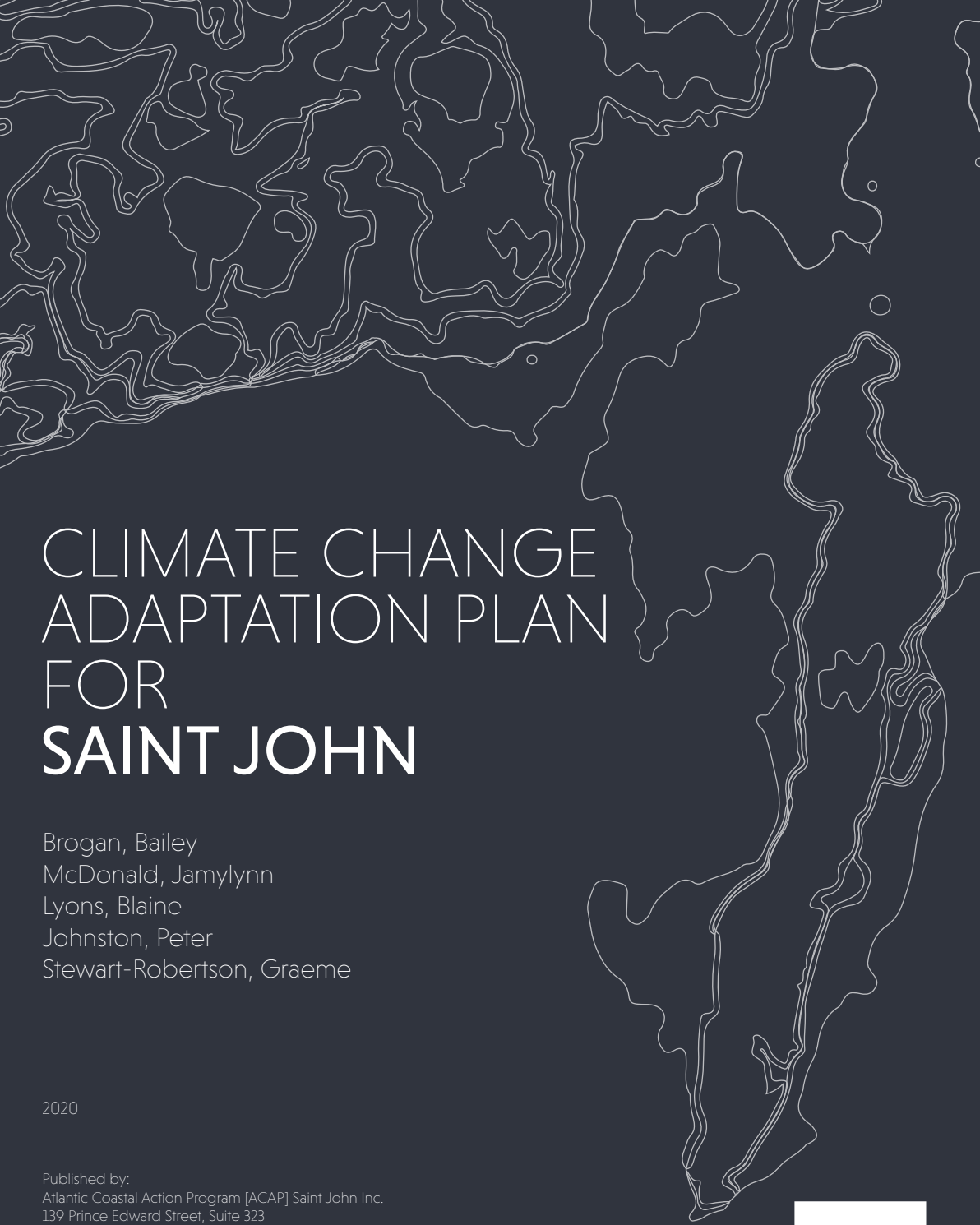

CLIMATE CHANGE ADAPTATION PLAN FOR SAINT JOHN

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ACAP SAINT JOHN

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This work would not have been possible without the support of our Steering Committee members Hans Arisz, Kelly Baker, Monica Boudreault, Jennifer Brown, Mike Carr, Corey Cooper, Marc Doucet, Lori Lambert, Nick Landry, Kendall Mason, Jaclyn Mitchell, Eddie Oldfield, Prativa Pradhan, Andy Reid, Susan Steven-Power, Kelly Williston and Samir Yammine.

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The development of this Adaptation Plan and the success of its implementation is due to the continued collaboration between the federal, provincial and municipal government and the community including First Nations and Non Governmental Organisations.

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Executive Summary

The City of Saint John has a unique opportunity to recognize the risks associated with Climate Change and adapt municipal planning to enable the community to thrive under changing environmental conditions. Climate Change will result in an increase in temperature and precipitation, more frequent extreme weather such as post-tropical storms and ice storms, and rising sea levels. This shift in weather patterns and ocean levels will cause flooding, damage infrastructure, destroy habitats, isolate neighbourhoods, and create public health challenges. ACAP Saint John has completed a background report, *Understanding Climate Change in Saint John,* that describes the Climate Change projections and impacts for Saint John, New Brunswick. The Climate Change Adaptation Plan focuses on specific risks and actions that will be required to reduce the negative impacts of these changes on the natural and built environment.

ACAP Saint John has conducted extensive research to identify areas of concern throughout the City. Through a Gap Analysis of Existing Initiatives*, Integrating Climate Change into Municipal Planning in Saint John, New Brunswick,* was completed by reviewing municipal by-laws and existing municipal and provincial initiatives to identify available resources and reveal gaps in legislation. Research also involved community engagement which helped to voice public concerns. The public responses were included in the *Risk and Vulnerability Assessment* to highlight high risk issues in Saint John and guide the development of the *Action Register*, which provides 59 adaptation recommendations. The recommended actions are organized into eight objectives:

- Objective 1: Integrate Climate Change impacts into community planning.
- Objective 2: Reduce shoreline erosion & promote natural infrastructure.
- Objective 3: Protect natural spaces, local habitats & migration routes.
- Objective 4: Provide public education on how to deal with the impacts of Climate Change.
- Objective 5: Reduce the impact of Climate Change on human health.
- Objective 6: Support vulnerable groups to increase adaptive capacity.
- Objective 7: Increase resilience to flooding & sea level rise.
- Objective 8: Increase resilience to extreme weather.

The Adaptation Plan takes into consideration the ongoing social and environmental inequity that exists in Saint John, whereby areas with the most severe poverty rates are also those living in high flood risk areas or in closest proximity to highly vulnerable coastal areas. As well, the public health challenges associated with Climate Change are explored and specific actions are suggested to keep residents safe.

As municipal documents are updated, the Climate Change Adaptation Plan can be integrated, further encouraging implementation of the recommended actions and creating an aware and prepared society. Adapting to Climate Change is necessary for the City of Saint John to protect the communities that give this historic City the vibrant, maritime personality it is known for. Through implementation of this Adaptation Plan, the City has an opportunity to become a Canadian leader in climate resilience and coastal adaptation.

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1. Introduction

Climate Change is already being felt in New Brunswick from rising temperatures, sea level rise, higher intensity precipitation events, increased severity of inland and coastal flooding, accelerated rates of coastal erosion, and loss of land that will continue to have negative impacts for the City of Saint John (the City) if no adaptation occurs (NBDELG, 2014a). Adaptation broadly refers to any adjustment that is made to respond to the existing or anticipated impacts of Climate Change on natural or built environments (Natural Resources Canada, 2007). This Adaptation Plan will prepare the City of Saint John for Climate Change by identifying high risk issues and by recommending actions that will reduce vulnerability. By following these recommendations, the City can save costs associated with disaster recovery and repeat infrastructure failure, while maintaining an educated and prepared community.

In the City of Saint John, home to approximately 65, 575 people, a large portion of urban development is found in low-lying areas, along the coast or within former wetlands or watercourses. This has resulted in recurrent flooding for properties in these areas. This Plan identifies high risk flood areas and provides suggestions on how the City can proceed in adapting to more frequent flooding events.

The socio-economic challenges in Saint John, whereby 22.5% of the population are living below the poverty line is also addressed in the Adaptation Plan. Through implementation of recommended actions, the City has an opportunity to demonstrate how adaptation can be effective for all citizens. Coordination between the City of Saint John and the Saint John Emergency Measures Organization (EMO) is critical for ensuring the safety of vulnerable residents during and after climate-related events.

The Adaptation Plan provides the City with the necessary information to make decisions and actively prepare the community for Climate Change. Working in conjunction with PlanSJ, the Saint John Climate Action Plan, as well as provincial adaptation initiatives, the City of Saint John has an opportunity to become a leader in Climate Change adaptation and provide municipalities with best practices for stormwater management and coastal protection.

1.1 Goals

The overall vision of the Adaptation Plan is to appropriately prepare Saint John for the changing climate; however, several goals were identified to guide the development of this plan. These goals are reflected throughout the plan but are expanded upon in **Sections 5-9**.

(1) Use climate projections (including 1 in 100-year storm levels up to the year 2100) in municipal planning to reflect the life expectancy of existing City infrastructure (**Section 5: Vulnerable Natural and Built Environments**);

(2) Protect and enhance the City's natural assets (including coastal areas, green spaces and water resources) through low impact development (LID) and green infrastructure (**Section 5.7: Habitats and Species at Risk**);

(3) To protect the well-being and prosperity of the City and its residents from the negative impacts associated with Climate Change by building adaptive capacity through awareness and preparedness education (**Section 6: Health and Public Safety**);

(4) Address how Climate Change will impact vulnerable groups and provide engagement opportunities to ensure all voices are heard during development of the Adaptation Plan (**Section 7: Vulnerable Populations**);

(5) Evolve alongside best science through partnerships with private sectors, non-governmental organizations, academic institutions and First Nations to achieve sustainable, long-term momentum for adaptation (**Section 8: Adaptation as an Opportunity**); and,

(6) Integrate adaptation into municipal plans including PlanSJ, SJ Climate Action Plan and three central Neighbourhood Plans to support the City's goals for sustainable futures up to the year 2035 and beyond (**Section 9: Monitoring and Review**).

1.2 Adaptation Framework

The adaptation toolkit "Building Adaptive and Resilient Communities" by the International Council for Local Environmental Initiatives (ICLEI), has been implemented by municipalities in British Columbia, Ontario and Newfoundland. ACAP Saint John has selected this toolkit to guide the adaptation planning process for the City. The framework consists of five key Milestones which incorporate science and lessons learned to direct adaptation and implementation (Figure 1). The research milestone of this framework is critical to identify and prioritize risks, vulnerabilities and adaptation opportunities. ACAP Saint John recognizes that successful implementation of the plan requires a comprehensive local assessment and proactive municipal planning (Revi et al., 2014).

Figure 1: Five key Milestones for Climate Change adaptation beginning with initiate, followed by research, plan, implement and monitor/review, retrieved from the ICLEI-Canada (n.d.).

1.3 Project Timeline

In 2018, ACAP Saint John was funded by the New Brunswick government through the Environmental Trust Fund (ETF) to develop a Climate Change Adaptation Plan for the City of Saint John. The project was initiated with the development of the Steering Committee (Milestone 1). The Steering Committee included representatives from various City departments, Saint John Water, Saint John Energy, EMO, QUEST Canada and the New Brunswick Department of Environment and Local Government (NBDELG). Throughout the development of the Adaptation Plan, the Steering Committee was consulted to verify current policies and provide input about the recommended adaptation actions.

ACAP Saint John facilitated public engagement sessions to communicate the intention of the Adaptation Plan and begin Milestone 2: Research. The first year of the project was heavily focused on researching adaptation plans from other Canadian municipalities and interpreting the projected climatic changes for Saint John. Completion of the Gap Analysis was useful for identifying adaptation actions that would be supported by existing municipal planning documents, and actions that would be unfamiliar for the City.

The second and final year of the project was dedicated to community engagement at in-person events and through the online Maptionnaire exercise (details included in Section 3). Input from these events was used to recognize priority areas and develop actions based on neighbourhood needs. As well, during the second year of the project ACAP completed the Risk and Vulnerability Assessment and the background report, *Understanding Climate Change in Saint John*. The Action Register and the draft report were continuously being updated and maintained on track for presentation to Council in March 2020.

2. Climate Change Overview

2.1 Physical Dimensions

Climate Change is one of the greatest challenges facing human civilization today. It directly impacts fundamental resources like food, water, and shelter. Impacts are already being felt, including warming atmospheres and oceans, diminishing snow and ice cover, and rising sea levels (IPCC, 2014). The Intergovernmental Panel on Climate Change (IPCC) is a United Nations scientific body and the foremost authority on Climate Change science. In its most recent report, the Fifth Scientific Assessment Report (AR5), the IPCC finds that warming of the climate system as a result of increased greenhouse gas (GHG) emissions to be irreversible. Higher concentrations of GHGs in the atmosphere have led to 2016 being the hottest year on record, and 2019 being second hottest (World Meteorological Organization, 2020). This aligns with a trend in global warming that has been observed over the last 60 years (Figure 2).

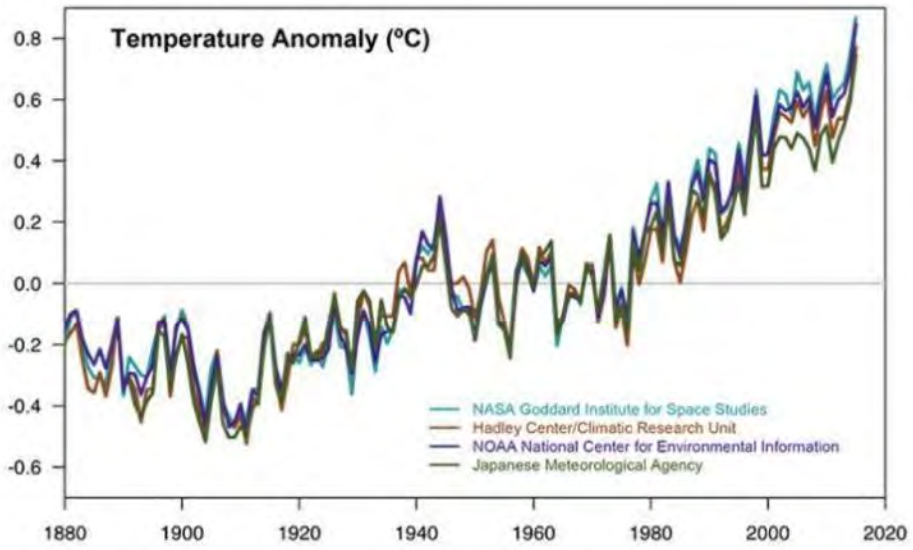

Figure 2: Temperature trends from 1880-2020 (National Aeronautics Space Agency, 2017).

2.2 Local Projections

Climate Change in Saint John will include a rise in temperature, changes to precipitation patterns, sea level rise, and increases in storm frequency and intensity. Details about local projections can be found below in Table 1. ACAP Saint John has completed a background report *Understanding Climate Change in Saint John*, that provides a more in-depth analysis of Climate Change projections and the associated impacts.

Table 1: Climate Change Projections for the Greater Saint John Area (Roy and Huard, 2016; Daigle, 2014; Bruce, 2011; Wotton et al, 2010; PCC, n.d.).

Category	Projections:
Temperature	● Mean annual temperature increases by 3.5°C by 2071-2100 compared to 1970-2000. ● Average winter temperature above -1°C by 2071-2100. ● Up to 70 annual hot days (25°C +) by 2071-2100. ● Annual freeze-thaw days increase from 82 to 87 by the year 2070.
Precipitation	● Annual rainfall increases by 85 mm by the year 2100 compared to 1970-2000. ● Precipitation patterns become more erratic and rainfall intensity will increase by 10%. ● Approximately 21 more rain days by 2070-2100.
Extreme Weather	● Increased severity and frequency of summer convective storms and ice storms. ● Increased severity and frequency of flooding from extreme rainfall, mid-winter thaws, ice breakups, and ice-jam flooding. ● Increased forest fire occurrence in Canada: 25% by 2030, 75-140% by 2100. ● Higher severity of drought: water deficit of 110% by the year 2080. ● Windstorm frequency increases by 8-15% (by the year 2050).
Sea Level Rise	● Saint John sea level rise of 86 cm +/- 38 cm from 2010 to 2100. ● Annual storm surge levels increase by 0.8 m compared to 2010. ● 1 in 100-year storm levels increase by 1.3 m by 2100 compared to 2010. ● Current coastal erosion rates of 0.59-0.99 m/yr.

2.3 Sea Level Rise

To determine the scale of sea level rise impacts in Saint John, ACAP Saint John used a Draft version of New Brunswick's Coastal Hazard Flood Mapping (CHFM) (Appendix A). These maps are used by the province to

identify coastal flood risk areas. This set of maps identifies future sea level rise and storm surge risks (Appendix A). The maps outline the current Higher High Water Large Tide (HHWLT) (4.6 m), HHWLT+1 m (5.6 m) (the average predicted level of sea level rise by 2100), and a 1 in 100-year storm event in 2100 (6.8 m). Projection data was collected from Daigle's 2017 Report, *Sea Level Rise and Flooding Estimates for New Brunswick Coastal Sections*. These maps were used in the Risk and Vulnerability Assessment as well as during our public information forums to identify areas at risk from sea level rise and the associated impacts. Using the CHFMs, the City of Saint John's GIS department compared projected sea level rise elevations to current infrastructure, emergency services, population statistics, and ecological parameters, to identify risks in the study neighbourhoods (North End, Central Peninsula and Lower West Side). ACAP was able to identify adaptation actions that will reduce impacts and protect infrastructure based on the risks identified (Table 2).

Table 2: Sea level rise projections for Higher High Water Large Tide (HHWLT) levels ranging from 2010-2100.

Sector	Sea Level Rise HHWLT (4.6 m) Risks (Highly Probable in 2010)	Sea Level Rise HHWLT + 1 m (5.6 m) Risk Events (20-50% probability in 2050, 50-100% probability in 2100	Sea Level Rise 2100 1-100 (6.8 m) Risks (1% possibility in 2100)
Evacuation Control Points	None.	20 Control Points affected (7 intersections, 1 evacuation center, 4 hazards, 2 childcare facilities, 1 health care facility, 5 miscellaneous sites).	39 Control points affected (20 intersections, 3 evacuation centers, 8 hazards, 2 childcare facilities, 1 health care facility, 5 miscellaneous sites).
Evacuation Routes	Red Head Road, Bayside Drive, Digby Ferry Road, Lorneville Road and the Saint John Throughway affected by flooding (approximately 11 km).	30 roads affected by flooding (approximately 50 km).	36 roads affected by flooding (approximately 66 km).
Buildings impacted	Damage to homes/businesses 28 (5,659 m^2) of buildings.	Damage to homes/businesses 1,877 buildings (566,735 m^2).	Damage to homes/businesses 2,264 buildings (756,005 m^2).
Properties Impacted	354 properties affected including 65 industrial properties. Combined property values of approximately $454,165,600.	1,449 properties affected including 157 industrial properties. Combined property values of approximately $988,739,600.	1,734 properties affected including 190 industrial properties. Combined property values of approximately $1,093,387,600.
Total population affected	14% of the total population live in impacted areas.	26% of the total population live in impacted areas.	32% of the total population live in impacted areas.
Low Income Populations	3% of people in flood impacted areas are considered low income.	6% of people in flood impacted areas are considered low income.	6% of people in flood impacted areas are considered low income.
Senior Populations	3% of people in flood impact areas are seniors (65+).	5% of people in flood impacted areas are seniors (65+).	8% of people in flood impacted areas are seniors (65+).
Habitat - Wetland	Coastal Squeeze approximately 1,033 ha.	Coastal Squeeze approximately 1,147 ha.	Coastal Squeeze approximately 1,176 ha.

Habitat - Forests	Loss of habitat approximately 537 ha.	Loss of habitat approximately 924 ha.	Loss of habitat approximately 1,039.5 ha.
Petroleum Storage Sites (Total storage 2000 L or greater)	Contamination: 29 sites at risk of flooding.	Contamination: 128 sites at risk of flooding.	Contamination: 168 sites at risk of flooding.

2.4 Extreme Weather and Flooding

The City of Saint John can prepare for flooding challenges associated with heavy precipitation and extreme weather by completing wet areas mapping to identify high risk infrastructure and populations, and ultimately reduce property damage during flood events.

2.4.1 Wet areas mapping analysis

ACAP Saint John retained Paul Arp and Jae Ogilvie of the Forest Watershed Research Center at the University of New Brunswick to conduct LiDAR—DEM based Surface Water Scenario Evaluations for the City of Saint John. This method has been publicly termed "wet areas mapping." This evaluation was used to identify areas at risk during extreme weather. Primarily, these areas will be experiencing flooding as a result of heavy precipitation combined with low drainage and retention capacity.

Seven scenarios were mapped to model how infrastructure might function during an extreme rainfall event (approximately 50 mm of rain within a 24-hour period):

- Scenario 1: All infrastructure blocked: bridges, road culverts, stormwater system
- Scenario 2: Bridges unblocked, road culverts blocked, stormwater system blocked
- Scenario 3a: Roads breached down to 3m, except the causeway; stormwater system blocked
- Scenario 3b: Roads breached down to 10m, except the causeway; stormwater system blocked
- Scenario 3c: Roads breached down to 14m, except the causeway; stormwater system blocked, except for Lansdowne Plaza area
- Scenario 4: Stormwater system placed at 3m depth, revealing drainage challenged areas
- Scenario 5: Coastal flooding potentials

Maps showing areas at risk of inland flooding (Scenario 2, 3c and 4) are shown in Appendix C.

2.4.2 Spring Freshet Flooding

In the spring of 2018 and 2019 the City of Saint John experienced record spring freshet flooding from the Wəlastəkw (St. John River), impacting infrastructure along the Wəlastəkw and Kennebecasis River. In both 2018 and 2019, the City of Saint John issued a voluntary evacuation for Randolph Island (past the Randolph bridge), Westfield Road, Ragged Point Road (past the St. Francois De Sales Church), Beach Road, and any other isolated areas along the Wəlastəkw, within the City. The voluntary evacuation impacted approximately 1,900 people in 2018 and 605 people in 2019. Residents that were impacted by flooding in 2018 and/or 2019, were eligible to apply to the Disaster Financial Assistance Arrangement (DFAA) funding for relief to repair or replace items damaged in the flood.

The 2018 flood reached 5.73 m above sea level whereas the 2019 flood peaked at 5.55 m. For the remainder of this Section, data from the 2018 flood will be shared since this is the highest level reached during both flood events (Figure 3). ACAP compared the property values of the 670 properties that were impacted by the flood and found that property values reached approximately $290,208,600. Approximately 29 roads were flooded resulting in the isolation of neighbourhoods. The impact of two major floods, two years in a row was felt throughout the community, and the City has begun to take action to increase resilience to freshet flooding.

