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Sustainable Town of MIDDLETON Heart of the Valley

Town of Middleton
Municipal Climate Change Action Plan

FINAL REPORT

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19 December 2013

Mr. Brian Smith, CAO
Town of Middleton
P.O. Box 340
Middleton, Nova Scotia
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Dear Mr. Smith:

RE: Final Report: Town of Middleton Municipal Climate Change Action Plan

CBCL Limited is pleased to submit this Final Report for the Town of Middleton Municipal Climate Change Action Plan.

Thank you for the opportunity to work on this interesting project. The discussions that we held with the Adaptation Committee very informative and I feel that they helped to inform participants about climate change issues in the Town and what actions can be taken to adapt to climate change.

I trust the report will prove useful to the Town, but if you have any questions, please do not hesitate to contact me.

Yours very truly,

CBCL Limited

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Executive Summary

The Town of Middleton Municipal Climate Change Action Plan (MCCAP) is divided into two sections: Section 1 **Adaptation** and Section 2 **Mitigation**. The Town has prepared this plan to proactively consider climate change impacts and hazard risks within Town boundaries. Across Nova Scotia, communities can expect changes to precipitation patterns, amounts and intensities, warmer temperatures, and more frequent severe weather events like storms, floods and droughts (SNSMR, 2011a). Although planning for a changing climate cannot prevent changes in Middleton, it is useful for anticipating potential hazard risks and impacts. Planning enables the Town to better respond to climate change, reduce risk, minimize damage, and enhance resident safety. Of utmost importance is limiting the damage to critical municipal infrastructure including water, wastewater and roads. The purpose of this MCCAP is to proactively plan for climate change and identify where adaptation and mitigation measures are necessary to improve public safety and community sustainability.

The MCCAP builds on the Town of Middleton's Integrated Community Sustainability Plan (ICSP) (2009). The ICSP establishes priorities and actions towards economic, environmental, social and cultural sustainability. The MCCAP picks up on the vision and broad goals of the ICSP with a particular focus on environmental change and infrastructure resilience. The Province requires the preparation of MCCAPs for the transfer of the Gas Tax Funds which provide financial assistance for municipalities to invest in environmentally sustainable infrastructure projects.

The MCCAP planning process determined that the primary hazard risk of concern in Middleton is flooding of the Annapolis River. Flooding has the potential for municipality-wide impacts if the water distribution system, power supply and main roads were affected. While the provision of clean water and protection of the water distribution system is a top priority for the Town moving forward MCCAP provides the following action steps for adaptation and mitigation.

Recommended Adaptive Actions:

- Consider water system changes and upgrades in the Town's capital budget planning;
- Assess the need to hire engineering consultants regarding mid and long term system upgrades and changes, and to conduct a cost-benefit analysis. To consider:
    - a new water disinfection and pumping site located away from the 100-year flood area/ a more centralized pressure system;
    - constructing a water tower; and
    - the elevation of the vents on the wellheads in relation to the height of a probable maximum flood and raise the vents above the flood level (not an immediate priority due to the unlikely nature of a probable maximum flood occurring);
- Investigate the potential to work with the Centre of Geographic Sciences at the Nova Scotia Community College to update water system mapping, and in the long-term to update the flood risk mapping;
- Work with the Regional Emergency Measures Organization to review Nova Scotia Power Inc.'s Emergency Preparedness Plan for the Nictaux Dam System (Nova Scotia Power, 2011)

to ensure coordination of the Town's notification and emergency response procedures with Nova Scotia Power's procedures;

- When the Municipal Plan Strategy is reviewed and updated, ensure that the Wellfield Protection Plan (2009) is incorporated into planning policies and development regulations (See **Section 7 of the Wellfield Plan** for detailed planning recommendations that form the integrated approach to wellfield management);
- When the Municipal Plan Strategy is reviewed and updated, revisit the goals and actions in the ICSP (2009) and ensure that sustainability goals are being addressed;
- Improve communication with other levels of government, and check in with data sets and monitoring conducted by other levels of government about climate change and Annapolis River water levels. Consider including the monitoring, recording and reporting of water levels into the job description of a Town staff member;
- Continue communication with hospital, school and college about emergency response plans, and any observations or monitoring of Annapolis River and Eel Brook water levels.
- Address erosion risks in the cemetery to minimize public health risk and to preserve the heritage of the cemetery;
- Work with the Province and social service providers to communicate with marginalized residents during climate related emergency events like floods and power outages;
- Work with REMO Annapolis in public education about emergency preparedness. Share information like: http://www.getprepared.gc.ca/index-eng.aspx.

Recommended Mitigative Actions:

- Install a SCADA system throughout the water and waste water pump inventory to monitor pumping efficiencies and identify groundwater infiltration in wastewater infrastructure or leaks in water infrastructure;
- Add insulation to poorly insulated Municipal buildings;
- Improve air sealing of Municipal buildings;
- Replace existing light fixtures with more efficient alternatives;
- Upgrade building controls with programmable thermostats;
- Consider switching to alternative heating fuel such as natural gas, propane, and wood;
- Ensure regular maintenance of the vehicle fleet and regularly review that the right-sized vehicles are being used for their intended purpose.

SECTION 1 ACTION PLAN - ADAPTATION

Section 1 of the MCCAP outlines Middleton's plan for climate change ***adaptation.*** Climate change adaptation refers to:

> "Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Various types of adaptation exist, e.g. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature-shock resistant plants for sensitive ones, etc." (SNSMRa, 2011: 3).

Adaptation approaches include *preserving* natural resource and habitat lands, *avoiding* development in areas at risk of hazard, *protecting* areas where hazard risk would be exacerbated by development, *accommodating* and tolerating climate change impacts, and *managing retreat* where it becomes necessary to relocate public and private assets at risk of severe risk climate change impacts, especially in coastal areas (SNSMRb, 2011).

Developing the Adaptation Plan for Middleton was a six-step process, and the findings of each step are detailed in the sections below:

1. Establishing an Adaptation Committee;
2. Identifying Climate Change Issues & Hazards;
3. Identifying Affected Locations;
4. Assessing Vulnerability of Facilities and Infrastructure;
5. A) Identifying Who Will be Most Adversely Affected;
5. B) Identifying Potential Economic Implications;
5. C) Identifying Potential Environmental Issues; and
6. Determining Priorities for Adaptation.

1.1 Step One: Adaptation Committee

The Middleton Adaptation Committee was formed in the fall of 2013 and represents a diverse range of expertise and experience. The Adaptation Committee (hereafter referred to as the Committee) is comprised of the following representatives from Council, town staff, and other local organizations:

NAME	POSITION
Brian T. Smith	Chief Administrative Officer (Acting)
Chris Barker	Fire Chief
Dave McCoubrey	Regional Emergency Management Coordinator
Gail Smith	Town Councillor
John Pearson	Director of Public Works
Marianne Daine	Director of Finance
Melinda den Haan	Town Councillor
Sharon McAuley	Planning Services Coordinator & Executive Assistant

1.1.1 Adaptation Committee Mandate and Terms of Reference

The mandate of the Adaptation Committee is to oversee the preparation of a Municipal Climate Change Action Plan before December 31, 2013. The Committee retained the consulting services of CBCL Limited to produce the MCCAP. The Committee has worked with the consultant to assess hazards, potential impacts, affected locations, risk severity, frequency and area, and rank municipal concerns in terms of priority. The Adaptation Committee is accountable to the Town of Middleton Council, and is supported by Council through having two Councillors on the Committee as well as providing representation from Town staff. The Adaptation Committee is currently established to oversee the preparation of the MCCAP, but Town Council and staff may consider retaining the committee following the establishment of the MCCAP. The formation of a regional climate change adaptation and mitigation committee with Annapolis County and nearby towns is also under consideration.

1.1.2 Stakeholder Consultation

The Adaptation Committee and consulting team focused on talking to key informants and reviewing documents prepared by stakeholders (*see citations throughout and list of references*), rather than holding broad public consultation, which was not Provincially required for this planning process. Many key stakeholders sit on the Adaptation Committee, enabling important contributions and insights throughout the planning process. The MCCAP builds on the Integrated Community Sustainability Plan process, which included broad public consultation included participation of a diverse age range of residents from children to seniors, targeted stakeholder consultation, and an in-depth workshop with the steering committee (Middleton, 2009).

1.2 Steps Two & Three: Potential Hazards, Impacts and Affected Locations

The goal of **Step Two** is to identify climate change impacts and hazards. To achieve this goal, local weather-related and climate events in the past, as well as evidence from recent climate change scenarios (Richards and Daigle, 2011) were assessed to determine the potential climate change hazards and impacts for Middleton. Which of these potential climate changes could exacerbate or cause current and future potential hazards were then identified. Which changes in the climate could potentially bring opportunities to Middleton were also considered. The objective of Step Three is to identify locations within the Town of Middleton municipal borders that have been impacted by climate events or hazards in the past, and where they may occur in the future. In determining potential affected locations, the Committee considered local topography, geology, flood risk areas,

erosion prone areas, hazard prone areas, cultural and historic sites, existing land uses and future land use zoning in these locations.

Steps Two and Three were conducted simultaneously and the findings are thus combined below. To methodologically guide the Committee's discussion on the current and potential future impacts of climate change related hazards, a Climate Change Hazard Impact Matrix was established and is included as *Appendix A*. The following sections describe anticipated climate changes for the Middleton area and discuss past and potential hazards, anticipated impacts, and possible locations under section headings that correspond with the matrix in *Appendix A*. Potential benefits to climate change are also discussed in the following sections.

1.2.1 Anticipated Climate Changes for Middleton

Local climate science experts Richards and Daigle (2011) developed climate scenarios and climate change best estimates for representative communities across Nova Scotia and PEI. The climate scenarios consider both the current climate and scenario-produced possible future changed climates. For the Town of Middleton, the closest representative community/climate station analyzed by Richards and Daigle is Greenwood, which is also a non-coastal, Annapolis Valley location. A complete table showing the climate scenario data for Greenwood can be found in *Appendix B*. While in the long-term sea level rise and storm surge may eventually impact the regional watersheds and river systems, in non-coastal Middleton these are of minor concern. The climate scenarios indicate in general, communities across Nova Scotia can anticipate potential higher temperatures and increased precipitation amounts and intensities (Richards and Daigle, 2011).

1.2.2 Increased Precipitation Amounts and Intensity, and Flooding

In Middleton, the hazard risks associated with increased precipitation amounts and intensities, and the potential flooding of the Annapolis River and related creeks are of highest concern. With climate change, increased amounts of precipitation, and more intense rainfall events are anticipated. A 5% increase in the amount of rain by the 2020s, 9% by the 2050s, and 16% more rain by the 2080s can be expected (Richards and Daigle, 2011). Heavy, sudden storms are concerning, but smaller slow moving storms can also bring heavy amounts of rainfall and pose flood risks (SNSMR 2011b).

Warmer Winters and More Rain

With increased temperatures, warmer winters with fewer cold (less than -10°C) and very cold days (less than -20°C) can be expected. Richards and Daigle (2011) observe that precipitation is likely to increase most during the winter months, so more days with rain and less with snow can be expected. Winter precipitation brings concern about freezing rain and icy road conditions. Freeze-thaw cycles can also put stress on the built environment, such as concrete structures and asphalt roads, potentially resulting in cracks and potholes. As the climate warms over the long term, freeze-thaw cycles will decrease, but in the short and mid-term communities can anticipate freeze-thaw cycles as a potential impact in the winter months (Richards and Daigle 2011). A potential benefit of less snow is that the Town's budgetary needs for snow clearing will eventually decrease. Fluctuating winter climate conditions will also impact the timing and intensity of snow melt and spring run-off, which may impact the timing and intensity of potential flooding.

