Other Climate Change Adaptation Plans and Resources

FCM, Climate Change Adaptation Planning Handbook for Small Canadian Communities: http://www.fcm.ca/Documents/tools/PCP/climate_change_adaptation_planning_handbook_for_small_canadian_communities_EN.pdf

Municipal Climate Change Action Plan Assistance (Nova Scotia): MCCAP Assistant - nova scotia

Arviate Climate Change Adaptation Plan: http://www.arviat.ca/wp-content/uploads/2011/01/Arviat_Climate_Change_Adaptation_Plan_English_1008041.pdf

Saanich Climate Change Adaptation Plan: http://saanich.ca/living/climate/pdf/SaanichAdaptationDiscussionPaper2010-FINAL.pdf

Windsor Climate Change Adaptation Plan: http://www.citywindsor.ca/residents/environment/Environmental-Master-Plan/Documents/Windsor%20Climate%20Change%20Adaptation%20Plan.pdf

Stratford Climate Change Adaptation Plan: http://www.planningforclimatechange.ca/wwwroot/Docs/Library/CIPReports/CCMAP%20TOWN%20OF%20STRATFORD%20COMPLETE.PDF