Figure 3: Aerial view of Saint John during the Wəlastəkw spring freshet flooding in 2018.

In 2018, the EMO purchased a boat to assist in operations. As well, they invested in a larger boat for deep water situations that may arise. These actions confirm that EMO acknowledges the potential for future flooding events and is actively preparing to protect the community during future occurrences. Through communication with City staff, some of the impacted roads have been scheduled to be raised where feasible. Other municipal infrastructure (lift stations, pump stations, etc.) is being assessed to be relocated or protected from future flooding.

3. Community Engagement

The critical part of understanding the risk and vulnerabilities within Saint John involved gathering input from residents. From August 2018 to September 2019, ACAP Saint John conducted community engagement sessions using multiple formats to reach a variety of audiences, including community

workshops, information sessions, booths at community events, and an online survey. This input was used to identify what concerns residents had with regards to Climate Change, and what changes they would like to see in their community.

3.1. Participatory Mapping

Maps were used for public outreach to provide a visual representation of Climate Change impacts in the City of Saint John. This method allowed participants to identify risk areas and voice their concerns about assets located in these areas.

ACAP Saint John participated in a Sea Level Rise Workshop in August 2018 held by the New Brunswick Environmental Network (NBEN). The Coastal Hazard Flood Maps (CHFMs) were presented to workshop attendees and used to identify important coastal infrastructure, areas currently being affected by sea level rise, and areas at risk of future sea level rise impacts.

ACAP Saint John held two Climate Change Impacts and Adaptation Community Information Sessions in the fall of 2018. The information sessions were held to inform residents in three urban neighbourhoods (Central Peninsula, Lower-West Side and the North End) about the current neighbourhood planning processes and adaptation planning that is underway, and to discuss how Climate Change will affect each community. These sessions also provided opportunities for participants to provide feedback to ACAP on information that they felt was important to include in the Adaptation Plan. Similar to the NBEN workshop, the CHFMs were presented in these sessions and residents identified community assets, observed Climate Change impacts, and areas that may be at risk of future Climate Change impacts. Identified assets included recreational spaces, transportation routes (roadways, rail lines, and the cruise ship terminal), industrial assets (Port of Saint John, Ocean Steel), and historical sites (Partridge Island and Fort La Tour). This feedback is summarized in Figure 4.

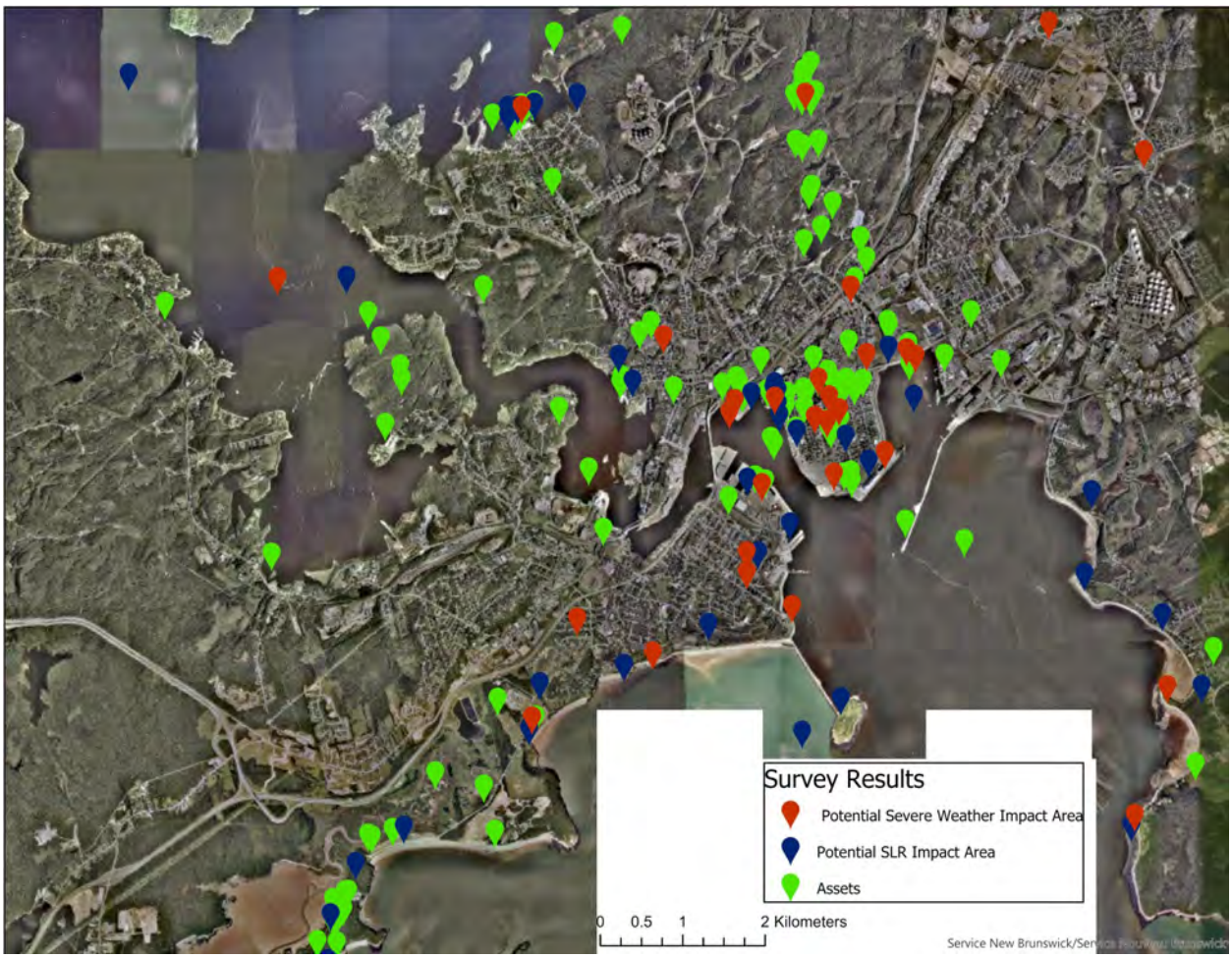

Figure 4: Results from community workshops and the Climate Adaptation Survey showing identified Assets, Potential Severe Weather, and Sea Level Rise Impact Areas.

Using "Maptionnaire" software, a map-based survey tool, ACAP developed an interactive Climate Adaptation Survey where residents could pinpoint specific areas of concern in the City. Participants were asked to identify their favorite places, assets, and areas that they feel will be impacted by Climate Change (i.e. sea level rise, extreme weather, and public health impacts). Respondents were also asked to suggest methods for future outreach, and actions that they would like to see completed in the City to adapt to Climate Change. The survey was made available on ACAP's website from May-September 2019 and received 297 responses. Residents identified where their favorite places were located, and assets in the City of Saint John. ACAP compared this with locations that residents noted may be at risk of Climate Change impacts (sea level rise, and extreme weather) (Figure 4). The number of assets and favorite places that residents indicated may be at risk of sea level rise and extreme weather impacts were 21 and 16 respectively, 9 of these locations were indicated at risk to both sea level rise and severe weather impacts. Interestingly, many of these locations (i.e. Irving Nature Park, Rockwood Park, RKYC) are natural and recreational spaces that are easily accessed by the public. The survey was promoted through media releases, social media, and at various community events throughout the summer. The survey responses, as well as the information gathered at previous public information sessions are summarized in Figure 4 above, and Table 3 below.

Table 3: Assets and favourite places that were identified to be at risk of sea level rise (SLR) and extreme weather through online public consultation.

Location	Number of responses that identified this area as important	Identified to be at risk of SLR	Identified to be at risk of extreme weather
Irving Nature Park	27	✓	
Rockwood Park	27		✓
Port Saint John	25	✓	✓
Royal Kennebecasis Yacht Club	12	✓	✓
Partridge Island	10	✓	
Anthony's Cove Road	6	✓	✓
Long Wharf	6	✓	✓
Market Slip	5	✓	
Tin Can Beach	5		✓
Courtenay Bay	4	✓	✓
St. John River/Harbour	4	✓	✓
Little River Reservoir	3	✓	
Queen Square	3		✓
Red Head Road	3	✓	
Bayshore Beach	2	✓	✓
Coast Guard Site	2	✓	✓
Cruise Ship Terminals	2	✓	
King Square	2		✓
Maclaren's Beach	2	✓	✓
Sand Cove Road	2	✓	
Forested area near Kennebecasis	1		✓
Fort La Tour	1	✓	
Hazen Creek Marsh	1	✓	
Kennebecasis River	1	✓	
Market Place	1	✓	
Railway	1		✓
West Side Wastewater Treatment Facility	1	✓	

To identify how residents felt that Climate Change would affect public health, participants were asked to identify locations where public health could be impacted, and then were asked a follow-up question whether this impact was either due to increased temperatures, vulnerability to ticks, or whether vulnerable populations were identified in this area (Table 4). Vulnerable populations and vulnerability to ticks were the only options chosen, however, two locations (Beach Crescent Lift Station and the Irving Oil Refinery) did not indicate any impact type.

Table 4: Public Health Impacts and identified by survey respondents.

Impact Type	Locations
Vulnerable populations	North End, Milford, Greendale, South Bay, Simms Corner, Fundy Heights, East Side, South End, Lower West
Ticks	Millidgeville, East Side, South End, Lower West
None Selected	Beach Crescent Lift Station, Irving Oil Refinery

3.2 Community Events

ACAP Saint John hosted a Climate Change Adaptation "Launch Party" at the Five and Dime on March 13, 2019 to celebrate the completion of three neighbourhood Adaptation Plans (North End, Central Peninsula and Lower West Side) as well as to introduce the Adaptation Plan to the public. The Launch Party was a free, informal event for the community to discuss their ideas and concerns around Climate Change Adaptation with team members from ACAP Saint John, as well as with the Mayor, Don Darling, and Member of Parliament, Wayne Long. Displaying information about how Climate Change will impact Saint John and its priority neighbourhoods allowed ACAP to collect feedback from residents through comment cards, surveys, and audio interviews.

At the annual Area 506 summer music festival, ACAP had a set-up in the Container Village dedicated to communicating Climate Change adaptation (Figure 5). To engage community members of all ages there was a mix of materials including maps, games, a selfie wall, and a visual ideas web to describe the adaptation planning process. A computer kiosk was set up inside the container, where residents could complete our Climate Adaptation Survey. ACAP is happy to have been successful at engaging all age groups in Climate Change conversations.

Figure 5: ACAP Saint John Container at the Area 506 Festival where community members were informed and engaged about Climate Change and adaptation in the City.

Another opportunity to engage the public in a discussion around Climate Change adaptation was at the Queens Square Farmers Market in September 2019. During this engagement session, ACAP showcased selected recommendations from the Action Register in order to collect community feedback and help prioritize the actions to be taken. An example rain barrel was set up to promote rainwater collection and start conversations about increasing precipitation. There was a high level of interest in the rain barrel, suggesting that promotion of storm water retention techniques may be successful in Saint John. The community market was a great opportunity for ACAP Saint John to actively engage members and communicate the importance of Climate Change adaptation for individuals, and for the City.

4. Risk and Vulnerability Assessment

A Risk and Vulnerability Assessment was developed to rank the severity of the Climate Change risks in the City of Saint John. This process followed the ICLEI *Changing Climate, Changing Communities: Guide and Workbook for Municipal Adaptation* and falls under Milestone 2 of the adaptation framework: Research.

4.1 Impact Statements

To describe how Climate Change will impact the community, impact statements were developed based on predicted climatic changes, the outcome of climatic changes, and the impact of each outcome. For example, an outcome of increasing precipitation would be an increase in the number of rain events and heavy rainfall events, and the impact associated with this outcome would be increased damages to infrastructure/properties due to localized flooding. Climatic changes such as increased temperature, increased precipitation, extreme weather events, and sea level rise were identified based on climate data

(Section 2). Service areas (i.e. parks and recreation, emergency services, transportation, etc.) that would be directly and indirectly impacted by climate impacts were identified based on background research and feedback from stakeholder consultation. Any of the service areas that were deemed to be directly impacted by Climate Change were assessed for vulnerability. For example, a service area that would be impacted by increased precipitation is transportation, due to road closures and damage to road infrastructure. The impact statements and the identified service areas are listed in Appendix D.

4.2 Vulnerability Assessment

Vulnerability refers to the susceptibility of a given service area to harm arising from Climate Change impacts (ICLEI-Canada, n.d.). Vulnerability is a function of the **sensitivity** of a service area to climate impacts and the **adaptive capacity** of the service area. Higher vulnerability is associated with high sensitivity and low adaptive capacity; the system cannot respond. The sensitivity of each service area was assigned by determining how the function of each sector would be affected and whether the service area is already experiencing stress. Sensitivity was rated on a scale from 1-5 with 1 meaning the "functionality will stay the same," and 5 meaning the "functionality will become unmanageable" (Figure 6). For example, localized flooding due to increased rainfall intensity will impact transportation infrastructure, and functionality of transportation infrastructure will get worse (S4).

If the impact occurs, will it affect the functionality of the service area?				
No – Functionality will stay the same (S1)	Unlikely – Functionality will likely stay the same (S2)	Yes – Functionality is likely to get worse (S3)	Yes – Functionality will get worse (S4)	Yes – Functionality will become unmanageable (S5)

Figure 6: Scale to determine the sensitivity of a service area due to Climate Change impacts (ICLEI-Canada, n.d.).

Adaptive capacity identifies the service area's ability to adjust to a climate impact with minimal cost and disruption. Adaptive capacity is rated on a scale from 1-5 with 1 meaning substantial costs and staff intervention will be required, and 5 meaning little to no cost or staff intervention is necessary to adapt to Climate Change impacts (Figure 7). For example, for impacts associated with heavy rainfall and localized flooding to the transportation service area, adaptive capacity was rated AC3; the service area may be able to adapt to the projected impact with some cost and staff intervention.

Can the service area adjust to the projected impact with minimal cost and disruption?				
No – Will require substantial costs ($$$$$) and staff intervention (AC1)	No – Will require significant costs ($$$$) and staff intervention (AC2)	Maybe – Will require some costs ($$$) and staff interven-tions (AC3)	Yes – But will require some slight costs ($$) and staff intervention (AC4)	Yes – No to little costs ($) and staff intervention are necessary (AC5)

Figure 7: Scale to determine the adaptive capacity of a service area due to Climate Change impacts (ICLEI-Canada, n.d.).

Combining the sensitivity rating with the adaptive capacity provides the level of vulnerability for each impact (Figure 8). Service areas with low adaptive capacity and high sensitivity have a higher vulnerability to Climate Change impacts, whereas service areas with higher adaptation capabilities and lower sensitivity

have a lower vulnerability rating. Using our increased precipitation example, where the transportation service area will be impacted by localized flooding (sensitivity=S4; adaptive capacity=AC3), the vulnerability rating equals V4, or "medium-high." Included in Appendix D, Table 19 includes the sensitivity and adaptive capacity ratings that were assigned to each impact to determine of level vulnerability.

Sensitivity and Adaptive Capacity Matrix

	S1	S2	S3	S4	S5
AC1	V2	V2	V4	V5	V5
AC2	V2	V2	V3	V4	V5
AC3	V2	V2	V3	V4	V4
AC4	V1	V2	V2	V3	V3
AC5	V1	V1	V2	V3	V3

V1 = Low Vulnerability
V2 = Medium-Low Vulnerability
V3 = Medium Vulnerability
V4 = Medium-High Vulnerability
V5 = High Vulnerability

Figure 8: Scale to determine the vulnerability of a service area due to Climate Change impacts (ICLEI-Canada, n.d.).

4.3 Risk Assessment

The same impacts identified in the vulnerability assessment were assigned a risk rating by developing an understanding of the consequences and likelihood (probability) of occurrence. To calculate the risks, the likelihood rating is multiplied by the consequence rating ($risk = likelihood\ x\ consequence$). Events that are guaranteed to happen and have severe consequences will have a higher risk. Events that are unlikely to occur but have severe consequences may be medium or low risk. The tables used to determine the likelihood and consequence of climate impacts can be found below.

4.3.1 Likelihood and Consequence Ratings

The likelihood of an impact occurring is determined by the projected impacts of Climate Change in Saint John (listed in Section 2) and is ranked from 1-5 with 1 meaning an impact is "rare" and 5 meaning an impact is "almost certain" (Figure 9). To use our example from above, the likelihood of damage to the transportation service area due to localized flooding is 5 (almost certain to happen more than once a year).

LIKELIHOOD RATING	RECURRENT IMPACT	SINGLE EVENT
Almost Certain 5	Could occur several times per year	More likely than not- probability greater than 50%
Likely 4	May arise about once per year	As likely as not – 50/50 chance
Possible 3	May arise once in 10 years	Less likely than not but still appreciable – probability less than 50% but still quite high
Unlikely 2	May arise once in 10 years to 25 years	Unlikely but not negligible – probability low but noticeably greater than zero
Rare 1	Unlikely during the next 25 years	Negligible – probability very small, close to zero

Figure 9: Scale to determine the likelihood of Climate Change impacts occurring (ICLEI-Canada, n.d.).

ACAP modified the consequence table provided in the ICLEI Guide to support local assets and needs. Each category represents different community impacts: health & safety, public services (power, sewer, water etc.), community lifestyle, natural environment, and infrastructure. The categories are ranked from 1-5, with 1 being an insignificant consequence and 5 being a catastrophic consequence (Table 5). Each Climate Change impact is assessed in all five categories to give a total consequence value out of 25. The total is multiplied with the likelihood to give the risk rating. By assigning this risk rating ACAP Saint John was able to prioritize the actions identified in the Action Register.

*Table 5: Consequence Rating Scheme. *Loss of service refers to loss of power, water or public services (i.e. administration).*

Rating	**Community Impacts**				
	Health & Safety	**Public Services**	**Community Lifestyle**	**Natural Environment**	**Infrastructure**
1. Insignificant	No injury, negligible concerns for physical and mental health.	Minor disruption for a small portion of customers. No disruption to public administration.	Temporary with no loss of function. "Annoyances"	No impacts to the natural environment.	No damage and little costs associated. Routine activities to resolve issues. Short recovery within 24hrs.
	1	**1**	**1**	**1**	**1**
2. Minor	Minor physical injuries. Small mental impact for few residents.	Significant disruption for small portion of customers. Public administration under severe pressure in localized instances.	Temporary disruption results in noticeable loss of function. Short-term impacts to daily routines.	Minor impacts to the natural environment to be reversed within three (3) months.	Minor damages and small costs involved for repair effort. No insurance claims placed. Short recovery time, within days to one week.
	2	**2**	**2**	**2**	**2**

3. Severe	Serious injury, non-life threatening but requiring medical services. Noticeable mental health impacts.	Extended periods without service in localized areas. Public administration under severe pressure.	Notable disruption to the well-being of residents. Routine can be re-established within up to six (6) weeks.	Major impacts to the natural environment to be reversed within one (1) year.	Moderate damage and a small number of insurance claims. Major costs involved for repair efforts. Moderate recovery time, weeks up to two (2) months
	3	**3**	**3**	**3**	**3**
4. Major	Life-threatening injuries leading to loss of life. Long-term mental health impacts.	Long-term localized disruption or loss of service* altogether. Residents rely on back-up generators for an extended period. Public administration struggling to remain effective, danger of failure.	Serious impacts create a long-term (months) disruption to the daily routine and well-being of residents.	Severe impact to the natural environment could be reserved within five (5) years. Danger of continuing environmental damage.	Major damage and numerous insurance claims. High costs involved for repairs and relocation. Long-term recovery, several months up to two (2) years. External aid requested to assist in recovery
	4	**4**	**4**	**4**	**4**
5. Catastrophic	Multiple lives lost and city-wide injury. Severe mental health impacts.	Long-term city-wide disruption for an unknown period. Public administration in decay, failure to be effective.	Permanent disruption of daily routines and well-being of residents. “Life-changing”.	Disastrous impacts on the natural environment are irreversible.	Extensive structural damage and copious insurance claims. Financial aid required to balance the cost of repairs. Long-term recovery, years to decades. External aid required to assist in ‘state of emergency.
	5	**5**	**5**	**5**	**5**

To illustrate how these methods were applied, the consequences of damage to the transportation service area due to localized flooding are represented in Table 6. A summary of the consequence and likelihood tables for other impacts in the City is included in Appendix D (Table 20).

Table 6: Consequence table of damage to infrastructure/properties due to localized flooding under the increased precipitation climatic change.

INCREASED PRECIPITATION		**Damages to infrastructure/ properties due to localized flooding (V4)**
Community Impacts	**Health and safety (5)**	3 - Noticeable mental health impacts, non-life threatening injury.
	Loss of service (5)	2 - Significant disruption and stress on public administration.
	Community and lifestyle (5)	4 - Long-term disruption to routine. Recovery in months.
	Natural environment (5)	1- No impact on the environment.
	Damage & recovery (5)	3 - Moderate damage and high repair costs.
	TOTAL (25)	**13**

Multiplying the likelihood and consequences of damage to the transportation service area due to localized flooding (likelihood=5; consequence=13) provided a risk rating of 65, or a medium risk.

4.3.2 Risk Rating

The calculated risks are arranged on a spectrum from very low risk to extreme (Figure 10). The interpretation of the risk levels is as follows:

- Extreme risks demand urgent attention at the most senior level and cannot be simply accepted as part of the routine operations without executive sanction.
- High risks are the most severe that can be accepted as part of the routine operations without excessive sanction, but they will be the responsibility of the most senior operational management and reported on at the executive level.
- Medium risks can be expected to form part of routine operations, but they will be explicitly assigned to relevant managers for actions, maintained under review and reported upon at senior management levels.
- Low risks will be maintained under review, but it is expected that existing controls will be sufficient, and no further action will be required to treat them unless they become more severe (ICLEI-Canada, n.d.).

Figure 10: Risk rating spectrum to rank Climate Change impacts (ICLEI-Canada, n.d.).

Impacts identified as high and medium-high risks are described in more detail below (Table 7). Included in Appendix D, Table 21 includes all the risk ratings for the Climate Change impacts in Saint John.

Table 7: Risks rated high and medium-high for Climate Change impacts in Saint John. Note that no impacts were identified to be very high or extreme.

RISK RATING	Climatic Change	Impact Statement	Vulnerability Ranking
High (96-110)	SLR	Increased loss of land due to flooding and coastal erosion	5 (High)
Medium - High (66-80)	SLR	Increased risk of habitat loss due to coastal squeeze	4 (Medium-high)
Medium - High (66-80)	Increased Precipitation	Higher spring freshet flooding due to increased precipitation	5
Medium - High (66-80)	Increased Precipitation	Isolation, accessibility and mental health challenges due to flooding	3
Medium - High (66-80)	Increased storm severity	Flooding due to storm surge	5

The high-risk impact identified through this analysis are the permanent loss of land due to sea level rise (SLR). **Saint John has high vulnerability and low adaptive capacity to the impacts of SLR**. Built infrastructure is recognized as a viable solution to protect assets from rising sea levels. The cost, construction timeframe, and longevity of these projects poses challenges for gaining momentum from the province, municipality, and private investors.