Annapolis River and Eel Brook Flood Risk

Increased precipitation is likely to increase the amount of water flowing into and through the Annapolis River catchment area, and may increase flood risk. Inland flash floods are "far and away the greatest threat to people's safety during heavy rainfall from hurricanes or tropical storms" (SNSMR, 2011b: 30). The Annapolis River marks the municipality's southern border. There are a few creeks that flow into to the Annapolis River, including Eel Brook which runs north-south through the western part of town, Slokum Brook on the far west of town, and Morton Brook on the far east, mostly just beyond town boundaries. Eel Brook runs through the most urbanized area, and is a key route for storm water drainage into the Annapolis River. The committee observes that the water level in Eel Brook has been high in recent storms, but has never flooded in recent memory.

Flood mapping for Middleton delineates the 100-year flood boundaries for the Annapolis River (See Figure 1 showing the 100-year flood line below). The Town's Protected Land (PL) land use designation corresponds with the flood risk mapping, restricting development within the River's floodplain area, and in the 8m watercourse setback areas designated PL along the creeks. This land use zoning is a good step towards protecting property and residents in the case of a flood. The committee notes that it is important to bear in mind that the "100-year flood" is likely to become more frequent with increased precipitation amounts and intensities. Committee members recalled the Annapolis River with high waters capable of flooding roads in 1954,1995, and again in 2003.

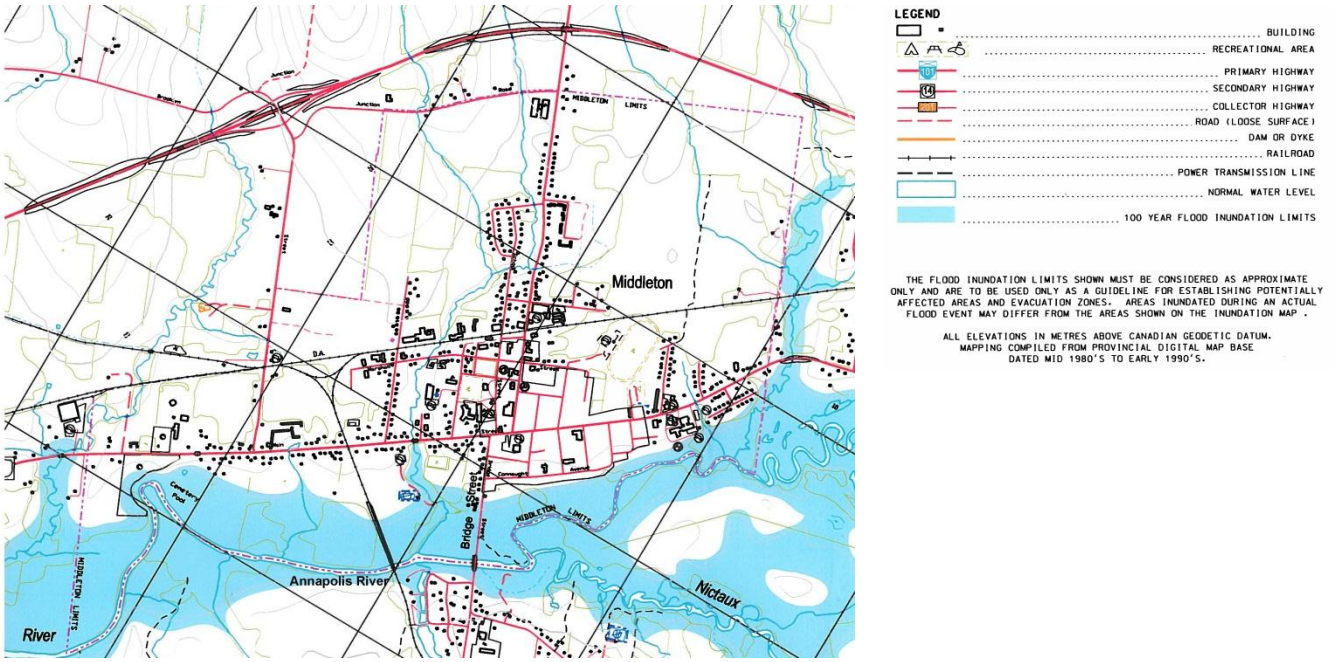

Figure 1: 100-Year flood Line (Nova Scotia Power, 2011, Plate 12.4)

Historically, the amount of water flowing through the Annapolis River is highest in spring, particularly April, and waters are high again in November. The highest primary water levels in the past two years have been between 3 and 3.5 metres. *Appendix B* shows four graphs illustrating the amount and height of water in the Annapolis River, measured by Environment Canada, Water Office

at Wilmot, the closest water station to Middleton. *Appendix B*, Figure 1 shows Peak Daily Discharge from years 1963-2010, and shows high discharge amounts in the early 1990s and in the early 2000s, with discharge reaching over 300m^3/second[1]. *Appendix B*, Figure 2 shows the maximum and minimum daily discharge by month using historical data for the period 1963-2010, and compares those with 2010 data[2]. This graph indicates highest maximum daily discharge in April, with high discharge rates again in November. Figure 3 shows maximum and minimum monthly mean discharge by month for the period 1963-2010, indicating that historically, the Annapolis River has a high discharge during the winter and spring (Jan-April), dropping during the summer months, and rising again in the fall (Sept-Nov). Figure 4 shows Primary Water Level for January 2012 to November 2013. The highest levels shown are between 3 and 3.5 metres.

With climate change, it is difficult to predict how the Annapolis River discharge, water levels, morphology, and flow will be impacted. Although, the current floodplain mapping and Protected Land designation is a good start, the Town will need to monitor the river in collaboration with other government departments, keep good records of observed changes, high water and flood events. Eventually, the Town will need to update the flood risk mapping, which may necessitate an extension of the Protected Land zoning and/or further restrictions on development in flood risk areas.

Potential Impacts - Increased Precipitation Amounts and Intensity, and Flooding

The impacts of increased precipitation amounts and intensities and flood include:

- damage to property and critical infrastructure (e.g. water, power, see further discussion in Step 4);
- disruption of roads;
- isolation and limits to access;
- evacuation;
- water contamination;
- increased runoff/ strain on storm water system;
- warmer winters, freezing rain/ icy road conditions;
- impact on septic systems and sewage treatment;
- habitat disruption; and
- fatalities and injury.

Development is restricted in the Protected Land zone, which corresponds with the 100-year flood line; however, there are some buildings within the affected area, most notably the Town's primary water disinfection site at the Well House located on the property of Soldier's Memorial Hospital, where floodwaters could affect the power supply and disrupt disinfection and pumps (see further discussion in Section 1.3.1). Flooded roads would impede access to and from homes, businesses and emergency services; for example, residents may be unable to access homes or the hospital, and emergency service providers may be cut off from accessing homes and other affected locations. In

[1] Graph shows amounts over 300m^3/s in approx. 2003, and tabular data indicates 273m^3/s maximum daily discharge on April 01, 2003 (Environment Canada, Water Office, 2013).

[2] 2010 is the most recent year in the historical data set.

an intense rain or flooding event, the Annapolis River and Eel Brook would likely contain debris and contaminants. Groundwater that the wellfield draws upon should remain uncontaminated in the event of a flood (see discussion in Section 1.3.1). Heavy rains will increase runoff and may place a strain on culverts and the storm water drainage system. Flooding, debris, contaminants and runoff will disrupt natural stream and wetland habitats. Depending on the severity of the rain and flooding, there could be potential impacts on septic systems. High, fast river waters and floods also have the potential to cause injury or result in fatalities (e.g. from drowning).

Past and Anticipated Future Flood Locations

- **Bridge Street**: According to the Committee's memory, in 2003 there was a rise in the Annapolis River water level of about 2-3 feet, resulting in water rising over the road, but the bridge itself remained above the water level.
- **Marshall Street**: The Committee stated that there had been concern about potential future flooding in the Marshall Street vicinity, including the areas near Bentley Drive and Junction Road. The Town has replaced the Marshall Street Culvert with a larger culvert thus minimizing the risk of rising water levels in Eel Brook overwhelming the culverts.
- **Junction Road**: The Committee is concerned about potential future flooding in the north end of town, towards the industrial park and college. Again the concern here is from rising water levels in Eel Brook.
- **Main Street/Hwy 1**: Where Eel Brook flows under Main Street/Hwy 1 could be an area of concern for potential future flooding, although it has not flooded in recent memory. The Committee noted that although the Annapolis River comes close to Hwy 1 at the western end of Middleton, near TRA Atlantic's warehouse, they have not seen any flooding there.

The Regional Emergency Management Organization (REMO) Annapolis is in the process of developing and revising a *Peacetime Emergency Plan* (2012). REMO's flood response plans include putting efficient, effective and economical mitigation strategies in place, such as sandbagging, and using equipment available through Emergency Management Office Nova Scotia, located at local Department of Transportation and Infrastructure Renewal sites.

There is the potential risk of a severe, large and rare flooding event associated with a breach in the Nictaux dam. See Section 1.2.6 for further discussion.

1.2.3 Hurricanes, Lightning & Wind

Storms and hurricanes can bring high winds and lightning, which can damage property and critical infrastructure by hitting these directly, or hitting a tree and causing broken limbs and branches to fall and cause damage. These hazards can impact any location in the municipality. Power and communications lines are especially vulnerable to high winds. Historical "climate normals" for Greenwood, NS (1970-2000) show a yearly average wind speed of 15.3km/hr, and the wind direction most frequently SW. The maximum hourly wind speed was recorded in 1964 at 113km/hr, and the maximum gust speed was recorded in 1976 at 188km/hr (Climate Canada, 2013).

Potential Impacts – Hurricanes, Lighting and Wind

The potential impacts of hurricanes, lightning and wind include:

- direct hits & fallen tree limbs and branches;
- damage to power & communication lines and other critical infrastructure;
- disruption of roads;
- limits to access;
- damage to private property;
- injury or fatalities;
- loss of crops / damage to forest resources; and
- lightning – fires.

In the case of communication lines being damaged, REMO Annapolis (2012) has an emergency telecommunications plan and alerting system in place. The Town of Middleton has the capacity to clear roads and minimize disruption by cleaning up fallen tree limbs and branches and other debris following a storm with high winds. Wet soil conditions can compound the impacts of storms, lightning and wind, as root systems and tree stability may be affected. Depending on where a tree limb falls or lightning strikes, private properties and municipally-owned buildings may be damaged. Fallen tree limbs and lightning strikes have the potential to injure people or cause fatalities, depending on when and where the damage occurs. The Town of Middleton has few agricultural and forest resource activities within its borders, therefore potential risk of damage is low. Lightning strikes have the potential to cause fires in either forested areas or buildings.

Power Outage

Damage to power lines could cause far-reaching power outage affecting Middleton residents, businesses, infrastructure and services depending on where and which lines were damaged. REMO Annapolis (2012) identifies the following possible major effects of power outage:

- loss of heat/ cooking; lighting;
- loss of water-pumps;
- food shortages/spoilage;
- traffic lights;
- loss of communications;
- fuel shortage; and
- money shortage.