The medium-high risk impacts identified through this analysis include coastal squeeze due to SLR, isolation, and decreased accessibility as a result of flooding from extreme precipitation, mid-winter thawing, increased storm severity, and impacts of storm surge.

- As the sea level rises **coastal squeeze** becomes an inevitable future for ecosystems. The adaptive capacity of these areas is low, resulting in a medium-high vulnerability rating. Programs to protect and enhance existing coastal environments are useful but organizations should start to prepare for the movement of species inland as water levels rise.
- **Higher spring freshet flooding due to increased precipitation** is a medium-high risk for Saint John. These events take a tremendous toll on infrastructure (roads and buildings). As the city anticipates more mid-winter thawing, the budget for infrastructure repairs will be challenged. The cost and timeframe for repairs assigns this impact a high vulnerability.
- **Flooding events creating isolation and accessibility challenges** is medium-high risk. Blocked roadways and access to homes has a significant impact on the mental and physical health of Saint John citizens. Although this impact has a medium vulnerability the likelihood prompts a medium-high risk rating.
- While many precautions can be taken to reduce the **potential of flooding from storm surge** the sensitivity of assets (including the port, roads, and buildings) provides the medium-high risk rating.
- An **increase in the severity of storms** resulting in infrastructure damages and power outages is a medium-high risk in Saint John. Proper precautions and preparations may allow for a faster recovery however each scenario will be different and developing priority lists and energy back up options (beyond back-up generators) is crucial.

4.4 Action Register

Based on the Risk and Vulnerability Assessment the greatest Climate Change risks for Saint John include sea level rise, heavy rainfall resulting in localized flooding, early winter thaws that lead to more severe

flooding, and loss of habitat due to coastal squeeze. The principal purpose of the City of Saint John Climate Change Adaptation Plan is to protect the well-being and prosperity of the city and its residents from these impacts. Eight objectives were established based on the six goals outlined in Section 1.1 as well as the risks identified in the Risk and Vulnerability Assessment (Table 8). The Action Register (under Milestones 3 and 4: Plan and Implement) recommends specific actions to help achieve the objectives. Included in the Action Register are actions that are ongoing. These actions are included to ensure continuation of processes and provide awareness of existing efforts within the City.

Table 8: Climate Change impacts and objectives for Saint John established through the Risk and Vulnerability Assessment. The third column details the outcome if no adaptation occurs.

Objective	Without action
1. Integrate Climate Change impacts into community planning.	Municipal planning documents for the City will not account for climate impacts reducing the resilience of the community.
2. Reduce shoreline erosion & promote natural infrastructure.	Higher rates of coastline erosion leading to property damage and/or loss of land.
3. Protect natural spaces, local habitats & migration routes.	Loss of habitat and coastal squeeze. Changes to predator prey relationships due to invasive species.
4. Provide public education on how to deal with the impacts of Climate Change.	Environmental changes are unfamiliar and confusing. Risks are unknown leading to a lack of preparedness and ultimately a lack of adaptation.
5. Reduce the impact of Climate Change on human health.	More health challenges and hazards associated with Climate Change events. Low adaptive capacity in high risk areas.
6. Support vulnerable groups to increase adaptive capacity.	Environmental changes are unfamiliar and confusing. Risks are unknown leading to a lack of preparedness and ultimately a lack of adaptation.
7. Increase resilience to flooding & sea level rise.	More frequent coastal flooding leading to the loss of private and public properties, and land.
8. Increase resilience to extreme weather.	Low response to emergency situations leading to long term disruption of community lifestyles and damages to municipal infrastructure.

The Adaptation Plan capitalizes on local initiatives and sustainability goals already in place to build on the City's existing strengths. Quick wins are prioritized for sustained momentum, while at the same time long term planning ensures critical energy, communications, health, and transit services are prepared for projected extreme weather events. Land-use changes, environmental monitoring, licensing, regulation, and civic engagement will be central to the success of the Action Register. Actions identified throughout this plan are referenced as (Obj. X-XX) and can be found in more detail in the Action Register (see Appendix F). Through implementation of the adaptation actions, Saint John will be able to increase adaptive capacity, and decrease vulnerability to Climate Change impacts. As adaptation actions are completed, the City can review the Risk and Vulnerability Assessment to ensure the risk ratings are still up to date.

5. Vulnerable Natural and Built Environments

In Saint John, properties and businesses will be at risk from the increased intensity of flooding and severity of extreme weather events. Each property affected may require a different approach to adaptation, based

on the resources available and the capabilities of the City, homeowners or business owners involved. This Section identifies infrastructure and natural spaces that are vulnerable to Climate Change.

5.1 Municipal Infrastructure

Public and private infrastructure including amenities, transportation systems, and healthcare facilities are likely to be affected by warming temperatures and precipitation changes. It is estimated that Climate Change will add 10-20% to infrastructure costs by 2030, and an additional 10-12% by 2080 (CBCL Limited, n.d.). An increase in the likelihood of storms, severe flooding, ice accumulation and freeze thaw events can decrease functionality and damage municipal infrastructure. In Saint John, grey infrastructure at risk may include water system infrastructure, such as pipes, fire hydrants, water towers, pumping stations, and water treatment facilities, and transportation infrastructure like roads, sidewalks, parking lots, and bridges.

Engineered stormwater management systems in the City are designed using intensity, duration, and frequency (IDF) curves to evaluate infrastructure capacity under heavy rainfall. Current IDF values are based on historical data from 1958-1994 and do not include an increase in precipitation under future climate scenarios. The City can research the process for developing a percent increase for IDF values to better prepare for an increase in precipitation intensity (i.e. short-term rainfall events) (Obj.8-55).

Identifying core infrastructure and priority areas impacted by mid-winter thaws and/or rain-on-snow events is recommended to increase the City's resilience to Climate Change (Obj.8-56). Using the wet areas mapping the City can identify areas prone to flooding during winter rain events and prioritize snow clearing/maintenance to reduce impacts to infrastructure (Obj.7-49). Bioretention infrastructure is recommended to reduce flooding challenges which can include isolation, loss of power, food shortage, and contamination (Obj.8-57).

As part of the asset management program, a risk management framework has been applied to identify and evaluate the risks of Climate Change on City infrastructure and identify the mitigation opportunities that may be available. This framework will identify infrastructure that is likely to experience failure due to climate impacts and will enable the City to remove or upgrade the asset. The risk management framework will inform a Climate Change Vulnerability Assessment that is currently underway and is assessing the impact that Climate Change will have on City infrastructure. This assessment is projected to be completed by May 2020.

The Action Register recommends using GIS software to incorporate natural assets into the Asset Management Plan (Obj.2-12) to account for the ecosystem services provided by wetlands, forests, and stormwater retention areas. Increasing the functionality of existing natural assets is significant for adapting to Climate Change.

5.2. Industrial Infrastructure

Vulnerable industrial operations in Saint John include: the Port of Saint John; Canaport LNG; Irving Oil Refinery; J.D. Irving Pulp and Paper Mill; and AIM Recycling. Through flood risk mapping, ACAP Saint John

has identified the number of petroleum storage sites at risk to coastal flooding due to sea level rise. Recommendations for the City include identifying petroleum storage at risk (Table 2) and options to relocate beyond the flood zone (Obj.7-41). Petroleum storage sites over 2000L are registered with the Department of Environment and Local Government and information about the type of petroleum product and amount on a property are available through Service New Brunswick. Industrial infrastructure can be hazardous, and adaptation is required to reduce the potential for contamination and disruption of services.

5.3 Energy and Communication Infrastructure

The City of Saint John partnered with QUEST Canada for the *Municipalities and Utilities Partnering for Community Resilience* project, to develop a Climate Risk and Resilience Assessment with a specific focus on the impacts of Climate Change on energy distribution services. QUEST completed calls and surveys with municipal staff and conducted three full day workshops with municipal staff, utility companies, provincial staff, and ACAP Saint John.

During the first workshop, attendees participated in a mapping exercise that highlighted risk areas, strengths/assets, alternate sources of power/heat, possible improvements and green infrastructure, areas to 'build back better', zones to discourage development, and emergency muster points. Risks that were identified by participants included flooding, fires in vacant buildings, and energy transmission lines vulnerable to ice loading during freezing rainstorms. QUEST's results found that Saint John is at high risk to hydrological and atmospheric events (i.e. storm events, flooding) and was assessed to have a medium resilience to these risks. Contaminations and hazardous spills were also listed as a high risk with a high resilience to respond to this type of event. Hazards rated as "medium risk" included food, water, and power shortages, and forest fires with a medium resilience to these hazards.

QUEST provided a comprehensive list of recommendations to increase energy resilience in the City of Saint John. These recommendations include creating better communication between energy utilities, the City, and the public. The Adaptation Plan recommends developing a list of facilities (for example grocery stores, gas stations, or retail centres) that have back power or alternative energy sources available during emergency events (Obj.8-53). The final resilience report also included a communications strategy to help the City communicate climate risks and secure financial resources. The Adaptation Plan supports the QUEST recommendations to increase the resilience of energy systems.

Maintenance of power lines including the trimming of overhanging trees is performed on a 3 to 5-year cycle by SJ Energy. The Action Register supports this ongoing effort and encourages the City to develop an inspection cycle to ensure the prompt removal of dead or diseased trees to protect power lines as storm frequency increases (Obj.8-54). Two Saint John Energy substations (1050 Rothesay Road and 23 Smythe Street) were identified to be impacted by coastal flooding due to sea level rise (Appendix B, Tables 17-18). Through communication with Saint John Energy staff, substations are able to be switched off remotely in the event of a flood, and much of the substation's critical infrastructure is elevated. The City has still recognized the vulnerability of the substations in the Uptown core and SJ Energy has secured funding from the Disaster Mitigation and Adaptation Fund for relocation of this critical infrastructure.

5.4 Buildings and Properties at Risk

Buildings and properties that are at risk of coastal flooding were compared to the Coastal Hazard Flood Maps for three sea level rise scenarios: HHWLT (4.6 m), HHWLT + 1 m (5.6 m) and a 1 in 100-year storm in 2100 (6.8 m). The buildings and properties that will be impacted are listed in Table 2. Based on the property values of properties that will be impacted in a worst-case scenario event (1 in 100-year storm in 2100) the value of property that could be flooded equals $1,093,387,600. The City should engage stakeholders that are located within flood risk zones to discuss adaptation options for their property (Obj.4-21).

Buildings are also at risk to extreme weather impacts such as wind or ice storms, seasonal flooding and heavy rainfall. In the spring of 2018 and 2019 the City of Saint John experienced extreme flooding on the St. John [Wolastoq] and Kennebecasis Rivers. Over 650 properties were impacted during the 2018 spring freshet equaling a combined property value of approximately $290,208,600. Properties across the City, especially in low lying areas, can be severely impacted by heavy rainfall events. Educating residents and encouraging green infrastructure and LID can help to reduce flooding impacts from heavy rainfall (Obj.4-25). As well, communicating the availability of flood risk maps will enhance homeowners' understanding of the vulnerabilities presented by Climate Change (Obj.7-44). Public survey results show that many residents do not believe they are vulnerable to flooding despite living in high risk areas (Comeau, 2017).

Visually identifying areas in 1 in 100-year flood zones is a critical step towards Climate Change adaptation. Flood risk maps are currently available for North Saint John, Kelly Lake, and the Marsh Creek Area. These maps were produced after 1 in 100-year flooding events that occurred in the 1970's. To adapt to a changing climate, this report recommends updating and extending the flood risk maps to include coastal and inland flooding (Obj.1-3). Once updated, the flood risk maps should be incorporated into municipal plans to restrict development in high flood-prone areas (Obj.1-2; CoastAdapt, 2012).

Since homeowner's insurance generally does not cover flooding from the overflow of a body of water, it is critical that new developments are built away from floodplains (Insurance Bureau of Canada, 2017). The City of Saint John should consult updated flood maps and comply with coastal development protocols established by the Government of New Brunswick to limit development in high risk zones (Obj.1-1).

5.5 Transportation Infrastructure

Three sea level rise scenarios, HHWLT (4.6 m), HHWLT + 1 m (5.6 m), and 2100 1-100 (6.8 m) were compared to emergency routes to determine essential routes that will be impacted by sea level rise and are shown in *Appendix B: Emergency Routes and Control Points at Risk of Coastal Flooding*. Under the HHWLT (4.6 m) scenario, which demonstrates present day high water conditions, five roads (Bayside Drive, Red Head Road, Lorneville Road, Digby Ferry Road and the Saint John Throughway) are at risk of coastal flooding. These roads are also impacted in the two other coastal flooding scenarios. Under the HHWLT + 1 m scenario (5.6 m), 30 emergency routes (approximately 50 km) are at risk of coastal flooding. Under the 1 in 100-year storm in 2100 scenario (6.8 m), 36 emergency routes (approximately 66 km) are at risk of coastal flooding (Appendix B, Tables 15-17). ACAP Saint John determined whether an alternate route would be available to allow emergency vehicles and residents to pass; this is important because

residents could become stranded in their neighbourhoods due to flooding. Under the HHWLT flooding scenario, 2 out of 5 (40%) emergency routes did not have an alternate route, under the HHWLT + 1 m flooding scenario 10 out of 30 (33%) emergency routes did not have an alternate route and under the 1 in 100-year storm in 2100 scenario, 10 out of 36 (27%) emergency routes did not have an alternate route (Appendix B, Tables 15-17). It is important to note that only emergency routes were studied in this assessment and the actual number of roads that are impacted by sea level rise could be higher. Adaptation strategies, including raising roadways, are recommended to ensure essential emergency routes remain accessible in the future (Obj.7-42,45).

The Courtenay Bay Causeway is a roadway that separates the forebay from the Courtney Bay and is a primary route used to connect the Central Peninsula to East Side neighbourhoods. During storm events, storm surge and high tide can make this route dangerous for motorists and pedestrians. Historically, parts of the Causeway have been washed out by wave action leading to roadway closure. SJ Energy has been proactive to move streetlights and power lines to the Marsh Creek side of the Causeway to reduce infrastructure damage. The Courtenay Bay Causeway represents a key point of failure under sea level rise conditions. When the Causeway is breached under a 1m (5.6 m) sea level rise scenario, approximately 22 emergency routes are expected to be impacted by sea level rise (Figure 11). This level does not change drastically when you consider a 1 in 100-year storm in 2100 (6.8 m) as 23 emergency routes are expected to be impacted. Adapting the Causeway by raising the roadway will help to avoid extensive sea level rise impacts in East Saint John. Specifically, the Adaptation Plan encourages the City to review the recommendations from the 2009 Terrain Marsh Creek Diversion Project to increase the functionality of the Courtenay Forebay and protect areas along Marsh Creek and East Saint John (Obj.7-46).

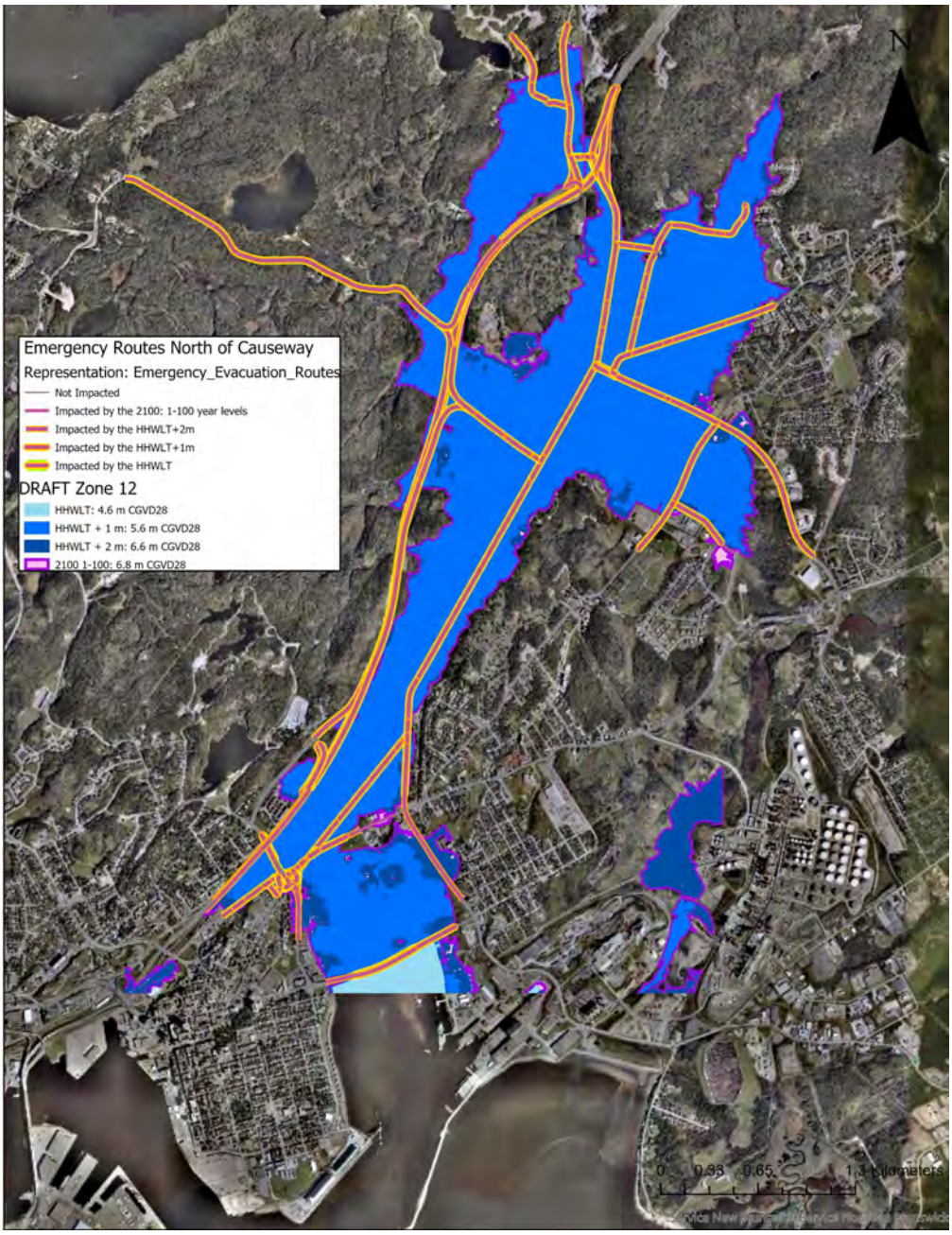

Figure 11: Emergency routes that are impacted by coastal flooding during a breach of the Courtenay Bay Causeway.

5.6 Cases Studies of Extreme Coastal Instability

In Saint John, both developed and undeveloped coastal areas are at risk of erosion and instability. It is recommended that the City of Saint John monitor areas experiencing high rates of erosion and investigate infrastructure that may require relocation (Obj.2-8,9). Natural infrastructure is recommended for reducing shoreline erosion; however, the Action Register also recognizes that structural protection may be necessary in some areas. Partnerships will be required for the implementation of both structural and non-structural protection (Obj.2-10,11). ACAP has identified locations throughout the City that are

extremely vulnerable to coastal instability and will require adaptation. These locations are explored in further detail below.

5.6.1 Lorneville Cove

Historically, a landslide was experienced at Lorneville Cove following a period of high rainfall in 1977 (Spooner et al., 2013). Current evidence of creep may mean that a future movement will occur from continual erosion. In Figure 12, the previous mass movement along Lorneville Cove is observed. The bluff face consists of unconsolidated glacial till that is easily eroded away and very little vegetation is present to stabilize the slope from future erosion (ACAP Saint John, 2016).

Figure 12: Along Lorneville Cove there is evidence of previous mass movements. As water levels adjust to increased precipitation and sea level rise, erosion along this cove will continue. Adaptation using soft or hard protection techniques can help to limit erosion and maintain healthy shorelines.

Along a bridge that cuts across the estuary hard riprap protection has been installed; however, the road continues to be undercut during large storms. The western perimeter of the cove along Post Office Road has additional riprap made of concrete and asphalt but these protections will be worn down and broken apart over time (Figure 13).

Figure 13: Riprap protection has been installed around Lorneville Cove to reduce erosion during periods of high water. Monitoring erosion along this infrastructure will be required to ensure it continues working as storm events intensify throughout the century.

5.6.2 Sand Cove Road and Sheldon Point Trail

A study completed in 2004 by Fundy Engineers examined slope failures along Sand Cove Road and identified multiple tension cracks that display a history of movement. The report revealed that weak soils made up of sand and gravel on top of soft clay, are being easily removed by wave action along the coastline, furthering the instability (ACAP Saint John, 2016). Engineering consultants have been hired by the City to investigate ongoing erosion of the road.

Evidence of erosion can be observed at the start and along the Sheldon Point Trail (Irving Nature Park), where the bluff faces show multiple slope failure events (Figure 14). Along McLaren's Beach, at least three homes have been moved because of foundation damage, broken water lines, and bending of major structures including homes and garages (ACAP Saint John, 2016).

Figure 14: Mass movement occurring along the Sheldon Point Trail which is displaying multiple mass movement events as there are two exposed bluff faces identified in this image (ACAP Saint John, 2016).

Landowners have expressed interest in a breakwater or seawall to help stabilize the shoreline. In the 1970's, residents installed a two-part hard infrastructure to slow erosion, however waves have exceeded the height of the wall (Figure 15; ACAP Saint John, 2016). This example is useful to show the limitation of hard protection. Adaptation solutions should consider natural infrastructure for long-term protection of the coastline. Other options include the construction of a berm to limit current erosion and support the slope above or the placement of a series of wells that help control the water content in the soil. Presently, the City of Saint John has not taken any action and erosion remains an ongoing issue in the area.

Figure 15: A series of two hard protection methods put in place by a local resident along McLaren's Beach. Closest to the shore is a small layer of stone and then behind that, a wooden seawall built to protect the coastline from wave action. Just above the wooden sea wall, the bank has been undercut by large wave events leaving bushes hanging overhead (ACAP Saint John, 2016).

5.6.3 Irving Nature Park

The erosion experienced along Sand Cove Road has brought concern to municipal staff regarding access to the Irving Nature Park. This popular outdoor space could become isolated as a result of sea level rise and storm surge, which are leading to extreme erosion along the entry and coastal trails. The Irving Nature Park has experienced high rates of erosion forcing closure of an old trail and development of a new trail. The old trail is highly eroded along the cliffs edge and is dangerous for pedestrians. As storms intensify, strong winds and wave action will continue eroding the trails and access to Irving Nature Park.