A new Fire Hall is being planned and fundraised for in Middleton. The new Fire Hall would also serve as a community centre, and comfort station with a power generator where residents could congregate in the event of widespread power outage, or other severe emergency.

1.2.4 Erosion and Landslides

Erosion and landslides are considered of minor, rare, and small hazard risk in the Town of Middleton. On average the storm sewer system works effectively and is only at 2/3 capacity, which helps minimizes erosion in the built up areas.

Potential Impacts – Erosion and Landslides

Erosion and landslides could cause the following impacts:

- damage to property and infrastructure;
- water contamination/ siltation;

- habitat disruption;
- road and access disruptions; and
- slumping in banks along the river.

The Committee has not observed slumping in the banks along the Annapolis River. Some erosion of the Annapolis River bank has been noted near the cemetery following flooding events. The Committee expresses concern about future worsening of erosion near the cemetery. Town Council should take action to ensure that no future graves are placed in an area of erosion risk, to avoid potential water contamination and thus a threat to public health, as well as to protect the historic significance of the cemetery.

1.2.5 Warmer Summers and Droughts

Even through increased amounts of precipitation can be expected as a result of climate change, soil conditions can still be very dry because of warmer temperatures and increased evaporation (Richards and Daigle, 2011). With the warming climate, while coastal areas will experience some cooling effects from the ocean, inland Nova Scotia locations, like Middleton will be most affected by increased temperatures. This is likely to increase the number "cooling degree days" within a year and lead to more energy used to run air conditioners. Hot days (exceeding 30°C, currently about 6/year) and very hot days (exceeding 35°C, currently about 0/year) are currently rare in Nova Scotia, but communities like Middleton will have to adapt to increases in both, with hot days increasing to 32.7/year in the 2080s and very hot days increasing to 2.2/year (Richards and Daigle, 2011).

Potential Impacts – Warmer Summers and Droughts

- groundwater recharge reduction;
- habitat disruption (e.g. low water levels in streams, ponds and wetlands, risk of fire); and
- loss of agricultural productivity.

Middleton's primary concern about warmer summers is the risk of drought and placing strain on the groundwater supply. The wellfield is located south of the Annapolis River in the Nictaux area. Strain on the groundwater would likely occur in the hottest times of the summer, especially August. Falling water levels in streams, ponds and wetlands will disrupt habitat for plant species and wildlife. The Committee considers risk of forest fire to be very low, given the limited amount of forested areas within Town boundaries. There is a risk of controlled grass fires spreading out of control because of increasingly dry conditions. A forest or grass fire could damage property and infrastructure, contaminate the water, and disrupt natural habitats. Middleton is fairly well protected from fires spreading from areas beyond municipal boundaries due to the buffering effect of the Hwy 101 to the north, and the Annapolis River to the south. There is little agricultural activity within the Town's borders; however, it is worth noting that the growing season is expected to be lengthened by about 1-2 months by the end the century (Richards and Daigle, 2011). This will require adaptation from farmers and even backyard gardeners in terms of the crops grown and will affect the need for irrigation and watering.

The Town of Middleton, and other maritime municipalities will need to adapt to warmer temperatures and Council may need to consider actions like issuing heat health alerts, and providing public air-conditioned cooling centres and special monitoring and services for vulnerable groups like young children and seniors. Drought conditions may also require restrictions on household, lawn

and gardening water uses. Warmer municipalities across Canada can provide examples for these measures, so Middleton will not have to reinvent the wheel as the climate gets warmer over time. A potential benefit of warmers summers is an extended tourism season, which will have positive economic impacts throughout Nova Scotia.

1.2.6 Nova Scotia Power Nictaux Dam and Probable Maximum Flood

Middleton is located in the near downstream area of the Nictaux Hydro System, a complex of pwer generated dams operated by Nova Scotia Power Inc. (NSPI). NSPI has a comprehensive Emergency Preparedness Plan for the system (Nova Scotia Power, 2011). The Emergency Preparedness Plan provides information on the watercourses, dams and other infrastructure in the system, emergency response procedures, notification and communications, site access, and warning systems. The Plan also includes excellent mapping showing the potential flooding in the area including Middleton under a 100 year storm (see Figure 1) and under an unlikely catastrophic event called a probable maximum flood (see Figure 2). The following section describes what constitutes a probable maximum flood. While the Emergency Preparedness Plan for the Nictaux Dam System (Nova Scotia Power, 2011) provides excellent procedures for NSPI to follow in the event of a dam breach, it does not provide procedures for the Town of Middleton to follow.

Probable Maximum Flood

The probable maximum flood represents the worst-case scenario of multiple events acting in a domino effect. Simulations of the dam system determined that a mid-August (summer/fall all-season maximum) probable maximum precipitation falling on the catchment area of the dams saturated by 1/100-year pre-storm combined with multiple breaches of the dams in the system could result in a probable maximum flood event. If the probable maximum flood were to occur, most critical infrastructure in Middleton would be under water, and there would be a town-wide crisis (See Figure 2, map of probable maximum flood below). While this is regarded as a rare possibility, the impacts would be severe and large. At this point, the Committee feels that Middleton would not have the resources or capacity to respond to a flooding crisis of this magnitude. Additional studies by Nova Scotia Power, and consultation between Middleton and surrounding municipalities, and REMO Annapolis may be required to assist in planning for an extreme flooding risk.

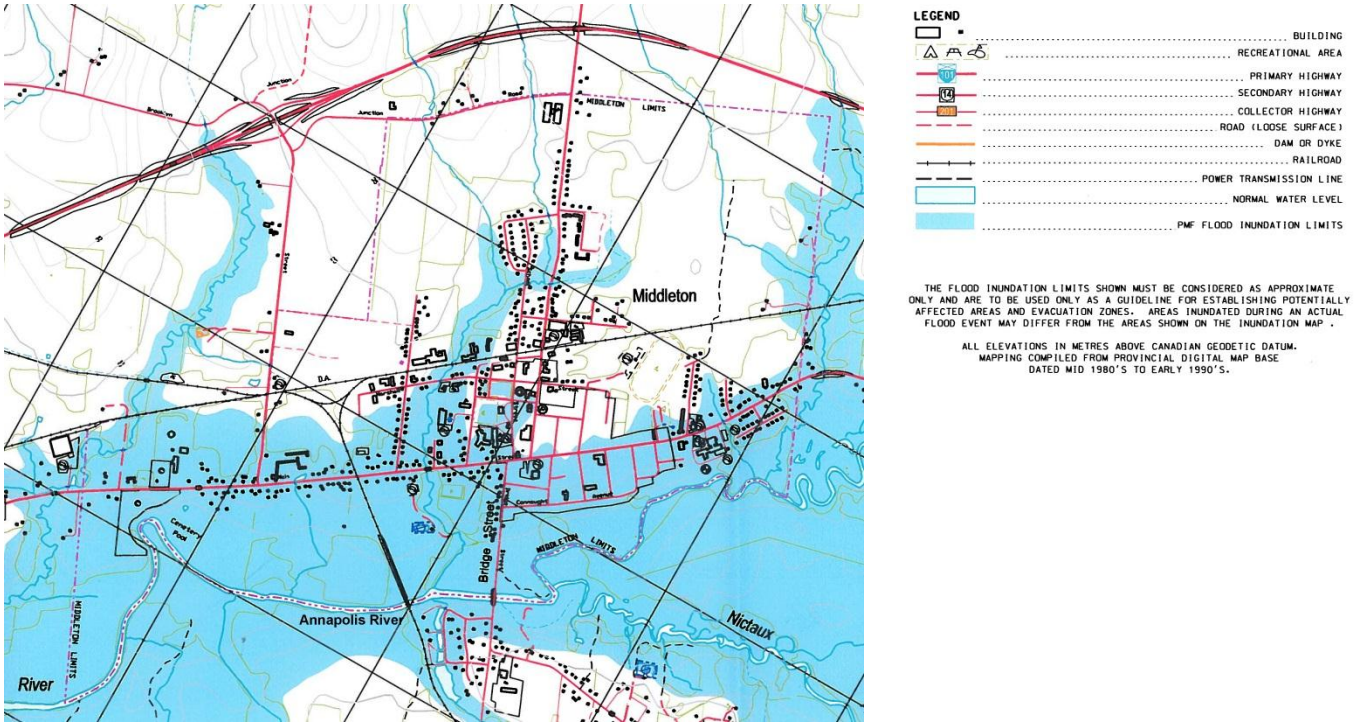

Figure 2: Probable Maximum Flood Line (Nova Scotia Power, 2011, Plate 12.13)

1.2.7 Earthquakes

Earthquakes in Nova Scotia are of such a low magnitude that they are rarely felt. Earthquakes are measured according to seismic energy on a Magnitude scale of 1-9. Earthquakes in the Magnitude of 1-3.5 are "recorded on local seismographs, but generally not felt" (NRCAN 2013a). A search of the NRCAN (2013b) earthquake database shows four low-magnitude (1.3-2.0MN) earthquakes near Middleton between 1985[3] and 2013 (see Figure 3 below):

- 19km SE from Middleton, Magnitude of 1.3MN, 2013/06/02;
- 16km SE from Middleton, Magnitude of 1.5MN, 2012/04/30;
- 20km SE from Middleton, Magnitude of 1.8MN, 2012/04/30; and
- 9km S from Kingston, Magnitude of 2.0, 2011/07/05

[3] Earliest date in the historical database for the Middleton area search.

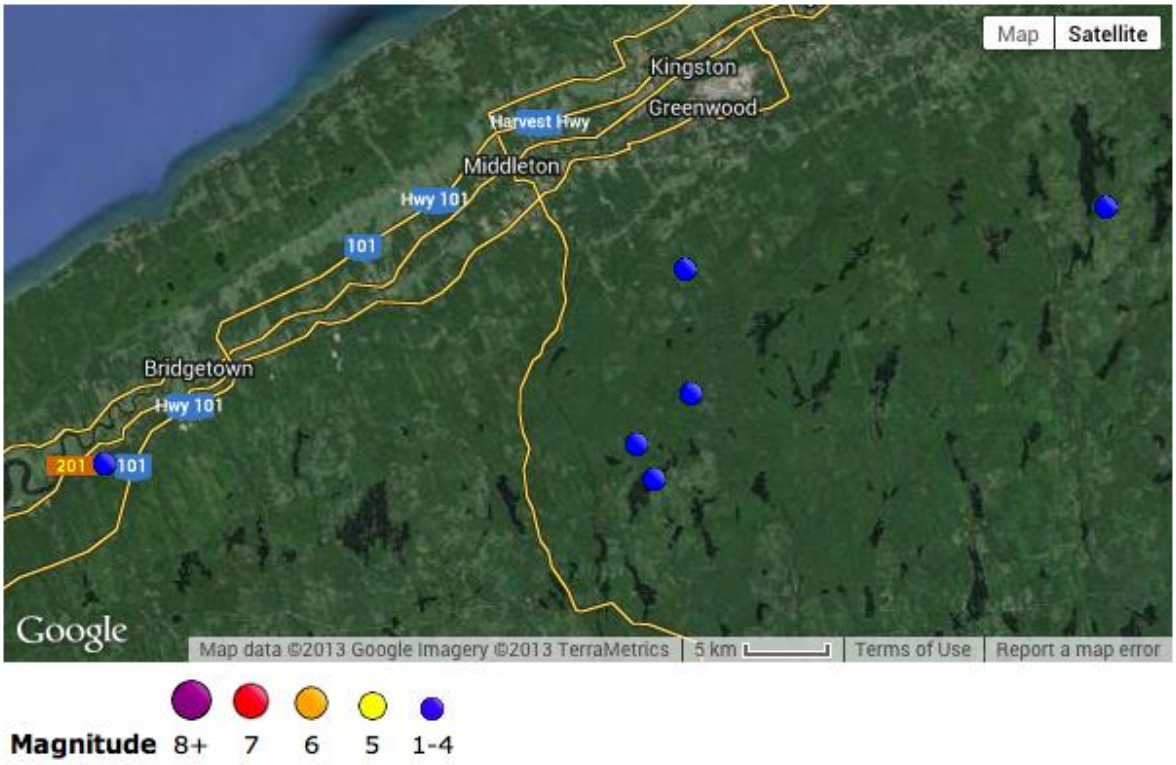

Figure 3: Earthquake locations near Middleton, NS 1985-2013 (NRCAN, 2013)

Climate change is unlikely to affect earthquakes (Health Canada, 2008). Earthquakes are considered a low, and rare risk within the Town of Middleton currently, and in the long term. Given the historically low magnitude of earthquakes in the region, feeling an earthquake and any resultant damage is highly unlikely.