5.6.4 Red Head Saint John

For decades the Red Head community has been plagued by higher erosion rates compared to other areas of the City. Residents fear losing their homes within the next 50 years as a result of erosional processes that are amplified by sea level rise (ACAP Saint John, 2016). Steep clay slopes with little to no vegetation have been created as a result of erosion, making access to parts of the Red Head beach difficult (Figure 16).

Figure 16: An exposed bluff face along Red Head beach. This image shows the larger boulders that have fallen out of the very fine sand mixture. Additionally, little vegetation is observed on the exposed slope and more dense intact vegetation is seen travelling down with the slump (ACAP Saint John, 2016).

Many residents of Red Head have already put in place their own protection, such as riprap or seawalls to try and minimize erosion of the shore. If not done properly by a coastal engineer, many of these hard engineering structures could potentially put neighbouring properties at risk. The Red Head area will continue to erode due to the shape of the cove and increasing wave action during high water. The City can promote natural infrastructure strategies as an adaptation option for homeowners and should prioritize high erosion areas along Red Head Road to reduce isolation during storm events (Obj.2-9).

5.7 Habitats and Species at Risk

The City of Saint John is situated at the estuary of the Wəlastəkw (St. John River), where freshwater meets the largest tides in the world at the Bay of Fundy. This distinct environmental setting has allowed for unique species and habitats to develop and thrive. Conservation of coastal ecosystems not only provides habitat for species at risk, but also protects shorelines from erosion. This section provides details about habitats and species at risk throughout Saint John including the Wəlastəkw, coastal ecosystems and forests.

5.7.1 St. John River (Wəlastəkw) Ecosystem

There are several watercourse systems in Saint John including the Wəlastəkw and its tributary the Kennebecasis River, as well as Newman's Brook, Marsh Creek and Little River (to name a few) which will all be impacted by increasing temperatures and precipitation. Water temperature, a key determinant of biological processes, is expected to increase in the Wəlastəkw putting stress on species that require specific temperatures for spawning and development. For example, the changing temperature will limit the growing season for Atlantic salmon (*Salmo salar*) and expand the growth of striped bass (*Morone saxatilis*) populations (Dugdale et al., 2017). Observed changes in Atlantic salmon migration have been related to changes in water temperature and flow, which will be impacted as the Climate Changes (Juanes, Gephard, & Beland, 2004).

Other threats to this ecosystem include changes to seasonal precipitation patterns which can create favourable conditions for the development of harmful algal blooms (cyanobacteria), reduced oxygen availability, and pollutant transport which can result in harmful levels of ammonia and methylmercury (Pinkney, 2014). The Adaptation Plan recommends monitoring contamination and sediment loading as a result of stormwater runoff to reduce the impacts of flooding and heavy precipitation on sensitive ecosystems (Obj.3-19). Protection strategies including restoration and monitoring programs along the Wəlastəkw are required to document changes in ecosystem function as a result of Climate Change (Obj.3-14,15).

5.7.2 Coastal Ecosystems

Coastal habitats are among the most vulnerable natural landscapes in Atlantic Canada due to the threats of coastal erosion and sea level rise which ultimately result in coastal squeeze (Stewart et al., 2003). In Saint John the coastal wetlands, salt marshes, and mudflats such as Saints Rest Marsh, the Musquash Estuary, and the Little River Estuary, host a large variety of invertebrates and fish, and provide feeding grounds for migratory birds. These habitats are valued for fostering biodiversity, retaining nitrogen, and filtering stormwater pollutants. These dynamic ecosystems can adapt to sea level rise and coastal erosion if no natural or anthropogenic barriers exist. Where barriers to habitat migration do exist, adaptation is required to preserve the intertidal habitats (Université Virtuelle Environnement et Développement Durable, 2016). The Action Register recommends identifying areas where soft or hard adaptation strategies can be used to protect ecosystems against coastal squeeze (Obj.2-10,11).

The sandy shorelines of Bayside Beach, McLaren's Beach and east toward Red Head contain a mixture of marram grasses and similar plants that can withstand salt spray and replenish sand dunes ultimately

providing resistance to wind and stabilizing nesting sites for shore birds (Stewart et al, 2003). To adapt to sea level rise, the Action Register encourages education through pilot projects that demonstrate how adaptation strategies, including the planting of native grasses, can reduce coastal squeeze (Obj.3-13).
There is a large concern for aquatic plants that exist in areas of significant warming. Studies observe that increasing water temperatures are affecting the growth and survival of cold-adapted seaweeds including rockweeds (*Ascophyllum nodosum*, *Fucus vesiculosus*), Irish moss (*Chondrus crispus*), and kelp (*Laminaria digitata*) (Wilson et al., 2015). The importance of these species is the habitat they provide for culturally and economically significant species such as mussels, clams, scallops, crab, and lobster. Monitoring at-risk cold-water species is recommended to maintain the functionality of the ecosystem (Obj.3-15).

Research on ocean acidification suggests a shift in local predator prey systems where sea stars (*Asterias rubens*) are experiencing decreasing growth, while mussel (*Mytilus edulis*) populations are increasing from reduced predation (Keppel, Scrosati, & Courtenay, 2015). Ocean acidification is a low risk for Saint John, however monitoring these changes is essential to understanding how acidification will impact the Bay of Fundy ecosystem in the future (Obj.3-18).

5.7.3 Urban Parks and Forests

Urban parks in the City of Saint John include King Square, Queen Square West, Little River Reservoir, Rockwood Park, Tucker Park, Irving Nature Park, and more. These park spaces add to the ecology and urban forest of the City and contain many mature trees. They are natural assets and are valued for the services they provide including recreation, culture, stormwater management, heat moderation, air purification, and carbon dioxide absorption. Canada's Acadian Forest has been identified as an area which will experience ecosystem changes as a result of Climate Change, including species lost, changes to species habitat range and productivity changes (Taylor et al., 2017). Saint John's urban forest includes trees in public spaces (street trees and parks) and on privately owned land. Plan SJ recognizes the important role of trees and vegetation in maintaining and enhancing the quality of life in the City and has policies to plant street trees in public spaces and on City rights-of-way (City of Saint John, 2011). The City plants street trees when roads are being upgraded to the current design guidelines and has recently planted trees in Chown Field and along the Harbour Passage.

A formal inventory of trees - including height, diameter, species, condition, and proximity to power lines, has been conducted in three Saint John neighbourhoods to fully understand the sustainability of the urban forest in the urban core. Approximately 2,605 trees were surveyed in the Central Peninsula, Lower-West Side, and North End (Figure 17). The inventory data showed that approximately 76% of surveyed trees were identified to be in good condition. This inventory suggests a significant proportion of the urban forest is comprised of invasive or introduced species, primarily Norway Maple (*Acer platanoides*) (29%), which is prone to disease and limb failure during storm events.

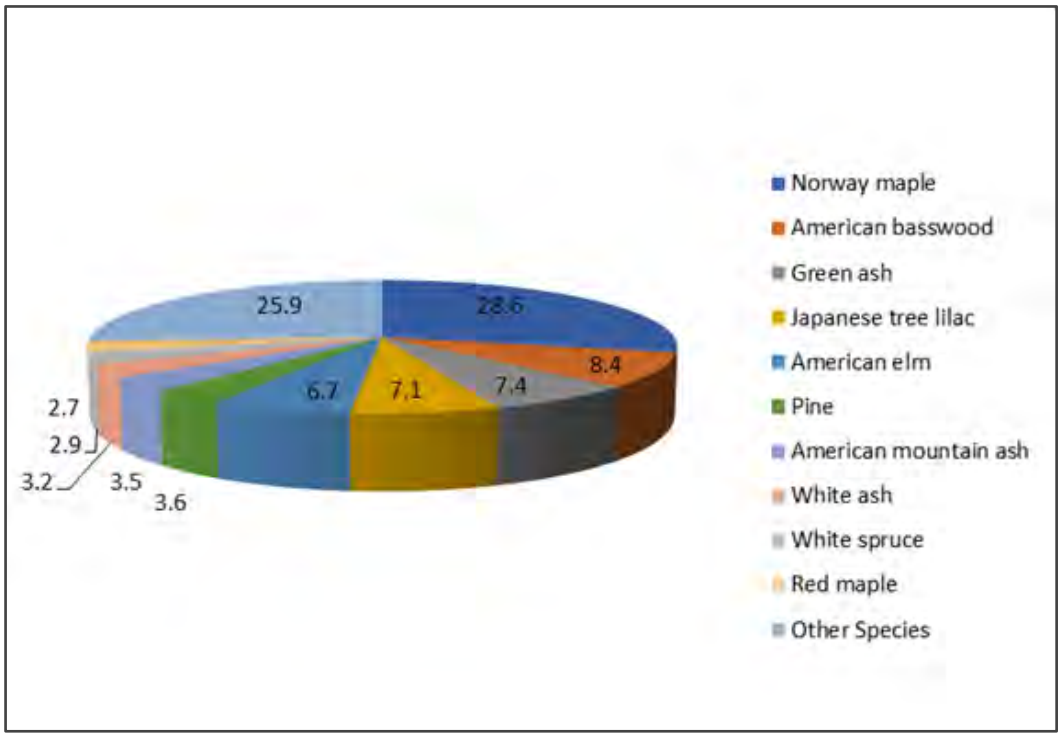

Figure 17: Species distribution of street trees surveyed in the Central Peninsula, North End, and Lower-West Side (2017-2019).

A sizable proportion (11%) of the study neighbourhoods' urban forest consists of Green Ash (*Fraxinus pennsylvanica*), White Ash (*Fraxinus americana*), or Black Ash (*Fraxinus nigra*), which have been known for their tolerance to urban environments. Until now, ash trees had very few diseases or problems with pests. The Emerald Ash Borer (EAB) is an invasive beetle that was first observed in New Brunswick in the Spring of 2018. The EAB has proven to be devastating in other Canadian municipalities due to the 5 to 10-year terminal lifespan once these trees are infected. Based on the number and size of the observed trees, the total replacement value of the Ash species was calculated to be approximately $406,804. Public awareness about invasive species including the EAB is recommended for the City of Saint John (Obj.3-17).

Due to the increase of wind and ice storms projected under future Climate Change conditions, monitoring tree growth around overhead utility lines is important for maintaining services for Saint John residents and businesses. The proximity of surveyed trees to overhead utility lines was observed during the tree inventory to identify areas that may be at risk due to limb failure or swaying branches. Overhead utility line conflicts were categorized into three fields: a) crown conflict (C) b) utility line overhead (OH) and no risk (NO) (Table 9). Trees that were sorted into the crown conflict category were observed to be near any overhead utility lines. After further discussion with Saint John Energy, the crown conflicts from the North End 2019 tree inventory were further divided to identify the type of utility line the tree was in contact with i.e. primary, secondary, communications, or service lines (Table 10). It was noted that trees touching the primary line were also touching the lines below.

Table 9: Overhead utility line conflicts for the Central Peninsula, Lower-West Side and North End tree inventories.

	Crown Conflict	Utility Line Overhead	No Contact
Central Peninsula	245	153	1,117
Lower- West Side	245	59	283
North End	87 *See below	13	397
Total	**577**	**225**	**1,797**

Table 10: Overhead utility line conflicts for the North End tree inventories.

	Contacting Primary Line	Contacting Secondary Line	Contacting Communications Line	Contacting Service Line	Total Contacting
North End	8	24	42	13	**87**

The ecosystem services that the observed trees can provide to the neighbourhood have been calculated using the i-Tree Software developed by the USDA Forest Service (2006) (Table 11). In total, the residents and the City of Saint John saves approximately $73.31 per tree in the study neighbourhoods (Total $190,972).

Table 11: Annual Public Benefits of Trees in the Central Peninsula, Lower-West Side and North End ($/tree).

Energy	CO_2	Air Quality	Stormwater	Aesthetic other	Total ($)
29.55	1.00	7.10	8.78	26.89	**73.31**

In order to address the impacts that Climate Change will have on urban parks and forests such as wind/ice storms and invasive species, and to manage urban forests to maximize their ecosystem services, it is recommended that the City of Saint John develop an Urban Forest Management Plan (Obj.3-16).

6. Public Health and Safety

Climate Change has a wide range of effects on public and private infrastructure, but also on public health and safety.

6.1 Water and Public Health

As the climate changes, the availability and quality of drinking water may be impacted. To maintain sustainable yields, the Adaptation Plan recommends that Saint John Water continues the routine monitoring of precipitation, groundwater, and surface water (Obj.5-32). Drinking water for the City of Saint John is sourced from Loch Lomond Lakes, which is sampled biannually and tested for bacteria, metals, turbidity, E. coli, and total coliform. Saint John Water also monitors for salt-water intrusion, and is encouraged to maintain this practice as sea level rises and storm surge becomes more extreme (Obj.5-33).

The New Brunswick Chief Medical Officer of Health encourages the ongoing monitoring of blue-green algae which is completed by the Department of Environment and Local Government. These provincial departments are responsible for public alerts of potentially harmful algal blooms and boil water advisories. Locally, Saint John Water has an ongoing monitoring routine to track bacterial and algal

blooms. The Action Register supports this monitoring (Obj.5-30) and recommends collaboration with the provincial government on developing a communication strategy to increase public awareness and educate residents about the dangers associated with Climate Change, including toxic cyanobacteria (Obj.5-27).

6.2 Coastal & Inland Flooding

The City of Saint John faces increased risk to public health and safety and increasing occurrence of severe flooding events. The impacts can range from immediate danger (contamination, injury, and mortality) to medium- and long-term conditions (diseases, food insecurity, or mental health issues) (Public Health Agency of Canada, 2018). The City is encouraged to host annual education sessions to review safety protocols before, during, and after flood events (Obj.7-43).

Coastal flooding has the potential to impact emergency evacuation points and emergency control points. An emergency control point is defined as a location near a building, intersection on evacuation center that is identified by emergency management personnel where officials will direct emergency control operations during an incident that could have an impact on the safety or well-being of the public (First 5 Minutes Pty, 2006). Under current high tide conditions (4.6 m) no emergency control points are impacted. Under the HHWLT + 1 m sea level rise scenario (5.6 m), 21 emergency control points are at risk of coastal flooding. Under the 1 in 100-year storm in 2100 sea level rise scenario (6.8 m), 40 emergency control points are at risk of coastal flooding (Appendix B, Tables 18-19). These impacts will need to be considered when developing municipal emergency response plans (Obj.1-6).

The Action Register includes several actions that can help the City adapt to increasing public health challenges as a result of flooding (Obj.5: Reduce the Impact of Climate Change on Human Health). Many of these measures are supported by researchers striving to find best practices for reducing vulnerability to flooding disasters (Government of Canada, 2018a; Kelder, 2014; Warren and Lemmen, 2014; Burton et al., 2016; Berry et al., 2016).

6.2.1 Immediate Dangers

Serious injury can be experienced directly from flood waters, rockslides, and from an increased risk of electrocution, electrical burns, or fire from damaged power systems (Public Health Agency of Canada, 2018; Burton et al., 2016; Séguin, 2008). Floods can cause mortality from drowning or from acute trauma from high stream velocity flow (Public Health Agency of Canada, 2018). Motor vehicle accidents are a major cause of death or injury during or following a flooding event in North America due to increased risk from impassable roads from washouts, wet driving conditions, and heavy traffic during evacuations. In the United States, 57% of deaths from floods are associated with motor vehicle accidents during and after the event (Public Health Agency of Canada, 2018).

Contamination of drinking water due to flooding is a concern for the City. Saint John Water routinely samples City water during and after flood events to ensure safety (Obj.5-34). Municipalities, the Insurance Bureau of Canada, and the Action Register promote the installation of backflow valves to adapt to increased stormwater volumes and reduce the potential for contamination from sewer backup (Obj.7-48). The Action Register also includes recommendations to use bioretention infrastructure (i.e. rain barrels,

rain gardens, bioswales) to reduce flood risks by capturing rainfall and promoting natural processes such as evapotranspiration and infiltration (Obj.8-57; Ministry of Environment and Climate Change, 2017).

6.2.2 Medium to Long Term Dangers

Food-borne diseases, including stomach and gastrointestinal problems, and water-borne diseases have a heightened risk of contraction and outbreak during and after a flooding event (Burton et al., 2016; Warren & Lemmen, 2014; Séguin, 2008). There is also an increased risk of zoonotic diseases, vector-borne diseases (see Section 6.3), and respiratory illnesses after a flood (Table 12).

Table 12: Examples of water-borne diseases, zoonotic diseases, and respiratory illnesses that can be transmitted by flooding impacts (Public Health Agency of Canada, 2018; Orkin Canada, 2018; Burton et al., 2016; Warren & Lemmen, 2014; Séguin, 2008).

Water-Borne Diseases	Zoonotic Diseases	Respiratory Illness
• Wound infections • Tetanus • Skin irritation • Eye, ear, nose, and throat infections • E. Coli • Stomach problems • Gastrointestinal problems	• Rat-bite fever • Salmonellosis • Hookworm • Hanta virus • Pulmonary syndrome	• Infection • Contamination • Mould • Dampness-related microbial growth • Exposure to hazardous materials such as asbestos

The long-term mental health impacts of flooding can be severe. Studies have shown conditions can range from anxiety, grief, or depression, to a heightened risk of violent behaviours, substance abuse, and post-traumatic stress disorder (PTSD). Two years after a flooding event in Canada, studies have shown participants still experienced depression, PTSD, and poor adjustment to everyday life due to psychological stress (Public Health Agency of Canada, 2018; Burton et al., 2016, Fernandez et al., 2015; Warren & Lemmen, 2014; Séguin, 2008). Mental health challenges are discussed further in Section 6.6.

6.3 Spread of Vector Borne Disease

Increasing temperatures and changing precipitation patterns cause shifts in insect migration allowing vector-borne diseases to be more easily transferred (Ellis, 2007). These environmental changes also have a direct impact on plant growth which can alter the abundance and distribution of species' habitat and increase vector survival rates (International Council for Local Environmental Initiatives Canada, n.d.). Vectors are species that do not cause a disease, but they carry and transfer the disease from one host to another; ticks and mosquitoes are examples of vector species.

6.3.1 Ticks and Lyme Disease

Lyme disease is a growing risk in New Brunswick due to the expanding range of Blacklegged Ticks (*Ixodes scapularis)*, the vector that can carry *Borrelia burgdorferi*, the causative agent of Lyme disease (Figure 18). Environmental data reveals a significant expansion of this vector in the United States, spreading North into Canada as a result of warmer temperatures. Researchers expect to observe a 213% increase in suitable tick habitat in Canada by the 2080's (Brownstein, Holford, & Fish, 2005).

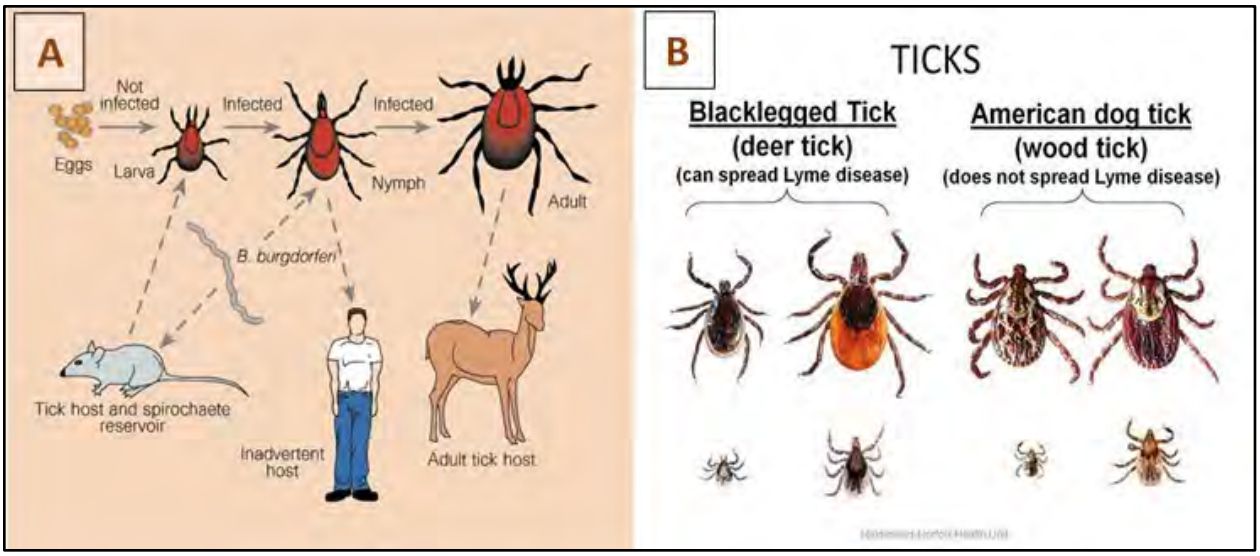

Figure 18: (A) The movement of Lyme disease through a host-vector relationship. The tick is the vector which will become infected with B. burgdorferi when it feeds on its host, which are often mice. Once the tick is infected it will pass the disease onto other hosts (deer or humans) (Barbour & Zuckert, 1997). (B) Blacklegged Tick and American Dog Tick comparison. Blacklegged Ticks are the vectors for spreading Lyme disease (Haldimand-Norfolk Health Unit, 2013).

On average, 12% of ticks tested in New Brunswick are positive for *B. burgdorferi*, a number that is higher for endemic areas like Greater Saint John (Government of New Brunswick, 2015). Based on provincial tick surveillance, known risk areas in the province include North Head on Grand Manan Island, Millidgeville, Grand Bay and Westfield, Saint John, Rothesay, and Quispamsis (Figure 19; Government of New Brunswick, 2015). Rockwood Park, a high endemic area in the City has a monitoring program and encourages park users to check for ticks on themselves and pets after visiting the park.

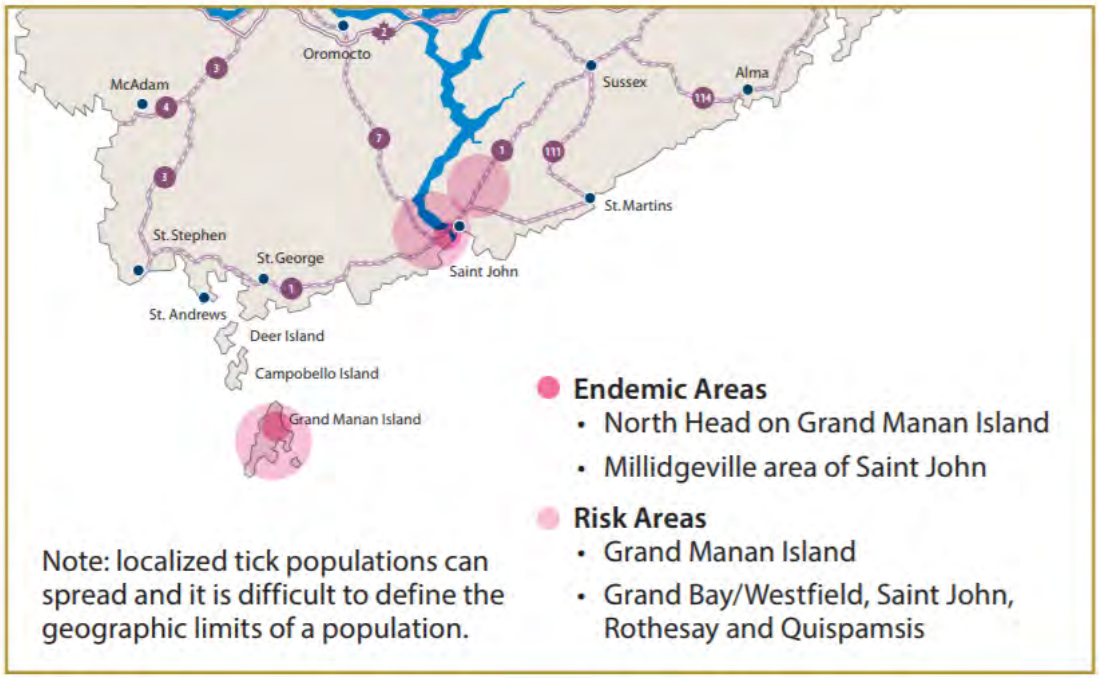

Figure 19: Areas of established or emerging tick populations in New Brunswick. The City of Saint John is considered an endemic area (Government of New Brunswick, 2015).

If you find a tick on yourself or your pet, it is important to remove the tick properly to avoid leaving part of the head or body attached. Tick prevention techniques, including safe removal can be found online: https://www2.gnb.ca/content/gnb/en/departments/ocmoh/cdc/content/vectorborne_andzoonotic/Tick-Borne_Diseases/how_to_be_protected.html

Lyme disease first presents itself as a rash, shaped like a bull's eye that can develop after 3 to 30 days into flu-like symptoms. Fever, chills, headache, fatigue, swollen lymph nodes, and muscle and joint aches are all common symptoms of the disease. **In the early stages, these symptoms can be treated with antibiotics for a full recovery.** If left untreated, Lyme disease can develop into more severe symptoms such as facial paralysis (Bell's palsy), aches and pains, heart disorders, neurological disorders, nerve pain, numbness of the hands or feet, and/or severe arthritis in limbs. In rare cases, Lyme disease can lead to mortality from complications involving infection of the heart (Public Health Agency of Canada, 2017).

To prevent bites and suppress ticks which may carry the disease, it is recommended to use synthetic insect repellents and wear personal protective gear (long sleeved shirts and pants) on trails or in tall grasses. Homeowners are encouraged to remove fallen leaves which can reduce the abundance of ticks by up to 80% (Foster, 2018). Vegetation control is an effective way to limit population growth, particularly the Japanese Barberry (*Berberis thunbergii*) which provides habitat for mice, the primary reservoir species for Lyme Disease (Williams et al, 2009). In order to adapt to the spread of blacklegged ticks in the Greater Saint John Area, the Chief Medical Officer of Health in New Brunswick intends to provide more funding to Regional Health Authorities. The risk of Lyme disease to residents of the City of Saint John can be reduced through increased collaboration between health authorities for enhanced surveillance, education, and awareness of the disease (Obj.5-31; Government of New Brunswick, 2015).

6.3.2 Mosquitos

Similar to blacklegged ticks, changing climatic conditions allow for the expansion of mosquito populations in urban areas. Mosquitos are a common outdoor pest and while most often the itch of the bite is the outcome, there are transmission risks associated with this species as well. Studies from the United States have shown that increasing temperatures and heavy rainfall are positively related to the distribution of West Nile Virus (Soverow et al, 2009). In Canada, a similar trend can be expected.

In October 2018, three crows were tested positive in the Saint John region for West Nile Virus. This was the first detection since 2003. The Chief Medical Officer of Health reminds the public that the most effective measure to prevent transmission is to protect yourself from mosquito bites (CBC News, 2018). Homeowners can reduce mosquito breeding habitat by removing standing water from their properties. As warmer temperatures begin earlier in the spring and continue later into the fall, the exposure period is lengthened. The Action Register recommends communicating the negative impacts of ticks and mosquitos as an adaptation to reduce any associated health risks (Obj.5-27).

6.4 Air Quality Degradation

The effect of increasing temperatures can accelerate the rate at which chemicals in the atmosphere react and create smog, which will increase the number of smog days in Saint John (Fann et al., 2016). Smog is a lung irritant that can exacerbate existing respiratory conditions like asthma, damage crops, deteriorate rubber, or corrode metal, and painted surfaces (NBDELG, 2018b). Seniors and children are especially vulnerable to acquiring respiratory infections from smog.

Since the introduction of the Clean Air Act in 1997, air quality in New Brunswick has been steadily improving (NBDELG, 2015). The industrial sector in Saint John, includes Canada's largest oil refinery, two pulp and paper mills, a drywall plant, and an electricity generation station, contribute to degrading air quality. Automobile emissions also contribute to poor air quality. Environment Canada's Air Quality Health Index is a tool that can be used to identify when air quality is a health risk for residents (Figure 20). Increased awareness and enhanced communication of the Air Quality Health Index can forewarn residents to reduce their exposure to harmful air (Obj.5-27).

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population	General Population
Low Risk	1 – 3	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate Risk	4 – 6	**Consider** reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High Risk	7 – 10	**Reduce or reschedule** strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider** reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High Risk	Above 10	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce or reschedule** strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

Figure 20: Environment Canada's Air Quality Health Index (Environment Canada, 2017).

Air quality can be significantly impacted by smoke from forest fires and can cause severe respiratory health challenges. Although forest fires are a low risk for Saint John, this smoke can become dispersed in the atmosphere and can impact areas far away from the source (NBDELG, n.d.). The Action Register includes recommendations for the development of a Forest Fire Plan that will focus on prevention and safety as well as the associated health impacts (Obj.4-26).

6.5 Extreme Heat

Dangerously hot temperatures are not something people in Saint John are used to worrying about, but heat waves are becoming increasingly common in Canada. Heat exhaustion and heat stroke (when core temperatures are above 40°C) can cause serious neurological and cardiac conditions. Signs of heat exposure include rashes, cramps, fainting, exhaustion, and the exacerbation of pre-existing conditions (Heath Canada, 2013). Health Canada studies observe that seniors (especially those over 75 years of age) and young children are more susceptible to the negative health impacts of heat exposure. Homelessness or social isolation are conditions which heighten vulnerability to extreme heat. ACAP noted that approximately 19% of the population of Saint John are above the age of 65 and approximately 2% of that population are considered to be low-income individuals. As well, those who work outdoors, such as construction workers, have higher exposure to heat stress. In the coming decades, temperatures will be rising, and residents of Saint John will need to be aware of the health risks associated with extreme heat (Obj.5-27).

Extreme heat is evaluated as a medium risk for the City of Saint John. The Government of New Brunswick has recognized the increasing danger of extreme heat and has prepared a heat alert system based on 3-level humidex scale (Government of New Brunswick, 2016a). Level 1 (heat alert) has a daily humidex of 35-39, Level 2 (high heat alert) has a humidex forecast of 40-44 for one day or longer, and Level 3 (extreme heat alert) has a humidex forecast of greater than 45 over one or more days. The City can adapt to extreme heat in the coming decades through awareness and accessibility of public cooling centres, public water

resources, and enhanced public warning systems that can alert residents to very hot days and safe behaviour (Obj.5-29). As well, the Action Register recommends SJ Energy identifies solutions to deal with increased energy usage during hot days (Obj.8-58). The City should monitor and update the Adaptation Plan as temperatures in the region increase.

Green spaces (urban parks, forests, and wetlands) help to moderate the concentration of heat in cities otherwise known as the urban heat island effect (Warren & Lemmen, 2004). When walking through the City on a summer day, a temperature difference can be felt when walking on a street with mature trees, compared to a street without. During ACAP's street tree inventory, staff noted anecdotally that when working on streets with a higher number of street trees they were more comfortable in the heat, and observed many people sitting outside on stoops, or in their front yard. The total green space in the City is approximately 34% of the land base. Increasing the amount of street trees and green infrastructure will help to moderate increasing temperatures in the City of Saint John. The Action Register recommends integrating low impact development and green infrastructure into community planning to adapt to multiple impacts of Climate Change (Obj.1-7).

6.6 Mental Health Impacts

Flooding, land degradation, coastal erosion, extreme temperatures, and more intense weather events have a range of impacts on residents in Saint John including: relocation or damage of property; loss of personal belongings or livelihood; disruption of networks and services; degradation of cherished natural spaces; food insecurity; or extinction of habitats or species. Any of these impacts would be distressing to individuals and communities. Other triggers, such as reduced income security, heightened costs of goods and services, limited access to basic facilities (energy, water, and communications), a rise in insurance costs, social isolation, and inadequate government response are potential mental stressors to individuals (Fritze et al., 2008). Researchers at the University of New Brunswick in Saint John are investigating the mental health impacts of the 2018 and 2019 Wəlastəkw River spring flooding. Woodhall-Melnick (2019) found that recent flooding events created negative experiences for mental health and well-being and found a need to include mental health into disaster responses. These results may encourage the need for support programs to ensure a positive recovery for the community.

Youth are especially susceptible to negative mental health impacts following a natural disaster or extreme weather event (University of Miami, 2017). Following a Category 2 storm that landed in Texas in September 2008, researchers found that one third of surveyed students aged 7 to 11 had not recovered from PTSD symptoms within a year of the event. Children who experienced stressful evacuations or lacked social support from family or friends following the event recovered poorly. Resources must be made available to support families who are experiencing mental health challenges following a weather event (Obj.5-28).

6.7 Public Health and Safety

Ensuring public health and safety is a priority for the City of Saint John and is recognized as an Objective of this Adaptation Plan (Obj.5: Reduce the impact of Climate Change on human health). Adapting to climate related health concerns at the community level begins with awareness. Moving contaminants out

of flood zones and having an alternate power source (generators or renewables) can ensure safety during floods and extreme weather events. The Action Register also suggests educating residents about alternative technologies and passive systems for back-up support during power outages (Obj.4-22). When enjoying outdoor recreation activities, wearing bug spray and protective clothing can reduce potential health challenges associated with ticks and mosquitos. As tick populations increase, outdoor monitoring for these pests as well as individual monitoring (full body checks) are simple adaptation actions that can protect residents from Lyme disease.

To reduce negative impacts, the Adaptation Plan recommends development of a Municipal Emergency Response Plan and policy that will address the impacts of Climate Change and the role of emergency response personnel during these events (Obj.1-6). As well, the development of a public health and Climate Change communications strategy is recommended to help residents understand how Climate Change can impact their health and how they can avoid negative outcomes (Obj.5-27). These strategies will require collaboration between multiple stakeholders such as residents, City staff and EMO officials, healthcare facilities, and Provincial government departments. In the New Brunswick Climate Change Action Plan, the Province of New Brunswick committed to developing a public health communication strategy, therefore collaboration with the province on this action would be possible (NBDELG, 2016). The public health and Climate Change communication strategy should include public education on:

- Heat stress and reducing risks of exposure during prolonged periods of heat;
- Limiting the abundance of tick host species in urban spaces (i.e. discouraging deer feeding and reducing brush and leaves);
- Recognizing the early symptoms of Lyme disease and preventative actions;
- Reducing mosquito breeding habitats to eliminate threats of vector borne diseases;
- Using air quality indexes to determine air conditions during periods of extreme heat;
- Safe work practices for outdoor businesses and seasonal employees during very hot days; and,
- Proper cleanup procedures after flood events.

Communication of emergency events is critical for ensuring public health and safety. Specifically, the communication of storm surge is a recognized gap in Saint John. The Action Register suggests the development of a communication plan to ensure storm surge warnings are communicated effectively to coastal residents (Obj.7-47). An update of the EMO website is encouraged, as this site is an important tool for communicating the future risks associated with storm surge, sea level rise, and extreme weather events (Obj.4-20). The recommended actions include promotion of residential emergency preparedness kits, which are imperative to ensuring public safety during emergencies (Obj.8-51). For events that may result in a long-term disruption to water infrastructure, it is critical that partnerships are established to ensure the distribution of drinking water (Obj.8-59). All the actions referenced in this Section are significant for ensuring public health and safety in Saint John.

7. Vulnerable Populations

Climate Change affects all demographics of the Saint John community and therefore adaptation planning must have an inclusive approach. It is an objective of this plan to support vulnerable populations and

ensure they are adequately prepared for climate risks (Obj.6: Support vulnerable groups to increase adaptive capacity).

7.1 Poverty, Food Security & Homelessness

High levels of poverty and a lack of affordable housing create unique challenges for adaptation. Poverty rates for priority areas in the city are available in Table 13. These neighbourhoods have varying demographics of age, gender, ethnicity, religion, and mental and physical ability. Low-income and single-parent families in Saint John have the second highest rate of poverty in Canada after Charlotte County, New Brunswick. According to the Saint John Human Development Council and Statistics Canada, the median income of single-parent families in Saint John is 55% less than the median family income (Statistics Canada, 2017; Human Development Council, 2014). The priority neighbourhoods identified in Table 13 are also areas identified as high risk to sea level rise and inland flooding, meaning the most vulnerable are also the most at risk. The City can utilize this information to prepare specific evacuation plans to ensure safety and assist residents during emergency events (Obj.6-38).

Table 13: Poverty rates for priority neighbourhoods in Saint John (Asher & Mackinnon, 2008).

Priority Neighbourhood	Percentage of People Living in Poverty
Waterloo Village	56.1%
The South End	37.5%
Crescent Valley	61.6%
Old North End	46.8%
Lower West Side	31.5%

Communicating risk and creating awareness in these neighbourhoods is critical to ensuring safety. Limited access to the internet can be problematic for these groups since webpage alerts and social media posts are often used to communicate emergency warnings. The Action Register recommends distributing a survey to determine the most effective means of communication within vulnerable groups (Obj.6-35). Other socio-economic challenges within these areas that heighten the severity of emergency situations include:

- The lack of resources available to prepare for climate events;
- Limited support to upgrade homes or relocate to a safer area;
- Poor quality housing predisposed to damage from flooding;
- Dependency on government assistance and insurance programs for home repairs which can take a long time to be addressed; and,
- Limited access to legal services including insurance.

To reduce the vulnerability of these groups, this plan recommends developing a public health and communication plan that will present climate risks and impacts (Obj.5-27). The messaging should be conscious that the priorities of these families may not be mitigation and adaptation. Creating relatable messaging that focuses on educating residents with plain language and answering questions is important

to engage and entice action. Encouraging small goals is important to refrain from overwhelming these groups with actions that may seem impossible.

7.1.1 Poverty: Seniors and Youth

Senior and youth poverty is a significant issue for Saint John as these demographics are highly vulnerable to Climate Change. Child poverty rates in the City are 10% higher than the Census Metropolitan Area (CMA) and the province, while poverty among seniors in the City is higher than the CMA but less than the provincial rate (Figure 21; Human Development Council, 2018). Financial challenges worsen the situation for these groups, who are more susceptible to climate impacts even in financially secure situations.

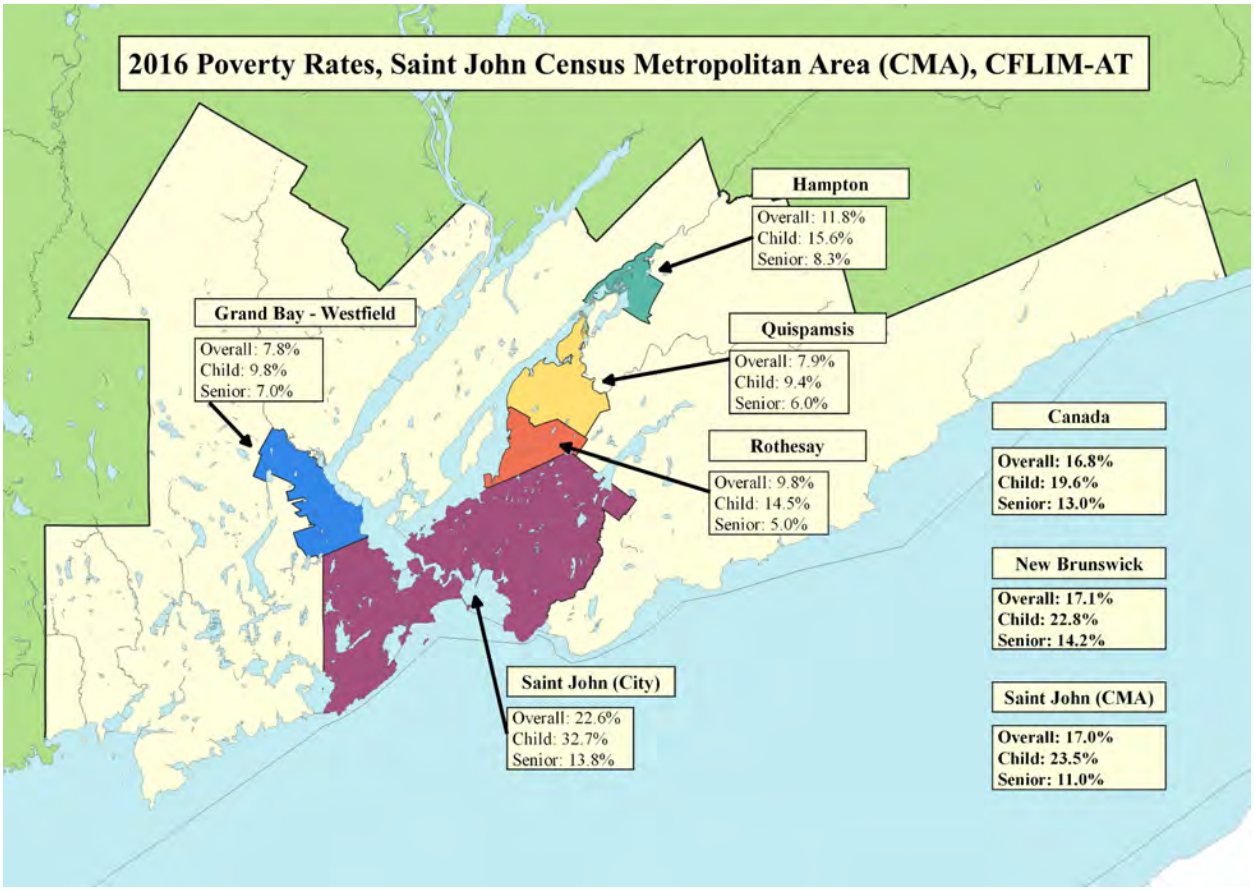

Figure 21: Poverty rates in the City of Saint John and Census Metropolitan Area which includes communities outside of the City (Human Development Council, 2018).

Seniors (65+) may be less likely to leave their home during an emergency as a result of limited mobility, dependency on medical services, and fear of looting or property damage. Isolation of these residents during extreme weather can lead to degrading health conditions and even death. Health Canada has found that seniors are more susceptible to heat stress and the negative health impacts of poor air quality that can be induced by Climate Change (Health Canada, 2013). Checking in on elderly neighbours and family members during extremely hot or cold periods is a critical action that can reduce vulnerability and save lives.

Young children, like seniors, are more susceptible to the health risks of extreme heat and flooding (Health Canada, 2013). Based on their stage of physical development and maturity of their immune system, children can be highly sensitive to illness or disease. During flood events, a lack of understanding about floodwater contamination increases the chances of contracting illnesses from ingestion of water. As well, lower capacity to regulate body temperatures will put children at risk of hypothermia (World Health Organization, 2018; Séguin, 2008).

7.1.2 Food Security

In priority neighbourhoods food security can be compromised during and after extreme weather events. Statistics show that New Brunswick has one of the highest rates of children living in food insecure households, creating more challenges for Climate Change adaptation (Figure 22).

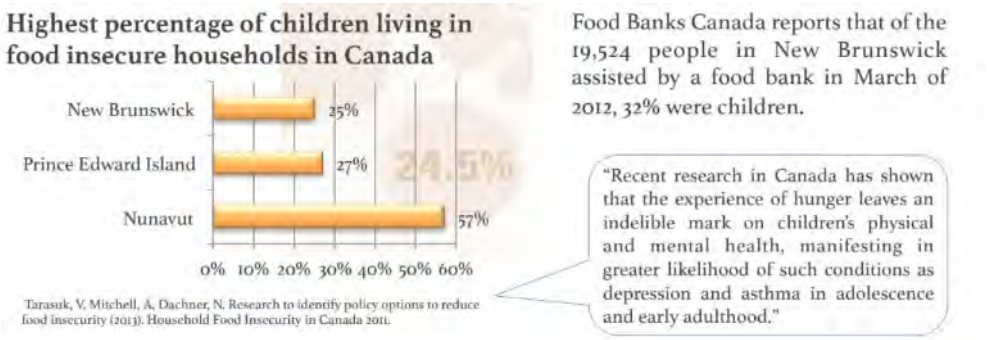

Figure 22: Percentage of children living in food insecure households in Canada, with New Brunswick having one of the highest rates of childhood food insecurity in Canada (Saint John Human Development Council, 2014).

To reduce food insecurity, community gardens are accessible in priority areas. In Saint John, these gardens have been successful for residents. Some gardens, such as the Crescent Valley Community Garden have designated plots to provide fresh produce to food banks in the area. Food banks are a useful resource serving over 3,000 individuals a month in 2016 (Human Development Council, 2017). Recommendations to increase community resilience and improve food security are included in the Action Register (Obj.7-50 and Obj.6-39). Providing educational workshops on topics such as gardening and creative meal preparation can help residents to benefit from community gardens.

7.1.3 Homelessness

Poverty, low average income, and food security are issues that directly impact homelessness in Saint John. This population is highly vulnerable due to a limited capacity to reduce exposure to the impacts of Climate Change. For instance, being homeless can mean higher exposure to heat stress without access to cooling options during heat waves (Health Canada, 2013). The Human Development Council (HDC) is actively working to find shelters and advocate for affordable housing to reduce the homeless population. To increase the adaptive capacity of these individuals, recommendations from the Action Register include coordination between EMO and HDC to ensure homeless residents are accounted for in emergency situations (Obj.6-37). As well, evaluation of shelter capacity and resources will help to determine where support is needed throughout the City (Obj.6-36). These actions combined with public education will help reduce vulnerability of these groups. Community groups such as the Waterloo Village Association, People

United of the Lower South End (P.U.L.S.E.), Outflow, and the Community Council on Homelessness (CCH), that support at-risk or homeless populations should be consulted to participate in the recommended actions.