1.3 Step Four: Facilities, Infrastructure and Service Delivery

The objectives of step four are to identify the key facilities and infrastructure in the Town of Middleton boundaries, to determine whether some will be more affected than others, and to evaluate the impact of climate change on the delivery of municipal services.

The following discussion represents the potential extra impact of climate change on facilities, infrastructure and service delivery in addition to regular maintenance, retrofits and renewal. In addition to the following discussion, *Appendix C* includes completed Infrastructure Risk Assessment Spreadsheets, using the framework established by Service Nova Scotia and Municipal Relations. The spreadsheets assess the potential risk posed to each municipal infrastructure by potential climate change impacts.

1.3.1 Water Supply and Treatment

Ensuring the cleanliness and safety of the public water supply and minimizing disruptions to the distribution system are top priorities. Climate change-induced droughts, insufficient groundwater recharge, and a severe flood could impact the water supply.

There are three production wells located south of the Annapolis River above the 15m contour elevation (See Figure 4 below). Details on the three production wells are as follows:

- "PW1 – 305 mm diameter, 94.1 m deep drilled groundwater production well, rated for safe yield of 910 L/min, equipped with a 25 HP Pleuger, Model QN63, 9 stage, submersible well pump with a rated capacity of 15.2 L/sec at a TDH of 86.9 m, with a 100 mm discharge header, to 150 mm main to a 250mm well field header pipe, discharging to a 200mm transmission main to the Town Control Treatment Building adjacent to the Soldier's Memorial Hospital;
- PW2 – 250 mm diameter, 78.1 m deep drilled groundwater production well, rated for safe yield of 800 L/min, equipped with a 25 HP Pleuger, Model QN63, 8 stage, submersible well pump with a rated capacity of 13.3 L/sec at a TDH of 86.9 m, with a 100 mm discharge header, to 150 mm main discharging to a 200 mm transmission main to the Town Control/Treatment Building adjacent to the Soldier's Memorial Hospital; and
- PW3 – 250 mm diameter, 78.1 m deep drilled groundwater production well. The well was rehabilitated in 2011. PW3 is rated for safe yield of 900 L/min, and is equipped with a 25 HP Grundfos Pump, with a rating of 900 L/min at head of 107 m. The riser pipe is PVC Certa-Lock 100 mm diameter with spline couplings, connected to a 150 mm main discharging to a 200 mm transmission main to the Town Control / Treatment Building adjacent to the Soldier's Memorial Hospital." (Town of Middleton/CBCL, 2013: 7-8)

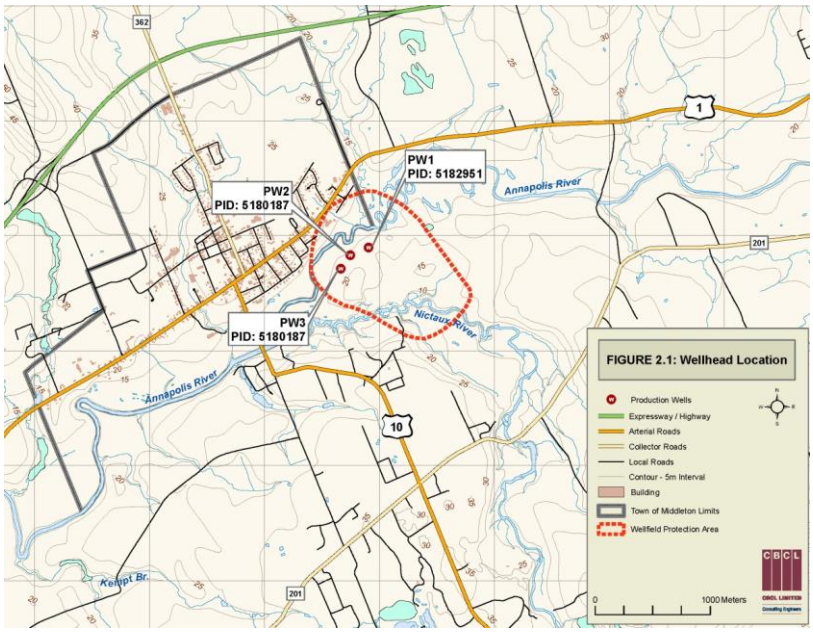

Figure 4: Wellhead Locations in the Middleton Wellfield (Middleton, 2009)

In early 2009, the Town of Middleton established a Wellfield Protection Area and Plan. The location of the wells themselves appears to be above the 100-year flood line; however, parts of the Wellfield Protection Area would be under flood waters. The wells were determined to be non-GUDI (i.e. not groundwater under the influence of surface water) and this is a situation in which flooding of the surface area should not contaminate the groundwater that the wells are drawing upon. However, depending on the heights of the vents on the wellheads, the wells could be affected by a probable maximum flood event.

The primary disinfection site is the Well House adjacent to Soldiers Memorial Hospital. The Well House is located within the 100-year flood area. If the Well House were to flood, the power supply could be impacted, disrupting the pumps and the chlorine disinfection system. The Committee considers the Well House disinfection site to be the weakest link in water system, when considering

flood hazard risks. Disruption to disinfection would necessitate the calling of a boil-water order throughout the town.

The town has a covered, in-ground concrete water reservoir located at 144 Gates Mountain Road, with a capacity for 220$m^{3.}$ Disinfection also occurs within the Reservoir Building (Middleton/CBCL, 2013). The Reservoir is outside of the 100-year flood risk area, as it is located far north of the Annapolis River, and is actually beyond Town boundaries within the County of Annapolis.

1.3.2 Wastewater Collection and Treatment

A new Town of Middleton Sewage Treatment Plant was operational in 2011. It is designed for an 8 million gallon capacity, although Middleton Public Works estimates that it could handle up to 9 million. In summer 2013 after a period of heavy rain, the capacity only reached 3 million, demonstrating the ample additional capacity the plant can handle. While the Town's ICSP discusses storm / sanitary sewer separation, the additional capacity provided in the plant seems to be capable of handling the additional storm flows for the time being.

The Plant has a very powerful generator in the case of a power outage. Water leaving the sewage treatment plant passes through wetlands before reaching the Annapolis River. The location of the new Sewage Treatment Plant is adjacent to the location of the former one. During heavy rains and high water during 2003, Committee members recalled that Public Works staff had to walk into the Treatment Plant because the access road was flooded, but the treatment building was not flooded, power was not impacted, and the holding ponds were not affected.

There are six sewage lift stations throughout the Town of Middleton. The primary concern with the lift stations in the event of a flood or power outage is whether or not they have back-up power and can continue to function.

1) PS#1 at the Treatment Plant is hooked into the large back-up generator that serves the treatment plant.
2) PS#2 at School Street and Reagh Avenue does not have the capability to be connected to a generator and is identified by Public Works as needing improvements and upgrades.
3) PS#3 at North Street has the capability to be connected to a back-up generator.
4) PS#4 at the Hospital can run off the Hospital's back-up generator.
5) PS#5, the lift station at Freeman Street will have the capability to be connected to a generator in Spring 2014.
6) PS#6 at Brooklyn and Main does not have the capability to be connected to a generator but does have a back-up wet well.

1.3.3 Stormwater, Roads, Bridges and Culverts

The Town of Middleton maintains all roads within Town boundaries, except for Hwy 1, and Hwy 101, which are maintained by the NSTIR. NSTIR is developing its own climate-ready designs and climate change adaptation plans (SNSMR, 2011a). In the case of a flood affecting Hwy 1, the main route out of town would be Hwy 101.

Stormwater in the central area of Middleton is directed into Eel Brook, which flows into the Annapolis River. Middleton monitors and maintains culverts throughout town. In the case of an intense and sudden storm event, Eel Brook would be impacted, and could hold, not just water, but debris and contaminants. In 1995, intense rainfall, overwhelmed culverts and water rose over Highway 1.

1.3.4 Power Utilities and Supplies

Power hazard risk and potential impacts are discussed in Section 1.2.3. The extent of impact from a power outage depends on which part of the power supply system is impacted. For example, if the substation at Nictaux were affected, there would be more serious impacts than from a single power line being impacted during a storm. It should also be noted that the Town receives power from two different substations and in past power outages, there have been times when one part of the Town has power while the other does not.

1.3.5 Hospital and Nursing Home

Soldiers Memorial Hospital

Soldiers Memorial Hospital is located just outside the area prone to the 100-year flood on Hwy 1. Even if the hospital site itself does not flood, flooding in sections of Hwy 1 could impede resident and ambulance access to and from the hospital in certain parts of town. The Hospital is under Provincial jurisdiction and is managed by Annapolis Valley Health, which has a District Emergency Response Plan. The Middleton Wellfield Protection Plan (2009) identifies a risk of spill from the hospital's oil tank, and recommends continued cooperation between the Town and the Health District to ensure that the oil tank meets all safety standards, has secondary containment, and is addressed in the hospital's emergency response plan. The hospital has high standards for medical waste storage and has regularly scheduled pick-ups to dispose of these materials off-site, and thus poses a very low risk in the case of a climate change related flood event. REMO Annapolis conducted a flood response exercise with the Hospital in May 2013. The Hospital has a portable power generator, and is scheduled for a power upgrade. Discussions have been held regarding the relocation of the back-up power generator around to the front of the building on higher ground in a location less susceptible to flooding. The Hospital's emergency back-up location is Nova Scotia Community College; however, the college itself does not have its own back-up power generator.

The Town of Middleton's role is to facilitate good communication with the Hospital and the Annapolis Valley Health District, to ensure sharing of information about potential risks and emergencies that are climate and non-climate related, and to work together in supporting the health and safety of Middleton residents. The Well House and one sewage lift station are located on Hospital property, therefore good communication and cooperation between the Town and the Hospital are important for long-term adaptation and mitigation of any impacts from flooding that could impact the water disinfection system.

Heart of the Valley Long Term Care Centre

The Heart of the Valley Long Term Care Centre is located at the far eastern end of North Street, just north of the railway track. It appears to be out of the 100-year flood risk area. The Committee expressed concern about wetlands on or near the nursing home site that may be impacted in the case of heavy rains and rising water levels. The Centre has food for one week on-site, and the main concern in a climate related event like a flood is whether or not staff can safely access town roads to travel to the nursing home.

1.3.6 Schools and College

There are two schools in Middleton: Annapolis East Elementary School located at 325 Marshall Street, and the Middleton Regional High School at 18 Gates Avenue. Both are located outside of the 100-year flood risk area. However, the High School is close to Eel Brook, and although the flood risk maps do not show the Brook impacting the High School site, this is something to consider in future flood risk mapping exercises as the climate changes over time. If the schools were needed as an emergency comfort station, a portable generator located at the Fire Hall could be moved to one of the school sites. The Town of Middleton should also be in communication with the Annapolis Valley Regional School Board about emergency planning and response.

Nova Scotia Community College, Annapolis Valley Campus is located in the north end of town on Commercial Street (Route 362) at Junction Road, just south of Hwy 101. Eel Brook runs along the back of the college site, so is worth monitoring over time for increased water levels. The Committee is unaware of back-up power supply at the College. The Town should be in communication with NSCC about their emergency response plans.

1.3.7 Community and Municipal Buildings

Other than the aforementioned Well House disinfection building, anticipated impacts from flooding and other climate change related events are expected to minimally impact municipally-owned buildings outside of flood prone areas. The Town of Middleton owns the following buildings:

- Town Hall - 131 Commercial Street (outside of both 100-year and probable max flood (PMF) areas);
- Public Works, including storage building - 295 Marshall Street (outside of both 100-year and PMF areas);
- Sewage Treatment Plant - 204 Main Street (building appears just outside of 100-year flood area, but is adjacent to Eel Brook and just north of the River, so should be monitored closely, also is within the PMF area);
- Library - 45 Gates Avenue (outside of 100-year flood area, but within the PMF area);
- Swimming Pool - 29 Gates Avenue (outside of 100-year flood area, but within the PMF area);
- Fire Hall - 49 Church Street (outside of both 100-year and probable max flood (PMF) areas);
- Visitor Information Centre - 8 Bridge Street (outside of 100-year flood area, but within the PMF area); and
- Rotary Park Pavilion including storage building - 337-339 Marshall Street (outside of both 100-year and PMF areas).

The proposed new Fire Hall location does not appear to be affected by the 100-year flood line, but a portion of the lot on which it is to be located could be impacted by a probable maximum flood event.

1.3.8 ICSP Infrastructure Considerations

The Town of Middleton Integrated Community Sustainability Plan (ICSP) (2009) identifies actions already underway and new actions that the Town will take to improve sustainability (social, cultural, environmental and economic sustainability). Many of these actions address climate change mitigation and adaptation. In terms of Infrastructure, the ICSP encourages active transportation and supports improving the connectivity of the existing trail network, and expanding the trails network alongside other infrastructure projects. Supporting walking and bicycling is addressed, and is included in the ICSP's bank of sustainability ideas to implement in the long-term. The ICSP recognizes Middleton's built heritage resources and recommends improving the heritage building inventory. Developing the heritage preservation plan should take into consideration the location of heritage buildings, whether or not they fall within the 100-year flood area, and what capacity and resources the Town has to mitigate impacts from climate events like floods through sandbagging, etc. The ICSP supports the continued implementation of and monitoring of the Wellfield Protection Area to ensure the safety of the Town's drinking water supply. Mitigation specific actions addressed in the ICSP are discussed Section 2.3 of this MCCAP.

1.3.9 Adaptation Projects to be Integrated into the Town's Capital Investment Planning process

Upgrades to the water system are a priority for the Committee to have addressed in the Town's capital investment planning process (see further discussion in Section 1.5). The Committee identifies the water system, especially the Well House disinfection site as the infrastructure facility that is most vulnerable to flooding, the risk of which is likely to increase with climate change.

The Town is also planning and fundraising for a new Fire Hall, which would also serve as a community centre, and a community comfort station in the case of an emergency, including climate-related events like floods and power outages. The SNSMR Municipal Climate Change Action Plan Guidebook (2011a) recommends adding climate change risks considerations into Requests for Proposals for new capital projects.

1.4 Step Five: Social, Economic and Environmental Considerations

1.4.1 Step Five A) Social Considerations

The ICSP (2009) identifies that Middleton has an aging population with large proportion of residents over 55 years old. The median age, 45.3 years, is higher than the Provincial median (41.8 years)[4]. Between 2001 and 2006, the population of seniors increased by 15%. The population of youth also increased, but only by 6%. While the town has developable land and sewer capacity, there has been little new house construction in Middleton or young families moving to town. The aging population has the potential to reduce the number of volunteers for community organizations, and volunteer

[4] 2006 census data, reported in ICSP (Middleton, 2009).

fire protection services. If the number of volunteer fire fighters is reduced, Middleton's ability to respond to climate related emergencies would be impacted.

The median household income for Middleton residents is $40,351 - lower than the Provincial median of $46,605. There are 19.9% households in Middleton with pre-tax low-incomes - higher than in the Province as a whole (13.8%). The unemployment rate is 11.9% - higher than the Province as a whole (9.1%). Low-income residents are more vulnerable to climate change hazards and impacts. REMO Annapolis recommends that all households have 72 hours of resources on hand for emergencies, like food and water. Having these resources available is challenging for residents with tight budgets and fixed incomes. The Committee expressed concern about low-income residents without vehicles being able to safely evacuate an area in case of an emergency, like a flood, especially as fire fighter volunteer capacity is reduced over time with the aging population. The Committee is interested in developing a central registry or list of community leaders from local churches, charities, service clubs, etc. who could help communicate with and relocate seniors, low-income households, special needs residents and other marginalized populations in the case of a climate related emergency event, like floods and power outages. Provincial departments and social services may be able to play a role in developing these resources.

The Committee acknowledges the growing significance of Facebook in assisting Town communications. During a recent water main break, an announcement went out through the Town's Facebook page, and the Town observed 2,200 website hits that day. Due to literacy concerns and limited access to computers, radio announcements and other means of communication (e.g. word of mouth, phone calls, etc.) still remain important in the case of a climate related emergency event.

1.4.2 Step Five B) Economic Considerations

Middleton's economy is service-based, with the service sector employing 65% of the working population in health, education, business and social services (Middleton, 2009). Middleton's small downtown has retail shops, banks and services like restaurants. The downtown area could become impacted by flooded culverts and flooding in Eel Brook. The industrial park is located in the north end of the town, outside of the 100-year flood risk areas. Middleton is a regional service hub for surrounding communities. If there were a flood or other severe climate related event, impacts would be felt not just by the 1,800+ Middleton residents, but by up to 5,000+ residents in the surrounding areas who rely on Middleton for shopping, work, health, education and other services and who would travel into the town for emergency services.

In terms of the fiscal sustainability, a severe climate related event could put serious strains on the municipality's budget. Depending on which facility or infrastructure component was affected, the cost of repair or replacement could be beyond the Town's capital budget capacity and strain the Town's ability to respond to the crisis. As identified throughout the MCCAP, the water system, especially the Well House disinfection site, is the most vulnerable to a climate related flood. Public Works has indicated that the wastewater system can be repaired in a relatively easy and cost-effective manner, but the water system would be more costly.

1.4.3 Step Five C) Environmental Considerations

The warmer temperatures and increased precipitation amounts and intensities that can be expected with climate change will inevitably impact the environment and natural habitats throughout Middleton. Of particular concern are the riparian zones around the Annapolis River and Eel Brook, which are vulnerable to flood risk. Sections within the flood risk area adjacent to the Sewage Treatment Plant and wetlands are also of particular concern in regards to potential contamination.

1.5 Step Six: Priorities for Action

The objective of step six is to prioritize the climate change adaptation issues that pose the greatest current and future risk, identify courses of action, and develop and approach to integrate adaptation priorities into municipal planning documents.

The top priority identified by the Committee is protecting the water supply. Public Works identified the need for long and mid-term upgrades and improvements for the water supply system. In the mid-term, there is a need for more engineering information on the water system and updated mapping.

As identified in previous sections, Council and Town staff will need to keep in close communication with other levels of government departments, regional organizations, surrounding municipalities and community organizations to share information about hazard risk monitoring, emergency planning and response, and adaptation and mitigation strategies.

Recommended Committee and Council Actions:

- Consider water system changes and upgrades in the Town's capital budget planning;
- Assess the need to hire engineering consultants regarding mid and long term system upgrades and changes, and to conduct a cost-benefit analysis. To consider:
    - a new water disinfection and pumping site located away from the 100-year flood area/ a more centralized pressure system;
    - constructing a water tower; and
    - determine the elevation of the vents on the wellheads in relation to the height of a probable maximum flood and raise the vents above the flood level (not an immediate priority due to the unlikely nature of a probable maximum flood occurring).
- Investigate the potential to work with the Centre of Geographic Sciences at the Nova Scotia community College to update water system mapping, and in the long-term to update the flood risk mapping;
- Work with the Regional Emergency Measures Organization to review Nova Scotia Power Inc.'s Emergency Preparedness Plan for the Nictaux Dam System (Nova Scotia Power, 2011) to ensure coordination of the Town's notification and emergency response procedures with Nova Scotia Power's procedures.
- When the Municipal Plan Strategy is reviewed and updated, ensure that the Wellfield Protection Plan (2009) is incorporated into planning policies and development regulations (See **Section 7 of the Wellfield Plan** for detailed planning recommendations that form the integrated approach to wellfield management);

- When the Municipal Plan Strategy is reviewed and updated, revisit the goals and actions in the ICSP (2009) and ensure that sustainability goals are being addressed;
- Improve communication with other levels of government, and check in with data sets and monitoring conducted by other levels of government about climate change and Annapolis River water levels. Consider including the monitoring, recording and reporting of water levels into the job description of a Town staff member;
- Continue communication with hospital, school and college about emergency response plans, and any observations or monitoring of Annapolis River and Eel Brook water levels.
- Address erosion risks in the cemetery to minimize public health risk and to preserve the heritage of cemetery;
- Work with the Province and social service providers to communicate with marginalized residents during climate related emergency events like floods and power outages.
- Work with REMO Annapolis in public education about emergency preparedness. Share information like: http://www.getprepared.gc.ca/index-eng.aspx

SECTION 2

ACTION PLAN - MITIGATION

Section 2 of the MCCAP outlines Middleton's plan for climate change ***mitigation***. Climate change mitigation refers to "a human intervention to reduce the sources or enhance the sinks of greenhouse gases." (SNSMR, 2011a). Preparing a corporate mitigation plan is a three-step process:

1. Collect energy and emissions information;
2. Complete energy and emissions inventory table; and
3. Set goals and identifying actions for mitigation

2.1 Energy and Emissions Information

Municipal energy consumers and greenhouse gas emissions sources include municipal buildings, recreational facilities, parks, streetlights, water/wastewater treatment and pumping facilities, solid waste management facilities, and municipal vehicles. Information regarding energy consumption from the municipally owned buildings, facilities and equipment were input into the Corporate and Emissions Spreadsheet developed by the Union of Nova Scotia Municipalities (2013). This information has been provided to the Municipality in a digital format.

2.2 Energy and Emissions Inventory Table

The following table (Figure 5) summarizes the information developed through the completion of the Corporate and Emissions Spreadsheet in section 2.1.