7.2 Medical Conditions

There are many cases where a pre-existing medical condition can be exacerbated by Climate Change impacts such as flood conditions, degraded air quality, extreme weather events, or by being unable to access regular medical care (Health Canada, 2013; Burton et al., 2016). Pre-existing medical conditions can include asthma, malnutrition, cardiovascular or respiratory illness, organ diseases and physical disabilities (limited mobility, hearing or sight), to name a few. Pregnant women are amongst the most vulnerable to flooding, extreme heat, and other climate-related events in Canada and may require additional assistance (Burton et al., 2016).

Currently, SJ Energy has a priority customer list and coordinates with EMO to ensure power is restored based on a priority basis. The Action Register recommends creating a voluntary signup for individuals who require electricity to run healthcare equipment as well as those who may need assisted evacuation (Obj.8-52). For this recommendation to be effective, collaboration between healthcare providers, community centers, EMO, and residents is necessary. Education around Climate Change impacts is also significant for these groups who may be isolated and unaware of their vulnerability (Obj.4).

7.3 Newcomers

The City of Saint John is home to a wide variety of first languages from all over the world. Approximately 4,075 immigrants, primarily from Europe, Asia, and the Americas live in the City. Of this population, 3,410 people have a mother tongue other than English or French and 640 people have no knowledge of these two official languages (Statistics Canada, 2017). These newcomer groups are vulnerable to Climate Change impacts due to the language barrier which limits their understanding of early warning systems and critical safety information (Burton et al., 2016). Syrian immigrants who arrived in the City in 2017 have expressed frustration over the quality and availability of interpretive services in Saint John (Figure 23; Chandler, 2017). Proficient interpretation services are vital for newcomers in Saint John to understand climate risk and emergency response procedures. To increase the resilience of newcomer groups, the Adaptation Plan recommends distribution of a survey to determine the best way to communicate warnings to vulnerable groups (Obj.6-35). This action will ensure that newcomers are consulted and informed about Climate Change impacts.

Figure 23: Syrian refugees raising awareness for the need for better interpreting services in the City of Saint John (Bingley, 2017).

7.4 First Nations

Approximately two percent of people that identify as First Nations in Canada, (16,123 First Nations and Métis people), live in New Brunswick (Statistics Canada, 2016). Maliseet communities, including Oromocto, Kingsclear, St. Mary's, Brothers Islands, and Mi'gmaq in Fort Folly are the nearest First Nations communities to the City of Saint John. According to Statistics Canada, 1,430 people have First Nations identity in Saint John, however there are many First Nation residents who are considered non-status (Statistics Canada, 2016). The New Brunswick Aboriginal Peoples Council found that non-status First Nations People nearly doubles the census of Aboriginal population by Statistics Canada (New Brunswick Aboriginal Peoples Council, n.d.).

Many First Nations communities in Canada face increased sensitivity from pre-existing ecological and socio-economic risk. In Canada, 73% of First Nations water systems are already at risk of contamination (Lui, 2014). Living in flood-prone and ecologically sensitive areas heightens the vulnerability of these communities to further contamination resulting from increased severity and frequency of flooding (Burton et al., 2016). Factors such as education, employment and living situation (on reserve or off reserve) will impact the ability of First Nations groups to respond to the impacts of Climate Change. This Adaptation Plan recommends consultation with First Nations groups to discuss climate impacts and explore Climate Change challenges and solutions (Obj.6-40).

8. Adaptation as an Opportunity

Climate Change adaptation can be seen as an opportunity for municipalities by taking advantage of the numerous co-benefits that occur. Many of the Action Register items will not only help Saint John adapt to Climate Change but also support the goals identified in municipal planning documents. Specifically, adaptation planning can assist in achieving the Plan SJ goals for creating a sustainable future (Figure 24). As plans are updated, Climate Change adaptation should be incorporated to ensure the City can take advantage of the co-benefits to improve environmental, social, and economic well-being of the City.

Figure 24: Plan SJ goals for "Sustainable Futures" (City of Saint John, 2011).

8.1 Cost Savings

From an economic perspective, Climate Change adaptation is an opportunity for municipalities to reduce the future costs associated with extreme weather events. The development of proactive infrastructure can result in long term cost savings for the City and its residents. Studies in Canada found that **for each dollar invested into adaptation, an estimated $9 to $38 can be avoided in future damages** (District of North Vancouver, 2017). The City of Saint John can expect severe economic costs if no adaptation occurs.

Improved stormwater management is recognized as a priority in Plan SJ, to protect City assets and growth, especially considering the recent storms and flooding events that have significantly impacted low-lying areas. Without adaptation, Climate Change is expected to cost Canadians $5 billion per year by 2020 and $21-$43 billion per year by 2050, which will largely be from flooding (Simon Fraser University, 2015). Although adaptation will be expensive for Saint John, the long-term investment is worthwhile. Acknowledging the co-benefits of adaptation actions can be helpful when securing funding and developing partnerships.

8.2 Green Community Planning

The adoption of the Climate Change Adaptation Plan is an opportunity for the City of Saint John to integrate sustainability into the development of community plans. These plans should include priority areas of economic, environmental, social, and cultural sustainability while also providing suggestions for the implementation of green infrastructure (Obj.1-5). The Central Peninsula Neighbourhood Plan, completed in January 2020, includes recommendations to increase greenery, prepare for the impacts of Climate Change, remediate environmentally contaminated properties and to realize the full potential of existing parks and open space networks (City of Saint John, 2018d). As the City works to complete the North End and Lower West Side Neighbourhood Plans, the action items from the Adaptation Plan can be integrated to create a healthy and sustainable community.

Green development has many co-benefits including the reduction of GHG emissions, improvements to air quality, enhanced stormwater management, urban cooling and energy savings, protection of biodiversity, and improvement of mental and physical health (Simon Fraser University, 2017). Adaptation recommendations for Saint John include development of green infrastructure in high risk flood areas (Obj.1-7 and Obj.4-25).

Green infrastructure such as green roofs, bioswales, and rain gardens can be installed to capture, store, and filter stormwater before it re-enters natural water bodies (Simon Fraser University, 2016). Protection of existing natural infrastructure like wetlands near Golden Grove Road and Glen Falls will reduce the risks of flash flooding. Conserving open green spaces will increase the City's stormwater runoff capacity, which will be increasingly burdened by higher annual precipitation levels. There are numerous benefits of green development that can help the City in achieving both Climate Change adaptation and mitigation goals.

8.3 Public Adaptation Opportunities

At the individual level, there are many opportunities for the public to adapt to Climate Change. The Action Register recommends education programs around emergency preparedness to reduce the negative impacts during and after storm events (Obj.4-23). The Action Register also includes a recommendation for the development of an online database for public information on adaptation including weather observations, local erosion, and adaptation feedback (Obj.4-24). When residents are aware of the risks and know how to respond to a hazardous situation, they can plan appropriately to keep themselves and their families safe. As extreme weather events become more frequently experienced, residents can develop communication networks throughout the community to check on neighbours, ultimately building community strength. This is a simple adaptation action that has a huge impact.

In coastal areas, residents can protect existing riparian buffers by monitoring invasive species and planting native vegetation. These actions will reduce the risk of land loss and property damage associated with sea level rise. For neighbourhoods experiencing flooding as a result of increased precipitation, ACAP promotes installation of water retention and storage devices to reduce property damage. These devices can include rain gardens, which will collect rainfall and increase natural infiltration, or rain barrels that capture runoff from rooftops. The water collected in rain barrels can be used for watering gardens and indoor plants,

washing vehicles and other outdoor cleaning. Setting up these devices will help Saint John residents adapt to increasing rainfall and conserve freshwater.

8.4 First Nations Engagement

ACAP Saint John respectfully acknowledges that this work is taking place on the unceded territory of the Wolastoqey and Mi'gmaq Peoples. First Nations communities adjacent to the City of Saint John have unique knowledge about the historical and contemporary relationship with the land and water. This perspective is necessary to strengthen the health and well-being of the City as the environment changes. In 2016, the 58th Legislative Assembly of New Brunswick's Select Committee on Climate Change reported significant changes to wildlife, plant species, traditional medicines, and waterways that "impact the culture and way of life for many First Nations Communities" (Government of New Brunswick, 2016b).

Many formalized documents have been prepared to ensure the active involvement of First Nations in decision-making. Specifically, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) details rights regarding traditionally owned, occupied, taken, or otherwise used lands and waters (United Nations, 2008). As the Climate Changes, the City of Saint John has an opportunity to engage with the adjacent communities to develop inclusive and thoughtful adaptation strategies (Obj.6-40). The Assessment of Modern Treaty Implications (AMTI) is a tool developed by the Government of Canada for assessing the impacts of government initiatives on the governance, employment, and resource management of Modern Treaty Areas. This tool may be useful for the City Council during implementation of the Adaptation Plan and can be found online: https://www.canada.ca/en/treasury-board-secretariat/services/treasury-board-submissions/guidance/assessment-modern-treaty-implications-appendix.html

9.0 Monitoring and Review

Implementation and review of the Adaptation Plan will fall to the City of Saint John. The process of monitoring and review is necessary to ensure the Adaptation Plan is working to benefit the City and reduce the negative impacts associated with Climate Change. The Action Register recommends the City establish an interdepartmental Climate Change Adaptation Committee (Climate Committee) to participate in decision making and ensure actions from the City of Saint John's Climate Change Adaptation Plan are being implemented (Obj.1-4). The Climate Committee will ensure that the Adaptation Plan will be updated with the best available science and best management practices.

9.1 Implementation Monitoring

The Action Register (Appendix F) describes detailed actions that support the eight objectives identified by ACAP Saint John. By identifying the lead department/partners, timeframe and priority level, the Action Register will guide the implementation of the adaptation actions. As the recommended actions are implemented, monitoring will allow the Climate Committee to review progress and identify challenges and successes. Tracking the process of implementation will also ensure that the underlying information of the Adaptation Plan (climate science and the Risk and Vulnerability Assessment) is up to date and that actions are being completed as scheduled.

The City can also monitor the effectiveness of the recommended actions to verify if the anticipated outcome is being achieved. If the actions are not increasing adaptive capacity, they should be re-evaluated and updated in the Annual Update Report (Section 9.2). Throughout the monitoring process, the Climate Committee can explore funding opportunities that might become available as adaptation becomes mainstreamed into municipal planning.

9.2 Updating the Adaptation Plan

The Climate Committee should produce an Annual Update Report for the plan. This report will summarize the findings from implementation monitoring (Section 9.1) and inform City Council about socio-economic changes that may influence the success of recommended actions, including changes to financial status and shifts in the identified vulnerabilities. Completed items from the Action Register will be identified and celebrated in this Update Report.

The checklist below is useful for drafting the Annual Update Report of the Adaptation Plan:

- Identify accomplishments and on-going work.
- Reaffirm the commitment of the Climate Committee.
- Highlight a list of actions that were not successfully implemented. Identify the barriers that exist and evaluate if current conditions will allow implementation now.
- Review the Action Objectives. Are they still relevant? Which objectives are more easily implemented?
- Once the high-risk actions are complete, the Climate Committee can begin to address lower risk actions.

A full comprehensive review of the Adaptation Plan is scheduled for 2030 (ten years after adoption). As municipal planning documents are updated, the adaptation actions should be integrated. This will help identify opportunities and increase the likelihood of actions being completed.

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Glossary

Adaptation
Initiatives and measures that reduce the vulnerability of human and natural systems to actual or anticipated Climate Change effects.

Climate
The average weather measured by the statistical description of mean variability of wind, precipitation, temperatures, etc. over a period ranging from months to thousands or millions of years.

Climate Change
The long-term changes in climate variables, such as precipitation, temperature, sea level, lake levels, and changes in the frequency and intensity of extreme weather events.

Coastal Erosion
The process of removal and transport of soil and/or rock from shorelines as a result of weathering by streams, glaciers, waves, or high winds.

Coastal Squeeze
A form of coastal habitat loss, where intertidal habitats such as salt marshes, mudflats, or sand dunes are lost or deteriorated due to high water levels. In response to sea level rise, defence structures (i.e. a sea wall) can prevent the inward migration of land.

Extreme Weather Event
An event that is rare compared to statistical reference distribution at a particular place, normally considered as rare or rarer than the 10th or 90th percentile, whereas extreme climate events are an average number of weather events over a certain period of time (e.g. seasonal rainfall).

Flash Flood
A flood in which warning time is extremely limited, that can be caused by hurricanes, violent storms, or dams breaking.

Flood
A significant rise of water level in a stream, lake, reservoir or a coastal region from excessive rain, severe storms, rapid snow or ice melt, blocked watercourses, failure of dams, land subsidence, or storm surges that inundates natural or built landscapes within city boundaries.

Greenhouse Gas (GHG)
Compounds that can absorb infrared radiation and trap heat in the atmosphere, contributing to The Greenhouse Effect.

Green Infrastructure
Development that utilizes and promotes the benefits of ecosystem services including stormwater management, water filtration, carbon storage, enhanced biodiversity, and community well-being.

Grey Infrastructure
Engineering and building projects that are made from concrete and/or steel and are typically impervious in urban settings.

Harmful Algal Blooms (HABs)
Occur when colonies of algae grow to produce toxic or harmful effects on people, fish, shellfish, marine mammals, and birds.

Higher High Water Large Tide (HHWLT)
A representation of the storm surge impacts associated with the moon cycle on the high tide. It is determined by taking the average of highest predicted water levels over a 19-year period.

Intensity-Duration-Frequency (IDF)
A graphical representation (curve) of the probability (frequency) a given depth of rainfall will occur, shown in rainfall intensity (e.g. millimeters per hour) and duration (e.g. in hours).

Low Impact Development (LID)
A land planning and engineering approach to manage stormwater runoff using green infrastructure or natural processes.

Light Detection and Ranging (LiDAR)
Technology that allows researchers to accurately measure and record land elevations and topographic features through the emission of laser pulses towards the earth's surface from an aircraft that measures the return time of the pulse - a useful technology for creating accurate flood hazard maps.

Lower Low Water Large Tide (LLWLT)
Average of lowest predicted water levels of tidal zones.

Resilience
The capacity of a system, community, or society exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure.

Risk Assessment
A function of the likelihood and consequence of a Climate Change impact - the sum of all consequences is totaled to assess impact, then multiplied by its likelihood of occurring to obtain a risk rating.

Sea Level Rise
Increase in mean sea level resulting from alterations in ocean volume due to local land movements and melting Arctic and Antarctic glaciers.

Service Areas
Areas in which a government or community manages, plans, or makes policies which affect the services or activities within a city's built, natural, and social systems.

Storm Surge
A localized, temporary excess in sea level height compared to normal tidal variations from severe weather conditions.

Stormwater Runoff
Water from precipitation or snowmelt that flows across the landscape and is not stored or taken up by plants. This can be rain, melting snow, or ice that washes off hard surfaces.

Urban Heat Island (UHI) Effect
The warming effect of built urban spaces on air temperature in comparison to surrounding rural areas.

Vector-Borne Diseases
An insect or living carrier that transmits a disease to a susceptible individual.

Vulnerability
The likelihood of a system suffering an adverse impact of a hazard, which is shaped by a population's or service area's capacity to anticipate, cope, resist, or recover from the impact of a natural hazard.

Vulnerability Assessment
Evaluation of human, natural, and built system sensitivities to Climate Change and the coping capacity of the system to respond to it.

Water-Borne Diseases
Morbidity caused microorganisms, biotoxins, and toxic contaminants that can lead to illnesses like cholera, schistosomiasis, or gastrointestinal illnesses that often occur after severe precipitation or flooding events.

Water Security
The capacity of a city to safeguard sustainable access to adequate urban water quality and availability.

Watershed
An area delineated topographically were all precipitation drains to one point or outlet.

Weather
The fluctuating state of clouds, wind, temperature, and precipitation that forms the atmosphere around us.

Zoonotic Diseases
Any disease or infection that is naturally transmissible from animals to humans, that may be bacterial, viral, or parasitic.

List of Acronyms

AR5	IPCC Fifth Assessment Report
AMTI	Assessment of Modern Treaty Implications
DEMs	Digital Elevation Models
DFAA	Disaster Financial Assistance Arrangement
EMO	Saint John Emergency Measures Organization
GHG	Greenhouse Gas
HABs	Harmful Algal Blooms
HHWLT	Higher High Water Large Tide
ICELI	International Council for Local Environmental Initiatives
IDF	Intensity-Duration-Frequency
IPCC	Intergovernmental Panel on Climate Change
LID	Low Impact Development
LiDAR	Light Detection and Ranging
LLWLT	Lower Low Water Large Tide
NB EMO	New Brunswick Emergency Measures Organization
UHI	Urban Heat Island

Appendix A. Coastal Hazard Flood Risk Mapping

Figure 25: Coastal hazard flood map showing flooding levels in the Central Peninsula, Saint John, NB.

Figure 26: Coastal hazard flood map showing flooding levels in the North End, Saint John, NB.

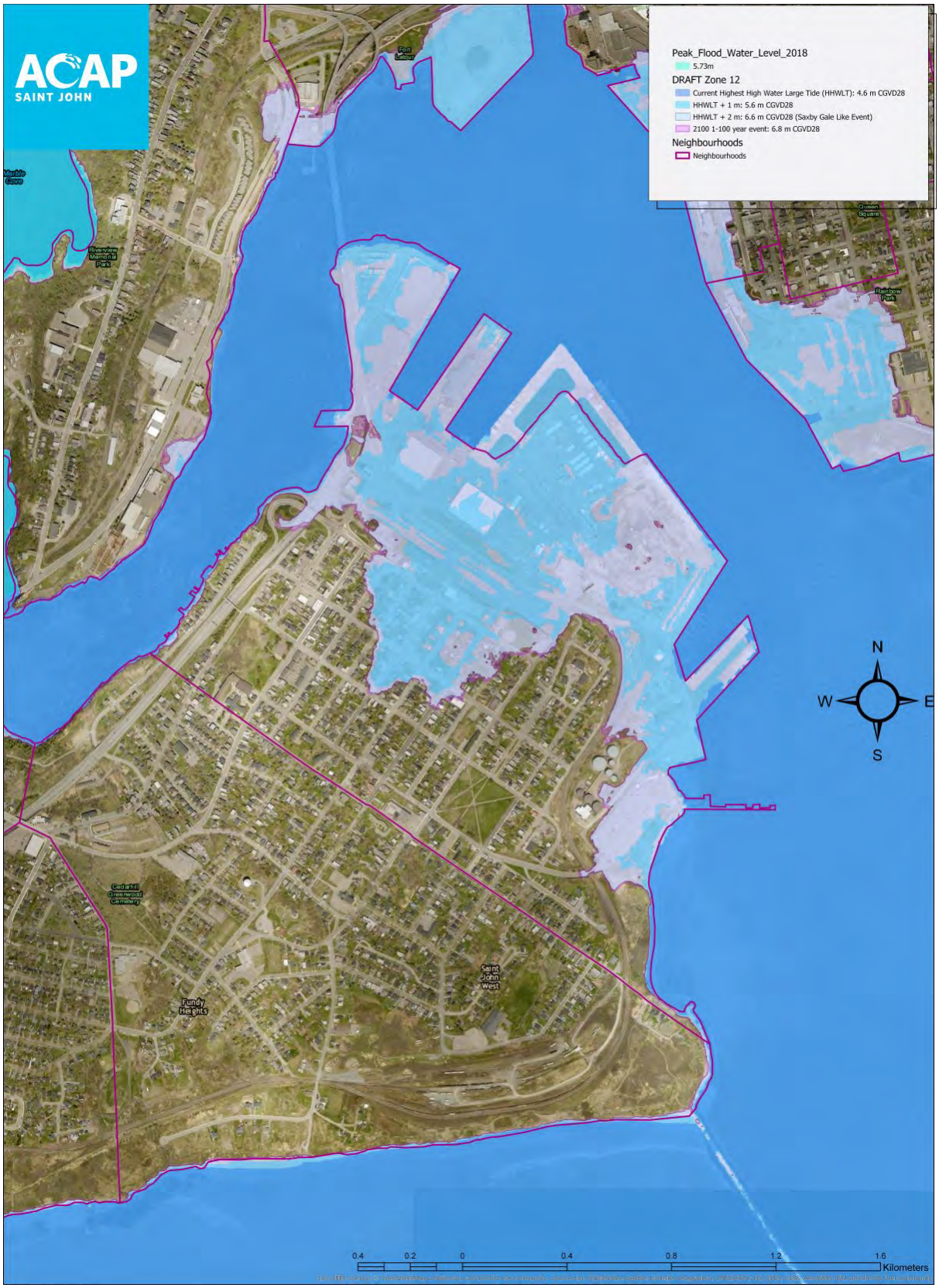

Figure 27: Coastal hazard flood map showing flooding levels in the Lower-West Side, Saint John, NB.

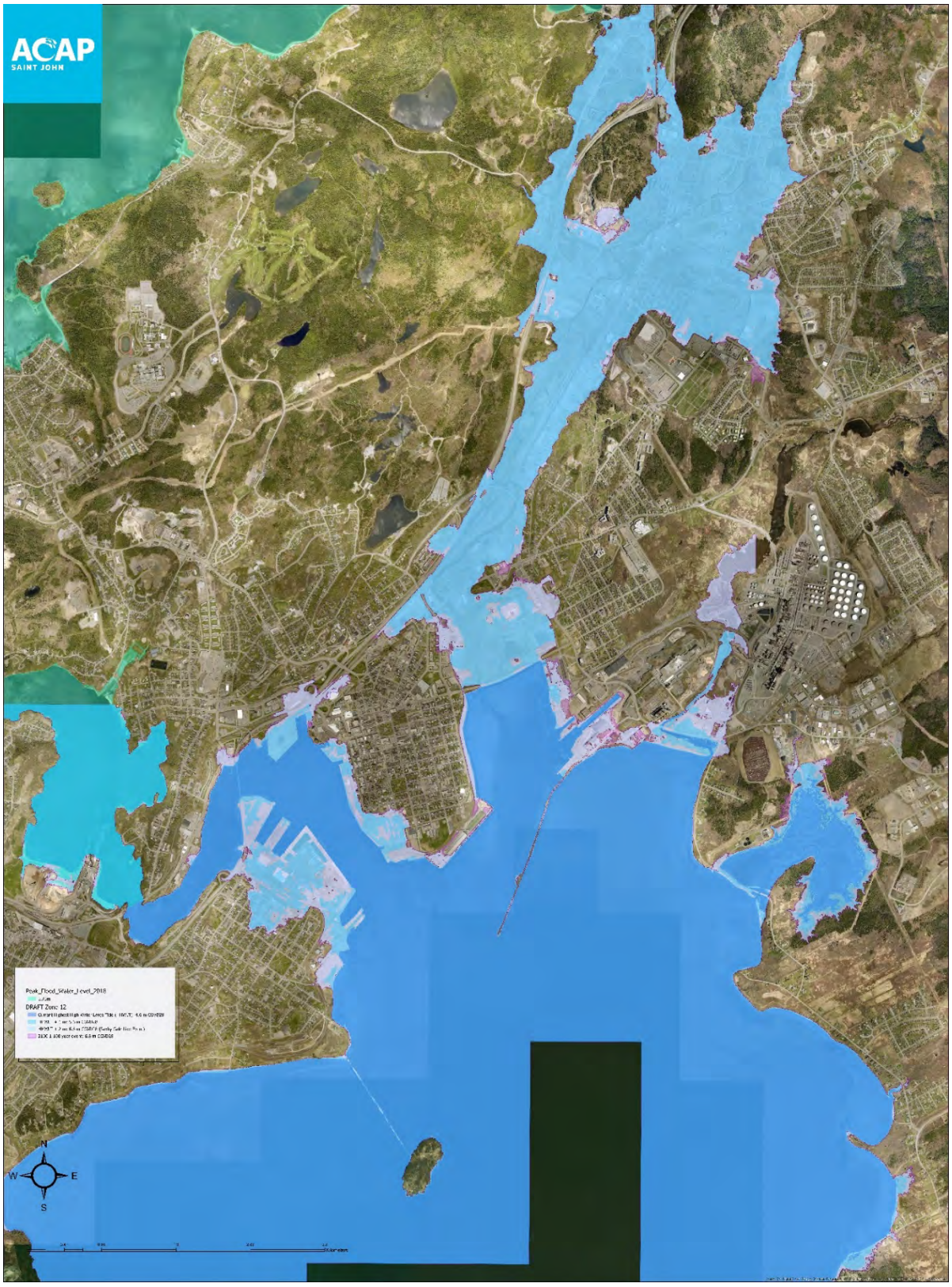

Figure 28: Coastal hazard flood map showing flooding levels in the East, Central and Lower-West neighbourhoods of the City of Saint John.