Emission Category	Energy Type	Energy Consumption	Cost ($)	Units	Emission Factor (tCO2/units)	Emissions (tCO2e)
Buildings	Electricity	176903	28,702	kWh	0.82839	146.54
	Nat. Gas	-	-	M3	-	-
	Fuel Oil	16,887	15,142	L	2.68	45.26
Water & Wastewater	Electricity	763,809	89,077	kWh	0.82839	632.73
Streetlights	Electricity	25,466	3,338	kWh	0.82839	21.1
Vehicles	Reg. Gasoline	3,908	5,150	L	2.34	9.14
	Diesel	4,835	6,474	L	2.63	12.72
Solid Waste	n/a	0.054	53.58	tonnes	0.5	0.027
Others	-	-	-	-	-	-

Figure 5: Energy and Emissions Inventory Summary Table

Figure 6 indicates the major producers of greenhouse gases from municipally owned buildings, facilities and equipment.

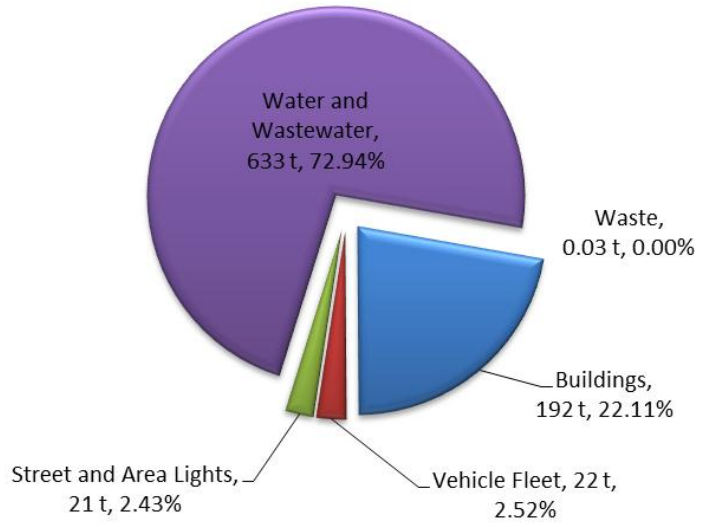

Figure 6: Greenhouse Gas Emissions by Sector (tonnes)

2.3 Setting Goals and Actions for Mitigation

The ICSP (Middleton, 2009) identified several new actions that the Town would undertake to address energy efficiency (See Figure 7 below).

New Action	Responsible Party and Partners	Timeframe / Targets	Outcomes & Community Benefits
Assess community facilities and operations and implement steps towards greater energy and water efficiency Establish a no-idling policy for the Town's vehicle fleet. Standard contracts for construction works tendered by the Town will include a requirement to comply with the Town's no idling policy. Take steps towards more energy efficient municipal buildings, i.e. install / replace insulation, install energy saving lighting systems, programmable thermostats, low-flow toilets, etc. Work with Nova Scotia Power to implement a program to replace streetlight bulbs with LED fixtures. Extend Town actions into a public education program encouraging local businesses and organizations to follow the Town's lead.	Lead: The Town's CAO will lead this effort. Support: The Director of Public Works will manage the operations of the vehicle fleet and contract, and work towards implementing the streetlight program whereas a champion would be required to spearhead the public education component. As aspects of this action are varied, specific leads are required as opportunities arise (e.g., building efficiency review, etc.).	2010: Review opportunities to improve building efficiency. Create no-idling policy for Town fleet and contracts. Begin negotiations with NSPI regarding upgrades to streetlights. 2011: Begin education program on no-idling campaign for visitors and residents alike. 2011 and beyond: Based on energy and water efficiency opportunities, develop and implement these projects.	Improving efficiency of water and energy use has obvious environmental benefits (e.g., reduced GHGs, etc.). The economic benefits are expected to be fairly substantial – in terms of reducing direct cost of operating municipal buildings but also in terms of reduced cost to operate municipal infrastructure (e.g., from reduced water demand and sewage production). Beyond these multiple benefits, social (e.g., health) and cultural (e.g., community action and pride) can result from these initiatives.

Figure 7: Efficiency Actions from the Middleton Integrated community Sustainability Plan (2009)

Following from the intentions listed in Table 7, the following measures are recommended as cost effective ways to reduce energy use and resultant costs and greenhouse gas emissions.

2.3.1 Water and Waste Water Pump Monitoring

Inefficient pumps can operate for long periods of time undetected. A worn centrifugal pump will typically exhibit a rise in pumping energy to compensate for a loss of pumping performance. These issues can be resolved with monitoring and diagnosis of water and waste water pumps with the use of a SCADA system. SCADA (supervisory control and data acquisition) systems collect runtime data, flow history and power quality information. SCADA systems can also be used to identify groundwater infiltration in wastewater infrastructure or leaks in water infrastructure. For example, data collected with a SCADA system with provide a baseline for pumping flow and power when the weather is dry. When it rains, groundwater infiltration can be detected through significant increases in flow and power. While the initial costs can be high for such a system, continual use of a SCADA system throughout the pump inventory will lead to long-term energy and cost savings.

2.3.2 Insulation

Adding insulation to an existing building envelope is one of the most effective ways to reduce energy use and save money. Simple paybacks are typically less than five years. Examples of upgrading building envelope include blown-in insulation in exterior walls and attics and insulating basement headers. Incentives are usually available to help offset installation costs.

2.3.3 Building Air Sealing

One of the largest sources of energy loss in buildings is due to uncontrolled air infiltration caused by poor building envelope sealing. Typical methods for improving air sealing include replacement of worn weather stripping on windows and doors, installing foam insulation in any voids around windows and doors, and caulking around building openings. These methods have typical paybacks of less than one year and prolong the life of building envelopes.

2.3.4 Lighting

Lighting typically accounts for up to 40% of a building's electrical energy use. Replacement of existing light fixtures with more efficient alternatives can lead to significant energy and cost savings. Some examples include : replacing existing T12 fluorescent lamps with T8's or T5's, installing LED light fixtures, installing compact fluorescent lamps (CFLs) to replace incandescent or halogen lamps , replacing magnetic ballasts with electronic ballasts in fluorescent light fixtures, installing occupancy sensors , and installing daylight control systems. Simple paybacks for such measures are typically five years or less. Efficiency Nova Scotia will typically provide rebates to building owners for lighting upgrades.

2.3.5 Building Controls

Upgrading building controls will reduce energy and costs. Cost effective methods including installing programmable thermostats, controlling building temperatures to a maximum of 21°C during the heating season and minimum of 24°C in the cooling season, and programming night temperature setbacks.

2.3.6 Alternative Heating Fuels

Generally, electricity and oil are the most common heating energy sources throughout most municipal buildings and facilities. Switching to alternate fuels such as natural gas, propane, and wood can reduce greenhouse gas emissions and heating costs.

2.3.7 Vehicle Fleets

Regular maintenance is a cost effective method to insure vehicles perform efficiently. A well maintained vehicle will use 5% to 10% less fuel than a poorly maintained vehicle. Ensuring proper tire inflation can also result in improved fuel efficiency. It is recommended to regularly review if each vehicle in the municipal fleet is best suited for its intended purpose as well. Vehicles oversized for their intended purpose should be replaced with smaller, more fuel efficient models. When the municipality purchases a new vehicle, consider fuel efficiency in the selection criteria.

2.3.8 Additional Resources

Additional mitigation resources are available on the Union of Nova Scotia Municipalities website: http://www.sustainability-unsm.ca/climate-changeenergy-efficiency.html

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APPENDIX A

Climate Change Hazard Impact Matrix

Appendix A: ***Climate Change Hazard Impact Matrix***

The following matrix outlines the Committee's subjective best estimate of impacts associated with different climate change hazards that have affected the municipality in the past or very recently. The discussion row (containing the bulleted points) illustrates key considerations, how much risk could be tolerated, and which hazards should receive priority attention. **Severity** is roughly determined by how important and costly the impacted infrastructure or facilities are and whether or not essential services would be disrupted, as well as how many people (especially vulnerable groups) would be impacted (e.g. fatalities, injury, illness, property damage, displacement). **Frequency** denoted as "often" would be highly likely within 5 years or less, "sometimes" would be an event likely to occur within 5-20 years, and "rarely" would indicate an unlikely event or one that has not occurred in recent memory. **Area** determined as "large" would be all or a majority of the municipality, "medium" would be a substantial area that impacts several properties, roads and critical infrastructure or facilities, whereas "small" would include a contained area, only one or two properties, and would be unlikely to impede an entire road. Detailed discussion of hazards and impacts can be found in the body of the report.

Hazards and Potential Impacts	Potential Locations	Severity			Frequency			Area			Overall Risk
INCREASED PRECIPITATION AMOUNT, INTENSITY AND FLOODING		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• damage to property and critical infrastructure (e.g. water, power) • disruption of roads • isolation and limits to access • evacuation • water contamination • increased runoff/ strain on storm water system • warmer winters, freezing rain/ icy road conditions • impact to septic systems and sewage treatment • habitat disruption • fatalities and injury	• Annapolis River • Eel Brook • Bridge Street • Marshall Street • Junction Road • Main Street/Hwy 1	✔	✔			✔			✔		High
		Notes: • Rankings based on the 100yr flood (not the more extreme probable maximum flood, which would be severe, rare and large). • Rankings based on past experience and local knowledge, but depending on the location and intensity of a future flood, these rankings could, of course, change to become more severe with a larger impact. • Severity is moderate-to-severe, because of the potentially town-wide impacts of an affected water system. Even if the actual flooded location is small or medium, if a flood affects critical water infrastructure, the impact could become large.									

Appendix A: ***Climate Change Hazard Impact Matrix***

HURRICANES, LIGHTNING AND WIND		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• direct hits and fallen tree limbs and branches • damage to power and communication lines and other critical infrastructure • disruption of roads • limits to access • damage to private property • injury or fatalities • loss of crops / damage to forest resources • lightning –fire	• Can occur throughout the Town. • Power lines are especially vulnerable.		✔	✔		✔			✔		Moderate
		Notes: • Severity is moderate-to-minor, because fallen limbs and branches that do not impact power lines or other infrastructure are minor, but if power lines are damaged, there could be a more serious impact. Power lines can be repaired relatively quickly, thus the potential impact is moderate and not severe. • Impacted area could be quite small (e.g. a single downed tree limb, obstructing one road), or there could be multiple areas of damage, thus the overall potential impacted area is ranked as "medium".									
EROSION AND LANDSLIDES		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• damage to property and infrastructure • water contamination/ siltation • habitat disruption • road and access disruptions • slumping in banks along the river	• Annapolis River near cemetery			✔			✔			✔	Low
		Notes: • Minor erosion noted along the Annapolis River near the cemetery. Concerns raised about potential future erosion moving closer to gravesites.									

Appendix A: ***Climate Change Hazard Impact Matrix***

DROUGHT		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• groundwater recharge reduction • habitat disruption • forest and agricultural pests • loss of agricultural productivity	• Wellfield and water system • Habitat throughout town		✔				✔	✔	✔		Moderate
		Notes: • Currently drought is a minor and rare concern, but with an increasingly warmer climate, the risk will increase to moderate. • If the wellfield is impacted enough to result in groundwater recharge reductions, parts or all of Middleton's water supply will be diminished and thus the area impacted is medium-to-large.									
NICTAUX DAM BREACH		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• large-scale flooding (see impacts listed above)	• Large area of town (see probable maximum flood map)	✔					✔	✔			Extremely unlikely
		Notes: • see discussion in report.									
EARTHQUAKES		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• damage to property and infrastructure	• Unknown			✔			✔			✔	Extremely unlikely
		Notes: • Earthquakes in Nova Scotia are of such a low magnitude that they are rarely felt. • No evidence of an earthquake within Middleton Town Boundaries (for data from 1985-2013, NRCAN, 2013b).									