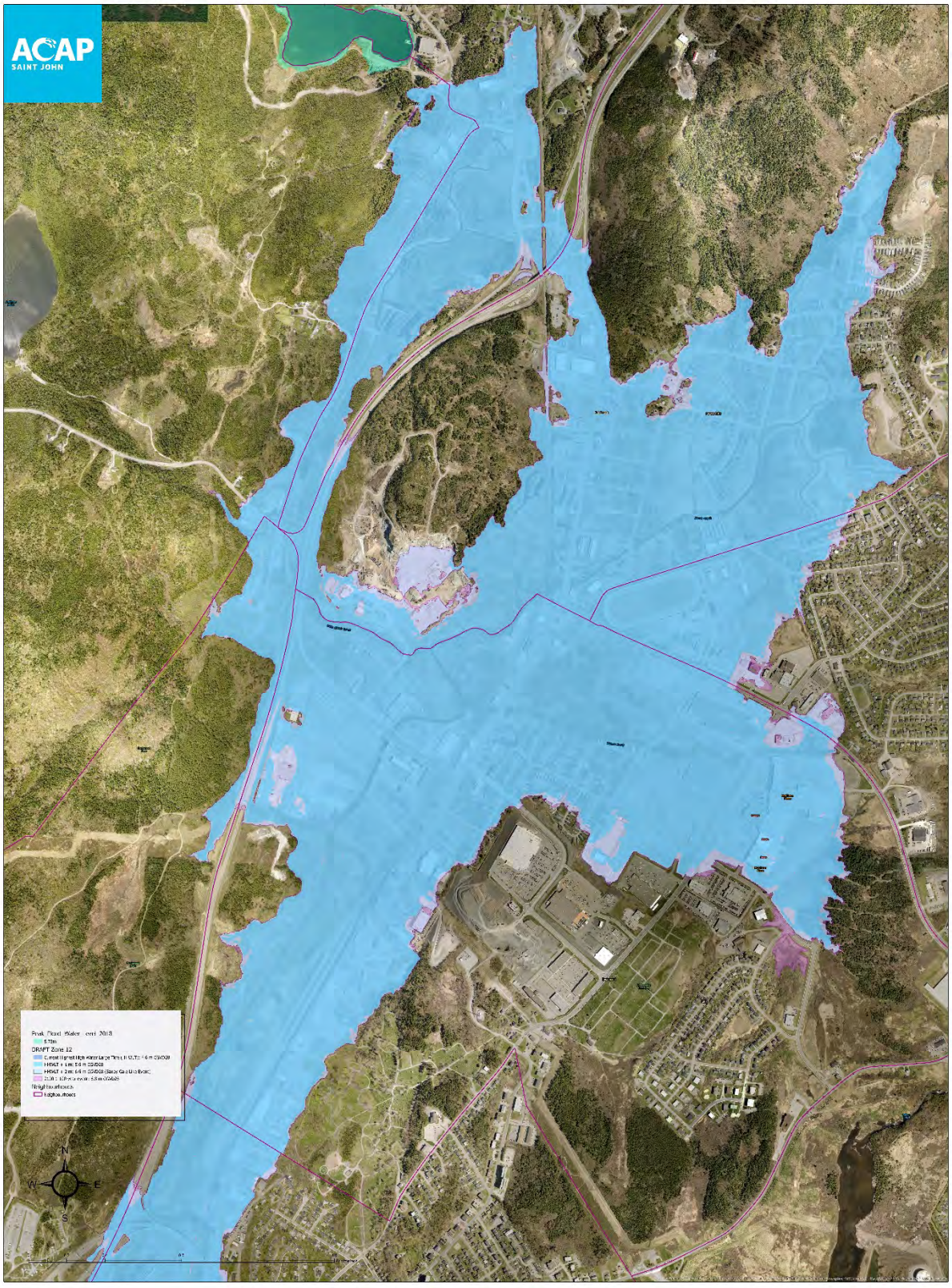

Figure 29: Coastal hazard flood map showing flooding levels in the East Side, Saint John, NB.

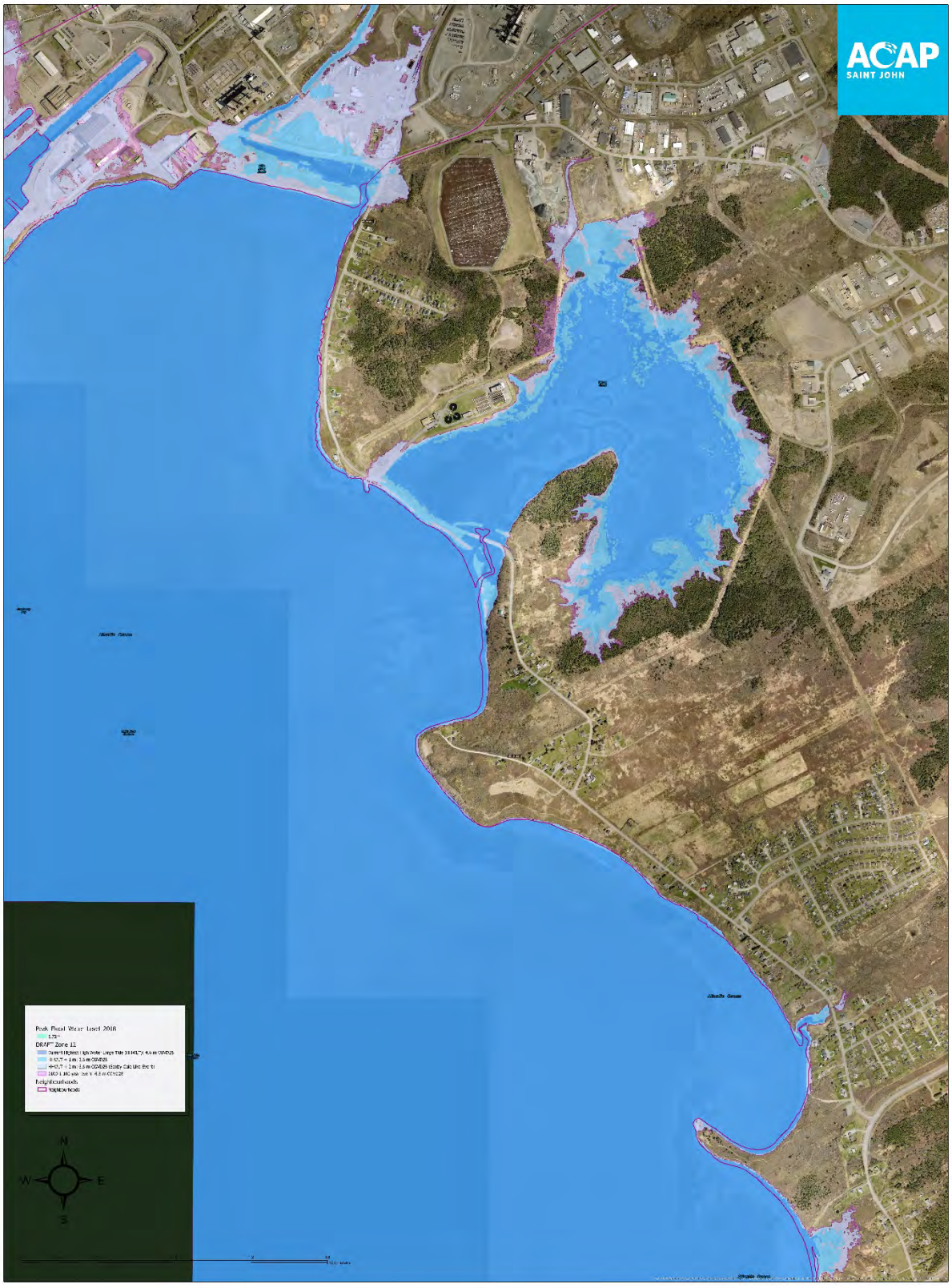

Figure 30: Coastal hazard flood map showing flooding levels in Red Head, Saint John, NB.

Figure 31: Coastal hazard flood map showing flooding levels in the West Side and Saint Rest's Marsh, Saint John, NB.

Appendix B. Emergency Routes and Control Points Sites at Risk of Coastal Flooding

Table 14: Emergency routes at risk of coastal flooding during the highest high water large tide in 2010.

Sea Level Rise HHWLT (4.6m) Risks (Highly Probable in 2010)						
Road	**Sections**	**Length (m)**	**Length (km)**	**Maintained By***	**Alternate Route Available (Y/N)**	**Comments**
Bayside Drive	1	652	0.65	CSJ/Private	Y	
Digby Ferry Road	1	49	0.05	CSJ/Private	N	Part of ferry terminal
Lorneville Road	2	1465	1.47	CSJ	N	Residents in between two flooded sections could become stranded
Red Head Road	1	2163	2.16	CSJ	Y	
Saint John Throughway	4	7114	7.11	DOT	Y	Alternate route but this blocks off a main transportation route
5	**9**	**11443**	**11.44**	**Total**	N= 40%	
* CSJ= City of Saint John DOT= Department of Transportation						

Table 15: Emergency routes at risk of coastal flooding after one meter of projected sea level rise.

Sea Level Rise HHWLT + 1 m (5.6m) Risk Events (1-2% probability in 2010, 20-50% probability in 2050, 50-100% probability in 2100						
Road	**Sections**	**Length (m)**	**Length (km)**	**Maintained By***	**Alternate Route Available (Y/N)**	**Comments**
Ashburn Road	1	145	0.15	CSJ	N	Residents/Businesses in Drury Cove could become stranded
Ashburn Lake Road	7	1753	1.75	CSJ/DOT	N	Rothesay Avenue and Mackay Highway also flooded
Bayside Drive	3	874	0.87	CSJ/Private	Y	
Brinley Street	1	108	0.11	CSJ	Y	
Broad Street	1	142	0.14	CSJ	Y	
Broadway Avenue	2	271	0.27	CSJ	N	Rothesay Avenue and Simpson Drive also flooded
City Road	16	926	0.93	CSJ	Y	
Consumer Drive	1	430	0.43	CSJ	Y	
Courtenay Bay Causeway	3	1255	1.26	CSJ	Y	Raising Causeway could reduce flooding upstream in Rothesay Ave area
Crowne Street	4	207	0.21	CSJ	Y	
Digby Ferry Road	1	49	0.05	CSJ/Private	N	Part of Ferry terminal
Drury Cove Road	3	564	0.56	CSJ	N	Residents/Businesses in Drury Cove could become stranded
Foster Thurston Drive	1	2412	2.41	CSJ	Y	
Gilbert Street	1	374	0.37	CSJ	Y	
Glen Road	5	647	0.65	CSJ/Private	N	Residents in Glenview Drive Mini home park could become stranded
Golden Grove Road	6	1197	1.20	CSJ	Y	

Haymarket Square	2	109	0.11	CSJ	Y	
Lorneville Road	2	1465	1.46	CSJ	N	Residents in between two flooded sections could become stranded
Lower Cove Loop	2	282	0.28	CSJ	Y	
Market Place	7	634	0.63	CSJ	Y	
McAllister Drive	9	2235	2.23	CSJ	Y	
Red Head Road	3	2598	2.60	CSJ	Y	
Rothesay Avenue	36	6857	6.86	CSJ	N	
Russell Street	2	410	0.41	CSJ	Y	
Saint John Throughway	32	21355	21.36	DOT	N	
Simpson Drive	7	876	0.88	CSJ	N	Flooding on Golden Grove and Broadway Drive
Thorne Avenue	3	325	0.33	CSJ	Y	
Water Street	3	642	0.64	CSJ	Y	
Waterloo Street	1	72	0.07	CSJ	Y	
Westmorland Road	2	1005	1.01	CSJ	Y	
30	**167**	**50217**	**50.22**	**Total**	N= 33%	
* CSJ= City of Saint John DOT= Department of Transportation						

Table 16: Emergency routes at risk of coastal flooding after 2.2 meters of projected sea level rise, representing a 1 in 100-year storm in 2100.

Sea Level Rise 2100 1-100 (6.8m) Risks (1% possibility in 2100)						
Road	**Sections**	**Length (m)**	**Length (km)**	**Maintained By***	**Alternate Route Available (Y/N)**	**Comments**
Ashburn Road	1	145	0.15	CSJ	N	Residents/Businesses in Drury Cove could become stranded
Ashburn Lake Road	7	1753	1.75	CSJ/DOT	N	Rothesay Avenue and Mackay Highway also flooded
Bayside Drive	7	1885	1.89	CSJ/Private	Y	
Brinley Street	1	108	0.11	CSJ	Y	
Broad Street	1	142	0.14	CSJ	Y	
Broadway Avenue	2	271	0.27	CSJ	N	Rothesay Avenue and Simpson Drive also flooded
Chesley Drive	8	886	0.89	CSJ	Y	
City Road	16	926	0.93	CSJ	Y	
Consumers Drive	2	548	0.55	CSJ	Y	
Courtenay Bay Causeway	5	1437	1.44	CSJ	Y	Raising Causeway could reduce flooding upstream in Rothesay Ave area
Crown Street	11	657	0.66	CSJ	Y	
Digby Ferry Road	4	490	0.49	CSJ/Private	N	Digby Ferry terminal
Drury Cove Road	3	564	0.56	CSJ	N	Residents/Businesses in Drury Cove could become stranded
Foster Thurston Drive	1	2412	2.41	CSJ	Y	
Gilbert Street	1	374	0.37	CSJ	Y	
Glen Road	5	647	0.65	CSJ/Private	N	Residents in Glenview Drive Mini home park could become stranded
Golden Grove Road	6	1197	1.20	CSJ	Y	

Haymarket Square	5	209	0.21	CSJ	Y	
Hilyard Street	1	374	0.37	CSJ	Y	
Lorneville Road	3	1718	1.72	CSJ	N	Residents in between two flooded sections could become stranded
Lower Cove Loop	2	283	0.28	CSJ	Y	
Main Street	1	151	0.15	CSJ	Y	
Market Place	7	634	0.63	CSJ/DOT	Y	
McAllister Drive	9	2235	2.23	CSJ	Y	
Mount Pleasant Avenue	4	168	0.17	CSJ/DOT (ramp)	Y	
Paradise Row	5	563	0.56	CSJ	Y	
Red Head Road	4	2837	2.84	CSJ	N	Residents in between two flooded sections (Hazen Creek & Beyea Brook) could become stranded
Rothesay Road/Avenue	36	6857	6.86	CSJ	Y	
Russell Street	3	506	0.51	CSJ	Y	
Saint John Throughway	64	31036	31.04	DOT	N	
Simpson Drive	8	912	0.91	CSJ	N	Flooding on Golden Grove and Broadway Drive
Station Street	1	319	0.32	CSJ	Y	
Thorne Avenue	5	670	0.67	CSJ	Y	
Water Street	6	774	0.77	CSJ	Y	
Waterloo Street	1	72	0.07	CSJ	Y	
Westmorland Road	2	1005	1.01	CSJ	Y	
36	**248**	**65762**	**66**	**Total**	N= 27%	
* CSJ= City of Saint John DOT= Department of Transportation						

Emergency Control Points at Risk

No control points were impacted during the highest high water large tide in 2010 (HHWLT: 4.6m).

Table 17: Emergency control points of coastal flooding after one meter of projected sea level rise.

Sea Level Rise HHWLT + 1 m (5.6m) Risk Events (1-2% probability in 2010, 20-50% probability in 2050, 50-100% probability in 2100		
Type	Name	Location
Intersection	Roadway	Thorne & Rothesay Ave
	Roadway	Crowne Street Overpass
	Roadway	Rothesay Ave & Russell St
	Roadway	Rothesay Ave & Spencer Street
	Roadway	McAllister Dr & Golden Grove Rd
	Roadway	McAllister Dr & Rothesay Ave
	Roadway	Ashburn Lake Rd & Route 1
Evacuation Center	Glen Falls School	10 Princess Court
Hazard	Irving Oil Ltd.	555 Courtenay Causeway
	Canadian Tire Gas Bar	564 Rothesay Avenue
	Cold Brook Esso	570 Rothesay Avenue
Child Care Facilities	South End Daycare Centre Inc.	310 Prince William St.
	Simpson Drive Early Childhood Centre	69 Simpson Dr.
Health Care Facility	Family Practice Continuous Care Clinic	168 Rothesay Ave.
Miscellaneous	Strescon Limited	101 Ashburn Lake Rd.
	Exhibition Grounds	125 McAllister Dr.
	Digby Ferry	170 Digby Ferry Rd.
	Exhibition Grounds	60 Golden Grove Rd.
	Saint John Energy Substation	1050 Rothesay Rd.

Table 18: Emergency control points of coastal flooding after 2.2 meters of projected sea level rise representing a 1 in 100-year storm in 2100.

Sea Level Rise 2100: 1:100		
Type	**Name**	**Location**
Intersection	Roadway	Thorne & Rothesay Ave
	Roadway	Crowne & Hanover
	Roadway	Exit 123 (Dorchester)
	Roadway	Crowne Street Overpass
	Roadway	Rothesay Ave & Russell St
	Roadway	Bayside Dr & Red Head Road
	Roadway	Route 100 & Paradise Row
	Roadway	Rothesay Ave & Spencer Street
	Roadway	Consumer Dr & Mark Dr
	Roadway	McAllister Dr & Golden Grove Rd
	Roadway	McAllister Dr & Rothesay Ave
	Roadway	Ashburn Lake Rd & Route 1
	Roadway	Route 1 Ramp
	Roadway	Main St. Overpass
	Roadway	Parkhill Rd & Golden Grove Rd
	Roadway	Rothesay Ave off Ramp
	Roadway	Rothesay Ave & Rothesay Rd
	Roadway	Rothesay Ave on Ramp
	Roadway	Ashburn Rd & Drury Cove Road
	Roadway	Ashburn Rd & Foster Thurston
Evacuation Centers	Harbour Station	99 Station St.
	Carleton Community Centre	120 Market Place
	Glen Falls School	10 Princess Court
Hazards	Ultramar	113 Bayside Dr.
	Midland Transport	114 Bayside Dr.
	Irving Wallboard	30 Jervis Lane
	Irving Oil Ltd.	555 Courtenay Causeway
	Canadian Tire Gas Bar	564 Rothesay Avenue
	Saint John Energy	70 Rodney Street
	Praxair	669 Bayside Drive
	Cold Brook Esso	570 Rothesay Avenue
Child Care Facilities	South End Daycare Centre Inc.	310 Prince William St.
	Simpson Drive Early Childhood Centre	69 Simpson Dr.
Health Care Facility	Family Practice Continuous Care Clinic	168 Rothesay Ave.
Miscellaneous	Saint John Energy Substation	23 Smythe St.
	Strescon Limited	101 Ashburn Lake Rd.
	Exhibition Grounds	125 McAllister Dr.
	Digby Ferry	170 Digby Ferry Rd.
	Exhibition Grounds	60 Golden Grove Rd.
	Saint John Energy Substation	1050 Rothesay Rd.

Appendix C. Inland Vulnerability Mapping

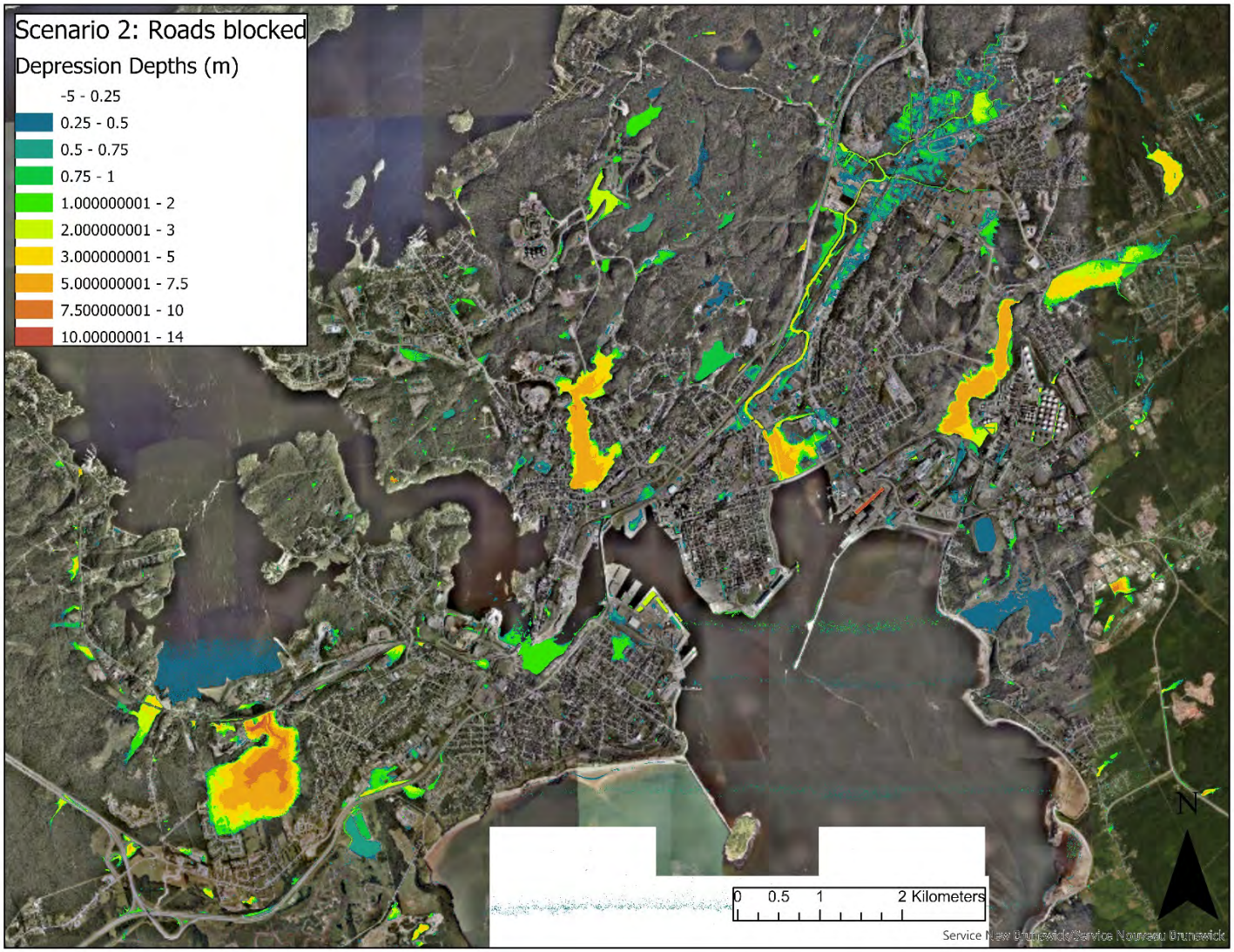

Figure 32: Inland vulnerability map. Scenario 2: Bridges, roads and stormwater system blocked.