APPENDIX B

Climate Change Scenario and Annapolis River Data

Climate Change Scenario Data for Annapolis Valley, Greenwood Climate Station

Table A 22: Annapolis Valley, Climate Station Greenwood A (id: 8202000) @ 44.98N, CHS site N/A

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	6.8	7.9	0.4	9.1	0.6	10.4	1.0
Winter	-4.4	-3.2	0.6	-1.7	0.8	-0.3	1.1
Spring	5.0	6.1	0.4	7.2	0.7	8.4	1.1
Summer	17.9	19.0	0.4	20.2	0.7	21.4	1.0
Autumn	8.5	9.6	0.4	10.8	0.6	12.1	0.9
Precipitation - Annual	1126.7	1157.6	27.6	1167.2	32.1	1201.8	41.9
Winter	310.3	325.3	12.3	333.1	15.9	351.3	20.4
Spring	259.8	268.4	11.0	272.3	14.8	282.9	19.4
Summer	250.4	254.6	14.8	253.8	19.7	254.1	32.6
Autumn	306.3	310.0	13.9	309.6	14.7	316.5	22.7

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4215.6	3874.9	3513.7	3164.4
Cooling Degree Days	138.6	202.4	293.0	401.6
Hot Days (Tmax > 30)	6.0	11.3	19.0	32.7
Very Hot Days (Tmax > 35)	0.0	0.2	0.7	2.2
Cold Days (Tmax < -10)	4.3	2.9	1.5	0.5
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1859.9	2075.4	2338.6	2716.2
Growing Degree Days > 10	967.2	1122.4	1314.3	1592.8
Growing Season Length (days)	173.6	186.8	208.4	224.1
Corn Heat Units (CHU)	2619.1	2919.7	3294.0	3621.4
Corn Season Length (days)	140.6	151.3	167.0	177.3
Freeze Free Season (days)	204.9	224.8	246.3	265.1
Days With Rain	132.9	144.7	150.7	155.9
Days With Snow	65.6	59.9	51.1	44.3
Freeze-Thaw Cycles - Annual	106.8	98.8	86.1	75.6
Winter	41.3	42.8	43.3	44.4
Spring	38.6	33.9	26.9	20.5
Summer	0.1	0.0	0.0	0.0
Autumn	26.9	22.2	15.9	10.8
Water Surplus (mm)	684.3	643.5	630.0	620.9
Water Deficit (mm)	54.2	60.3	73.6	87.6
Δ Intensity Short Period Rainfall (%)	0	5	9	16

From Richards and Daigle (2011: 62) Table A 22: Annapolis Valley, Climate Station Greenwood A (id: 8202000) @ 44.98N. p. 62)

Annapolis River data from Environment Canada, Water Survey of Canada, Wilmot, NS

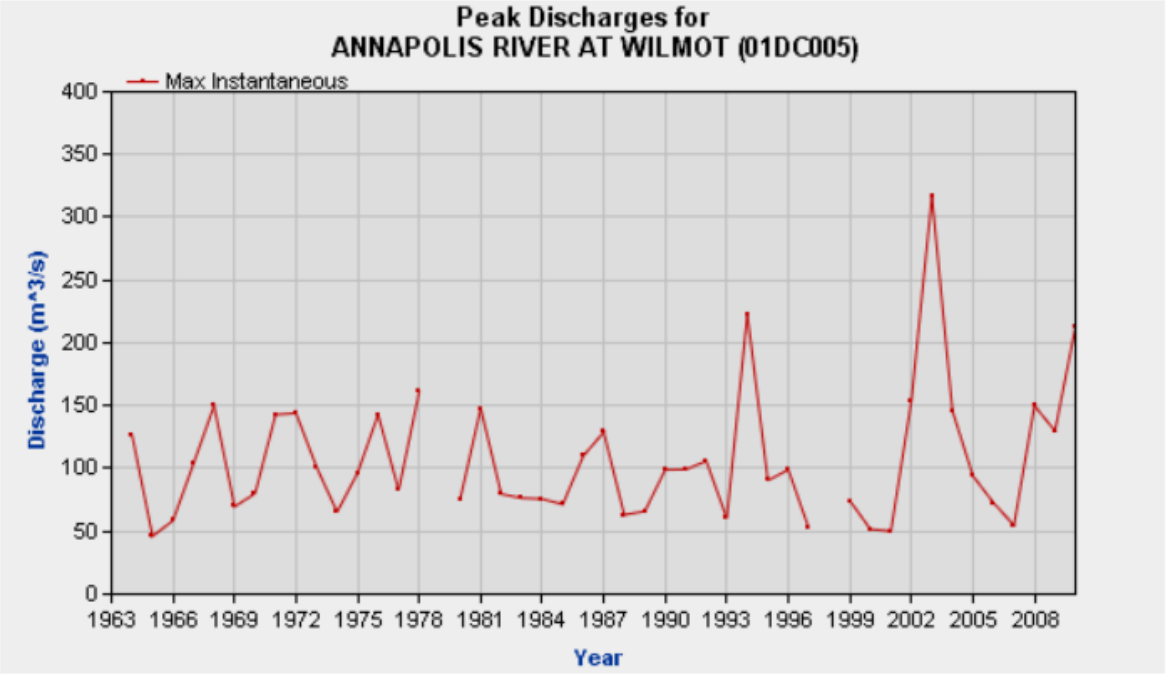

Figure 1) Peak discharges using historical data: 1963 to 2010 (Environment Canada, Water Office, 2013)

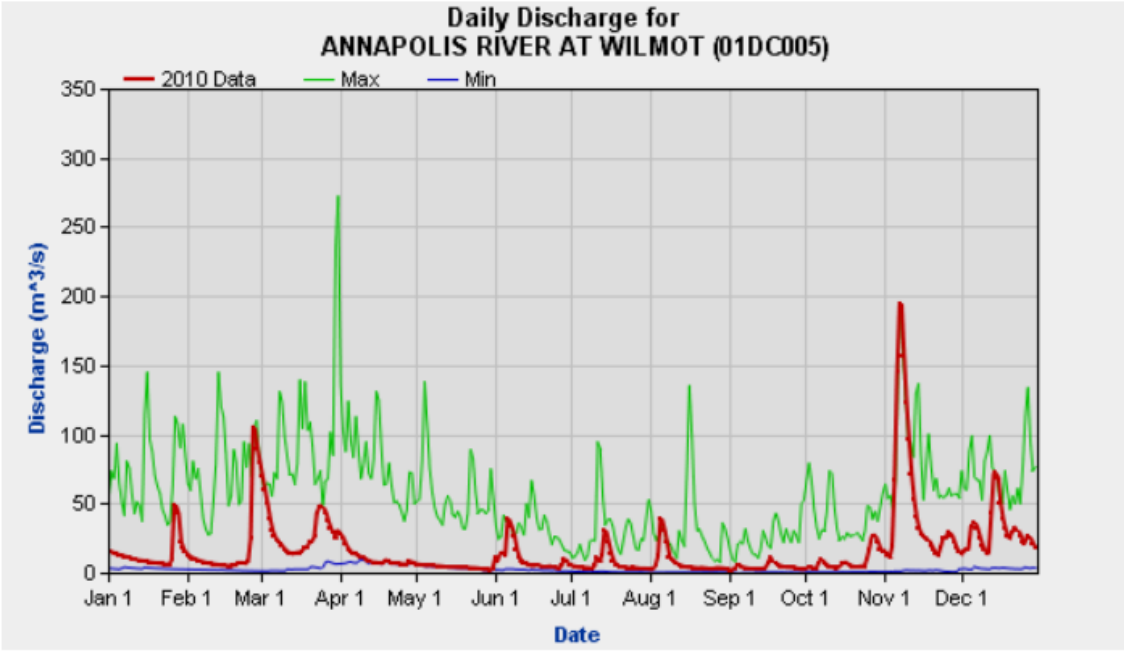

Figure 2) Maximum and minimum daily discharge by month using historical data: 1963-2010. (Environment Canada, Water Office, 2013)

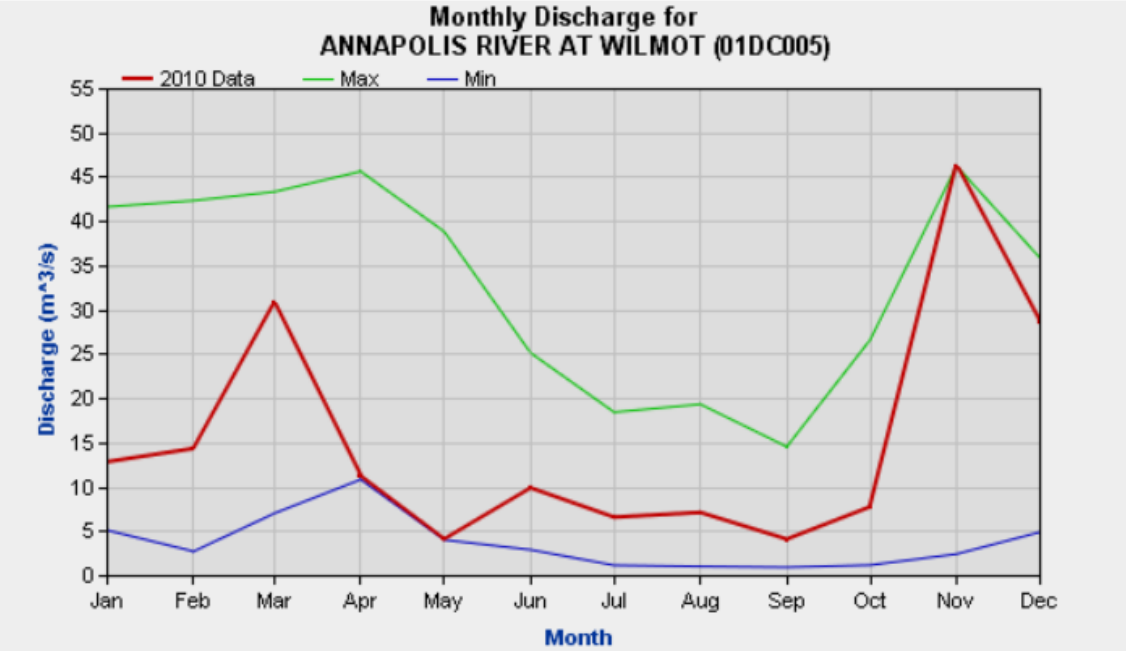

Figure 3) Maximum and minimum monthly mean discharge by month for the period 1963-2010 (Environment Canada, Water Office, 2013)

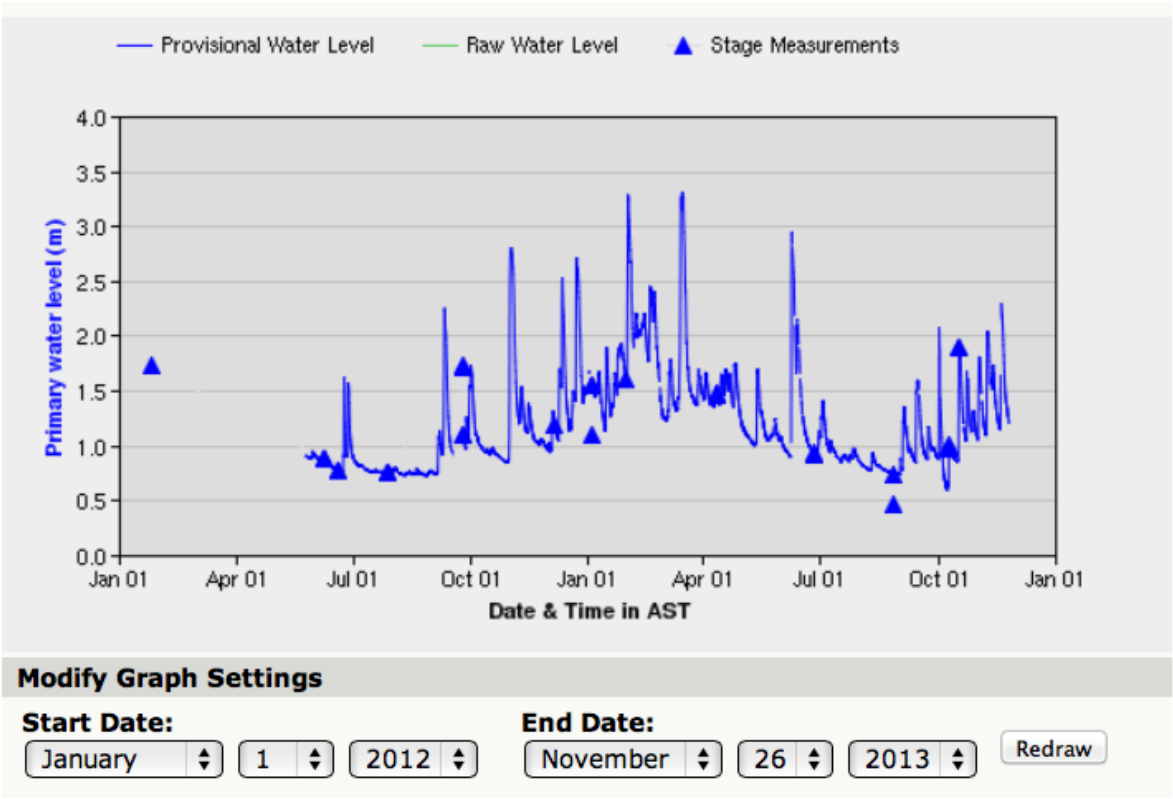

Figure 4) Primary water level (m) January 1, 2012 to November 26, 2013. (Environment Canada, Water Office, 2013)

APPENDIX C

Infrastructure Risk Assessment Spreadsheets

Climate Change Adaptation Plan

Municipal Asset	Sea Level Rise		Precipitation (extreme event)				Extreme Wind		Flooding		Temperature				Erosion		Earthquake		Total	Risk
			Snow		Rain						High		Low							
Water System																				
Water Source (Wells, Surface Water, Other)	N	0	L	1	L	1	N	0	L	1	M	2	L	1	N	0	N	0	**6**	**L**
Water Treatment Plant	N	0	L	1	H	3	M	2	H	3	L	1	N	0	L	1	N	0	**11**	**M**
Water Storage Facilities	N	0	L	1	L	1	N	0	L	1	M	2	N	0	N	0	N	0	**5**	**L**
Water Pumping Facilities	N	0	L	1	H	3	M	2	H	3	L	1	N	0	N	0	N	0	**10**	**M**
Water Distribution System	N	0	L	1	H	3	N	0	H	3	M	2	N	0	N	0	N	0	**9**	**L**
Individual Water Service Lines	N	0	L	1	L	1	N	0	L	1	L	1	N	0	N	0	N	0	**4**	**L**
Total	**0**		**6**		**12**		**4**		**12**		**9**		**1**		**1**		**0**		**45**	
Sanitary Sewer System																				
Wastewater Treatment Plant	N	0	M	2	H	3	N	0	H	3	N	0	N	0	N	0	N	0	**8**	**L**
Buildings	N	0	L	1	M	2	M	2	M	2	N	0	N	0	N	0	N	0	**7**	**L**
Wastewater Gravity Sewer	N	0	L	1	L	1	N	0	L	1	N	0	N	0	N	0	N	0	**3**	**L**
Wastewater Pressure Sewer (Forcemain)	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Pumping Stations	N	0	M	2	H	3	M	2	H	3	N	0	N	0	N	0	N	0	**10**	**M**
Total	**0**		**6**		**9**		**4**		**9**		**0**		**0**		**0**		**0**		**28**	

Municipal Asset	Sea Level Rise	Precipitation (extreme event)		Extreme Wind	Flooding	Temperature		Erosion	Earthquake	Total	Risk
		Snow	Rain			High	Low				
Storm Sewer System											
Catchbasins	N 0	M 2	M 2	L 1	H 3	N 0	N 0	N 0	N 0	**8**	**L**
Manholes	N 0	L 1	L 1	N 0	H 3	N 0	N 0	N 0	N 0	**5**	**L**
Pipes	N 0	L 1	M 2	N 0	M 2	N 0	N 0	N 0	N 0	**5**	**L**
Total	**0**	**4**	**5**	**1**	**8**	**0**	**0**	**0**	**0**	**18**	
Municipal Buildings											
Buildings	N 0	N 0	L 1	M 2	M 2	N 0	N 0	N 0	N 0	**5**	**L**
Total	**0**	**0**	**1**	**2**	**2**	**0**	**0**	**0**	**0**	**5**	
Landfills/Solid Waste Facilities											
Flooding	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	**0**	**L**
Access Road	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	**0**	**L**
Leachate Collection	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	**0**	**L**
Leachate Treatment	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	**0**	**L**
Buildings	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	**0**	**L**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Dams											
Flooding	N 0	M 2	M 2	N 0	H 3	N 0	N 0	N 0	N 0	**7**	**L**
Control Gates	N 0	M 2	M 2	N 0	H 3	N 0	N 0	N 0	N 0	**7**	**L**
Access Road	N 0	M 2	M 2	N 0	H 3	N 0	N 0	N 0	N 0	**7**	**L**
Fish Passage	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	N 0	**0**	**L**
Total	**0**	**6**	**6**	**0**	**9**	**0**	**0**	**0**	**0**	**21**	

Municipal Asset	Sea Level Rise	Precipitation (extreme event)		Extreme Wind	Flooding	Temperature		Erosion	Earthquake	Total	Risk
		Snow	Rain			High	Low				

Roads																			
Bridges	N	0	L	1	H	3	L	1	H	3	N	0	N	0	L	1	N	0	**9**	**L**
Traffic Signals	N	0	N	0	N	0	M	2	M	2	N	0	N	0	N	0	N	0	**4**	**L**
Street Lighting	N	0	N	0	N	0	M	2	M	2	N	0	N	0	N	0	N	0	**4**	**L**
Signs	N	0	L	1	N	0	M	2	L	1	N	0	N	0	N	0	N	0	**4**	**L**
Culverts	N	0	M	2	H	3	L	1	H	3	N	0	N	0	N	0	N	0	**9**	**L**
Sidewalks	N	0	H	3	M	2	L	1	M	2	N	0	N	0	N	0	N	0	**8**	**L**
Local Roads	N	0	H	3	M	2	M	2	H	3	N	0	N	0	L	1	N	0	**11**	**M**
Collectors	N	0	H	3	M	2	M	2	H	3	N	0	N	0	N	0	N	0	**10**	**M**
Total	**0**		**13**		**12**		**13**		**19**		**0**		**0**		**2**		**0**		**59**	

*Please note all of the drop boxes must be filled in for each of the asset classes

Risk Assessment Adaptation Measures - Water System

Water System	Water Source (Wells, Surface Water, Other)	Water Treatment Plant	Water Storage Facilities	Water Pumping Facilities	Water Distribution System	Individual Water Service Lines
Sea Level Rise						
Extreme Snow						
Extreme Rain		X		X	X	
Extreme Wind						
Flooding		X		X	X	
High Temp						
Low Temp						
Erosion						
Earthquake						
Impacts	The primary disinfection site is the Well House adjacent to Soldiers Memorial Hospital. The Well House is located within the 100-year flood area. If the Well House were to flood, the power supply could be impacted, disrupting the pumps and the chlorine disinfection system.					
Possible Adaptation Measures	Disruption to disinfection would necessitate the calling of a boil-water order throughout the town. Long-term adaptation plans include upgrading and replacing the current Well House with a site for disinfection and pumps away from the flood prone area.					

Risk Assessment Adaptation Measures - Sanitary Sewer System

Sanitary Sewer System	Wastewater Treatment Plant	Buildings	Wastewater Gravity Sewer	Wastewater Pressure Sewer (Forcemain)	Pumping Stations
Sea Level Rise					
Extreme Snow					
Extreme Rain	**X**				**X**
Extreme Wind					
Flooding	**X**				**X**
High Temp					
Low Temp					
Erosion					
Earthquake					
Impacts	access road could flood				power could be cut off from pumping stations
	plant itself and holding ponds unaffected in past				
Possible Adaptation Measures	monitoring of access road				addressing capacity of pumping stations to hook
	esnuring safety equipment and safe routes				to back up power, some current can,
	to plant for workers in case of road flood				others need upgrades

Risk Assessment Adaptation Measures - Storm Sewer System

Storm Sewer System	Catchbasins	Manholes	Pipes
Sea Level Rise			
Extreme Snow			
Extreme Rain			
Extreme Wind			
Flooding	**X**	**X**	
High Temp			
Low Temp			
Erosion			
Earthquake			
Impacts	overflow capacity of culverts		
Possible Adaptation Measures	monitor and widen culverts where necessary in future		

Risk Assessment Adaptation Measures - Municipal Buildings

Municipal Buildings	Buildings
Sea Level Rise	
Extreme Snow	
Extreme Rain	
Extreme Wind	
Flooding	
High Temp	
Low Temp	
Erosion	
Earthquake	
Impacts	power outages
Possible Adaptation Measures	back up generators and monitoring

Risk Assessment Adaptation Measures - Landfills

Landfills/Solid Waste Facilities	Flooding	Access Road	Leachate Collection	Leachate Treatment	Buildings
Sea Level Rise					
Extreme Snow					
Extreme Rain					
Extreme Wind					
Flooding					
High Temp					
Low Temp					
Erosion					
Earthquake					
Impacts	n/a				
Possible Adaptation Measures	n/a				

Risk Assessment Adaptation Measures - Dams

Dams	Flooding	Control Gates	Access Road	Fish Passage
Sea Level Rise				
Extreme Snow				
Extreme Rain				
Extreme Wind				
Flooding	X	X	X	
High Temp				
Low Temp				
Erosion				
Earthquake				
Impacts				
Possible Adaptation Measures				

Risk Assessment Adaptation Measures - Roads

Roads	Bridges	Traffic Signals	Street Lighting	Signs	Culverts	Sidewalks	Local Roads	Collectors
Sea Level Rise								
Extreme Snow						X	X	X
Extreme Rain	X				X			
Extreme Wind								
Flooding	X				X		X	X
High Temp								
Low Temp								
Erosion								
Earthquake								
Impacts	severe flooding (e.g. PMF) could rise over bridge				potential overwhelming of culverts	heavy snow, and sidewalk blockages	road coverage with snow	road coverage with snow
Possible Adaptation Measures	monitor, emergency reporting, alt routes				monitor and widen/upgrade where	efficient and prompt clearing	efficient and prompt clearing	efficient and prompt clearing