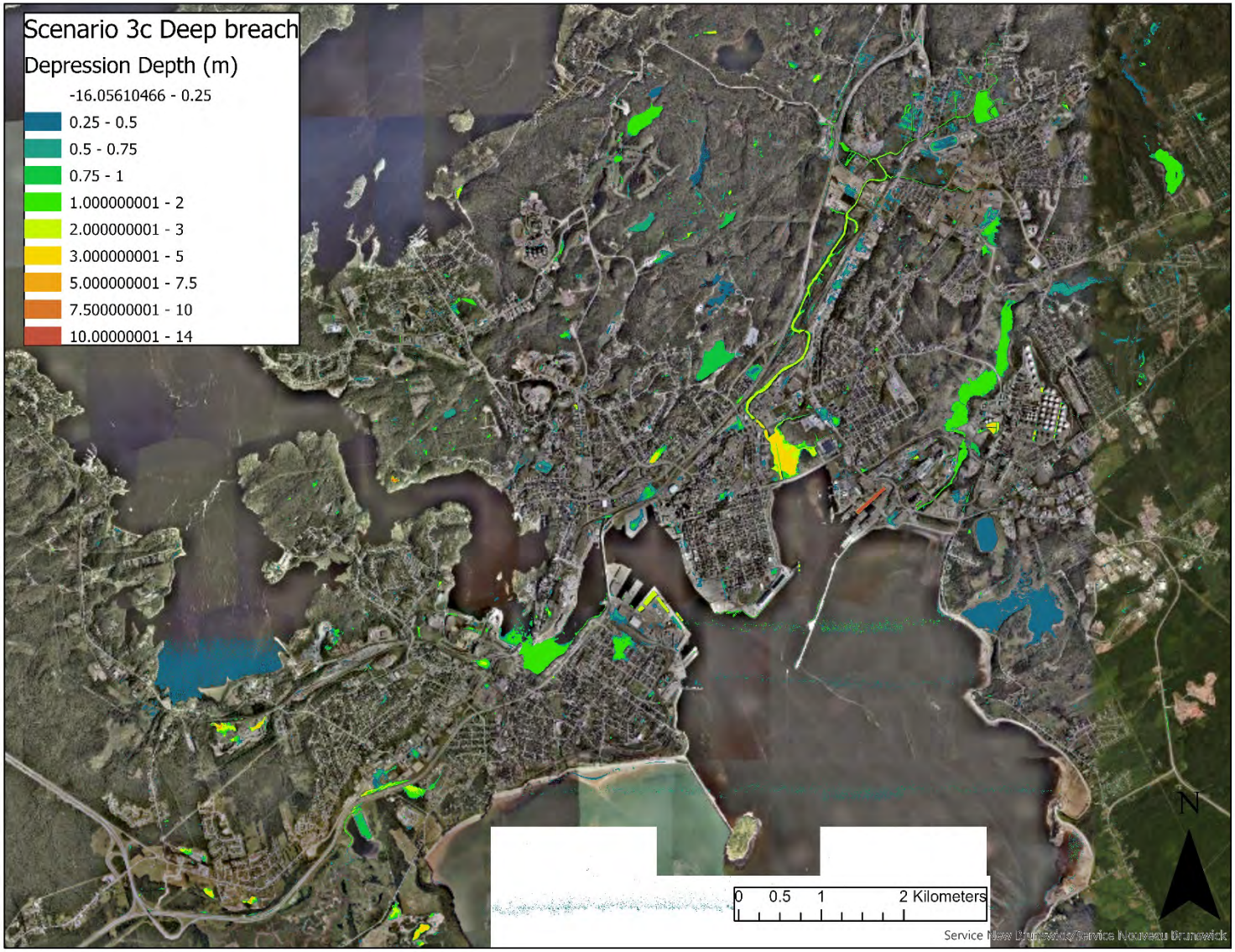

Figure 33: Inland vulnerability map. Scenario 3c: Roads breached down to 14m, except the causeway; stormwater system blocked, except for Lansdowne Plaza area.

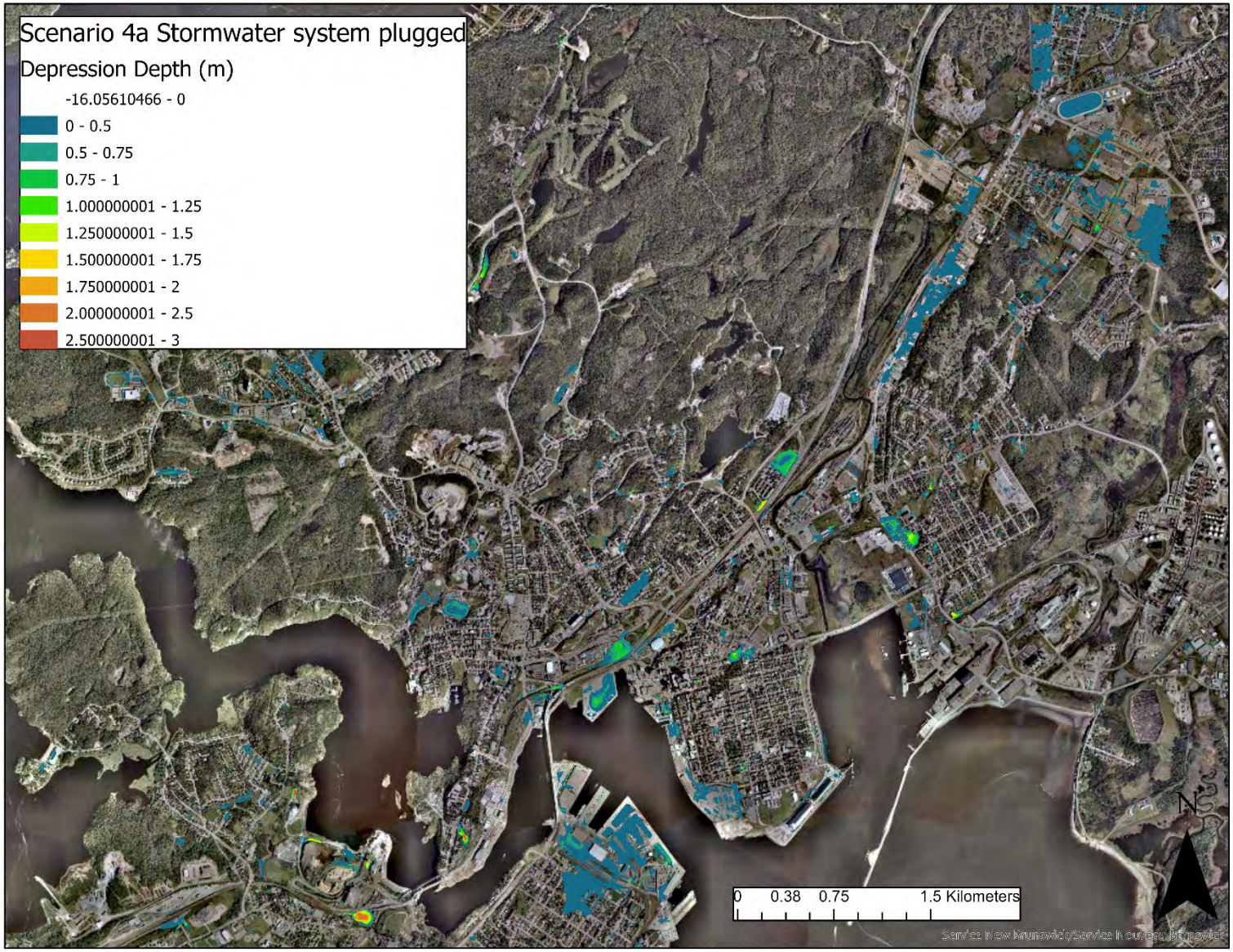

Figure 34: Inland vulnerability mapping. Scenario 4a: Stormwater system placed at 3m depth, revealing drainage challenged areas.

Appendix D. Risk and Vulnerability Assessment

IMPACT STATEMENTS
CLIMATIC CHANGE: SEA LEVEL RISE
● **INCREASED LOSS OF LAND DUE TO FLOODING AND COASTAL EROSION**
● **INCREASED RISK OF HABITAT LOSS DUE TO COASTAL SQUEEZE**
CLIMATIC CHANGE: INCREASED PRECIPITATION
● **CONTAMINATION OF LAKES AND STREAMS DUE TO INCREASED POLLUTANT/SEDIMENT RUNOFF**
● **DAMAGES TO INFRASTRUCTURE/PROPERTIES DUE TO LOCALIZED FLOODING**
● **CONTAMINATION OF LAKES AND STREAMS DUE TO COMBINED SEWER OVERFLOW**
● **ISOLATION, ACCESSIBILITY, AND MENTAL HEALTH CHALLENGES DUE TO FLOODING**
● **LAND LOSS DUE TO SLOPE MOVEMENT/EROSION**
● **HIGHER RISKS OF VECTOR BORNE DISEASE DUE TO INCREASED IN TICK AND MOSQUITO BREEDING HABITAT**
● **HIGHER SPRING FRESHET FLOODING DUE TO INCREASED PRECIPITATION**
CLIMATIC CHANGE: INCREASED TEMPERATURE
● **INCREASED RISK OF HEAT STRESS ON VULNERABLE POPULATIONS DUE TO EXTREME HEAT**
● **INCREASED ENERGY DEMAND FOR COOLING NEEDS IN THE SUMMER**
● **LOSS OF WORK FOR SEASONAL OUTDOOR EMPLOYEES DUE TO EXTREME HEAT**
● **STRESS ON HABITAT FOR COLD WATER SPECIES DUE TO LOSS OF COOL STREAMS FOR REFUGE**
● **INVASIVE SPECIES MIGRATION DUE TO WARMER WINTERS**
● **INCREASED DEMAND ON WATER SUPPLY DUE TO SUMMER DROUGHT**
● **INCREASED FOREST FIRE POTENTIAL DUE TO SUMMER DROUGHT**
● **INCREASE IN TICK POPULATIONS DUE TO WARMER WINTERS**
● **INCREASE IN INFRASTRUCTURE DAMAGE DUE TO INCREASE IN ANNUAL FREEZE-THAW CYCLES**
● **CONTAMINATED DRINKING WATER SOURCES DUE TO AN INCREASE IN TOXIC CYANOBACTERIA CULTURES**
● **REDUCED HEALTH QUALITY DUE TO A REDUCTION IN AIR QUALITY**
● **REDUCED SUITABLE HABITAT DUE TO OCEAN ACIDIFICATION**
CLIMATIC CHANGE: INCREASED STORM SEVERITY
● **INFRASTRUCTURE DAMAGES AND POWER OUTAGES DUE TO INCREASED EXTREME WIND AND ICE STORMS**
● **FLOODING DUE TO STORM SURGE**
● **FLOODING DUE TO WINTER PRECIPITATION AS RAIN**
● **FOOD SHORTAGE DUE TO POWER OUTAGES AT GROCERY STORES.**

Table 19: Vulnerability Assessment.

	IMPACT STATEMENT	Water	Environment	Transportation	Businesses	Industry	Housing	Parks and Recreation	Port and Harbour Management	Stormwater	Insurance	Public Health	Emergency Management	Neighbouhood Associations	Energy Management	Buildings	Forestry	Drinking Water
SLR	Increased salt water intrusion into GW sources due to SLR	S3 AC3 V3																
	Increased risk of habitat loss due to coastal squeeze.		S4 AC2 V4															
	Increased loss of land due to flooding and coastal erosion.		S3 AC4 V2	S4 AC1 V5	S4 AC3 V4	S4 AC1 V5	S5 AC1 V5	S3 AC4 V2	S4 AC1 V5									
INCREASED PRECIPITATION	Contamination of lakes and streams due to increased pollutant/sediment runoff		S3 AC4 V2							S3 AC4 V2								
	Damages to infrastructure/ properties due to localized flooding			S4 AC3 V4			S4 AC4 V3				S2 AC5 V1							
	Contamination of lakes and streams due to combined sewer overflow		S3 AC3 V3									S3 AC2 V3						
	Isolation, accessibility and mental health challenges due to flooding			S3 AC4 V2								S3 AC4 V2	S4 AC4 V3					
	Land loss due to slope movement/ erosion			S3 AC2 V3			S3 AC3 V3											
	Higher risks of vector borne disease due to increased in tick and mosquito breeding habitat											S3 AC2 V3						
	Higher spring freshet flooding due to increased precipitation			S4 AC2 V4												S4 AC1 V5		
INCREASED TEMPERATURE	Increased risk of heat stress on vulnerable populations due to extreme heat											S3 AC2 V3		S2 AC4 V2				
	Increased energy demand for cooling needs in the summer														S2 AC4 V2			
	Loss of work for seasonal outdoor employees due to extreme heat				S2 AC5 V1													
	Stress on habitat for cold water species due to loss of cool streams for refuge		S3 AC1 V4															
	Invasive species migration due to warmer winters		S3 AC3 V3														S3 AC2 V3	
	Increased demand on water supply due to summer drought																	S3 AC4 V2
	Increased forest fire potential due to summer drought												S2 AC3 V2				S3 AC3 V3	
	Increase in tick populations due to warmer winters											S3 AC2 V3						
	Increase in infrastructure damage due to increase in annual freeze-thaw cycles			S4 AC3 V4														
	Contaminated drinking water sources due to an increase in toxic cyanobacteria cultures							S2 AC4 V2				S3 AC2 V3						S4 AC3 V4
	Reduced health quality due to a reduction in air quality		S3 AC2 V3									S3 AC2 V3						
	Reduced suitable habitat due to ocean acidification		S3 AC1 V4															
INCREASED STORM SEVERITY	Infrastructure damages and power outages due to increased extreme wind and ice storms				S3 AC4 V2	S3 AC4 V2	S3 AC3 V3	S3 AC4 V2			S2 AC5 V1		S2 AC4 V2	S2 AC5	S3 AC3 V3			
	Flooding due to storm surge			S4 AC3 V4	S4 AC3 V4		S4 AC3 V4		S4 AC1 V5									
	Flooding due to winter precipitation as rain			S4 AC4 V3	S4 AC5 V3		S4 AC5 V3											
	Food Shortage		S2 AC5 V1									S3 AC2 V3	S3 AC3 V3	S2 AC4 V2				

S - Sensitivity:	1 (low sensitivty) - 5 (highly senstive)
AC - Adaptive Capacity:	1 (low adaptability) -5 (easily adaptable)
Vulnerability Rating:	
V1	Low Vulnerability
V2	Low-Medium Vulnerability
V3	Medium Vulnerability
V4	Medium-High Vulnerablility
V5	High Vulnerability

Table 20: Consequence and likelihood assessment of Climate Change impacts in Saint John, NB.

	IMPACT STATEMENT	LIKELIHOOD	CONSEQUENCE						RISK RATING
			Health & Safety	Loss of Service	Community & Lifestyle	Natural Environment	Damage & Recovery	TOTAL	
SLR	Increased salt water intrusion into GW sources due to SLR	2	1	1	2	2	2	8	16
	Increased risk of habitat loss due to coastal squeeze.	5	1	1	3	5	4	14	70
	Increased loss of land due to flooding and coastal erosion.	5	3	3	4	5	4	19	95
INCREASED PRECIPITATION	Contamination of lakes and streams due to increased pollutant/sediment runoff	3	1	2	2	4	2	11	33
	Damages to infrastructure/ properties due to localized flooding	5	3	2	4	1	3	13	65
	Contamination of lakes and streams due to combined sewer overflow	4	3	2	2	4	3	14	56
	Isolation, accessibility and mental health challenges due to flooding	5	3	3	4	2	4	16	80
	Land loss due to slope movement/ erosion	4	2	2	2	3	4	13	52
	Higher risks of vector borne disease due to increased in tick and mosquito breeding habitat	4	3	1	3	2	1	10	40
	Higher spring freshet flooding due to increased precipitation	4	3	3	4	3	4	17	68
INCREASED TEMPERATURE	Increased risk of heat stress on vulnerable populations due to extreme heat	5	4	2	2	2	1	11	55
	Increased energy demand for cooling needs in the summer	4	2	3	2	1	2	10	40
	Loss of work for seasonal outdoor employees due to extreme heat	5	2	1	2	1	1	7	35
	Stress on habitat for cold water species due to loss of cool streams for refuge	5	2	1	2	5	3	13	65
	Invasive species migration due to warmer winters	4	2	1	2	5	3	13	52
	Increased demand on water supply due to summer drought	2	2	3	4	1	3	13	26
	Increased forest fire potential due to summer drought	1	3	2	3	5	3	16	16
	Increase in tick populations due to warmer winters	5	3	2	2	4	2	13	65
	Increase in infrastructure damage due to increase in annual freeze-thaw cycles	5	2	2	2	4	3	13	65
	Contaminated drinking water sources due to an increase in toxic cyanobacteria cultures	4	4	3	2	3	3	15	60
	Reduced health quality due to a reduction in air quality	2	3	1	2	4	2	12	24
	Reduced suitable habitat due to ocean acidification	3	1	1	1	5	1	9	27
INCREASED STORM SEVERITY	Infrastructure damages and power outages due to increased extreme wind and ice storms	5	3	4	3	2	3	15	75
	Flooding due to storm surge	5	2	2	2	4	4	14	70
	Flooding due to winter precipitation as rain	5	3	2	2	2	3	12	60
	Food Shortage due to power outages at grocery stores.	3	3	2	3	1	2	11	33

LIKELIHOOD RATING: 1 (Rare) - 5 (Almost Certain)			
RISK RATING:			
Extreme	111-125	Medium	51-65
Very High	96-110	Medium-Low	36-50
High	81-95	Low	21-35
Medium-High	66-80	Very Low	5-20

Table 21: Risk and Vulnerability Assessment Results

RISK RATING	Climatic Change	Impact Statement	Vulnerability Ranking
High (96-110)	Sea level rise	**Increased loss of land due to flooding and coastal erosion**	**5 (High)**
Medium - High (66-80)	Sea level rise	Increased risk of habitat loss due to coastal squeeze	4 (Medium- high)
	Increased precipitation	**Higher spring freshet flooding due to increased precipitation**	**5**
	Increased precipitation	Isolation, accessibility and mental health challenges due to flooding	3
	Increased storm severity	**Flooding due to storm surge**	**5**
	Increased storm severity	Infrastructure damages and power outages due to increased extreme wind and ice storms	3
Medium (51-65)	Increased precipitation	Damages to infrastructure/ properties due to localized flooding	4
	Increased precipitation	Contamination of lakes and streams due to combined sewer overflow	3
	Increased precipitation	Land loss due to slope movement/ erosion	3
	Increased temperature	Increase in infrastructure damage due to increase in annual freeze-thaw cycles	4
	Increased temperature	Contaminated drinking water sources due to an increase in toxic cyanobacteria cultures	4
	Increased temperature	Stress on habitat for cold water species due to loss of cool streams for refuge	4
	Increased temperature	Increased risk of heat stress on vulnerable populations due to extreme heat	3
	Increased temperature	Flooding due to winter precipitation as rain	3
Medium Low (36-50)	Increased precipitation	Higher risks of vector borne disease due to increased in mosquito breeding habitat	3
	Increased temperature	Increased energy demand for cooling needs in the summer	2
	Increased temperature	Increase in tick populations due to warmer winters	3
Low (21-35)	Increased precipitation	Contamination of lakes and streams due to increased pollutant/ sediment runoff	2
	Increased temperature	Loss of work for seasonal outdoor employees due to extreme heat	1
	Increased temperature	Increased demand on water supply due to summer drought	2
	Increased temperature	Reduced health quality due to a reduction in air quality	3
	Increased temperature	Reduced suitable habitat due to ocean acidification	4
	Increased storm severity	Food Shortage due to power outages at grocery stores	3
Very low (5-20)	Sea level rise	Increased saltwater intrusion into GW sources due to SLR	3
	Increased temperature	Increased forest fire potential due to summer drought	2

Appendix E. Gap Analysis of Existing Initiatives

By analyzing gaps in local, provincial, and regional plans, we can determine actions that can be included in the adaptation plan that will work in conjunction with other adaptation strategies. This adaptation plan will provide recommendations to fill the gaps in existing policies and highlight policies that will support adaptation in Saint John. The Gap Analysis provides a brief overview of existing policies, initiatives, and plans, and includes fifteen recommendations to incorporate Climate Change into municipal and provincial planning.

Municipal policies that will be analyzed include:

- Municipal Plan, *Plan SJ* (2011)
- Move SJ, Transportation Strategy (2017)
- Emergency Measures Organization
- Asset Management: Asset Management Policy, *2016 State of the Infrastructure Report* (2017) and *Asset Management Road Map (2017)*
- City of Saint John Corporate & Community GHG & Energy Action Plans (2019)
- Flood Risk Area By-Law, *The City of Saint John Flood Risk Area By-law* (2005)
- Stormwater Management, *A By-Law Respecting Drainage in the City of Saint John* (2016) and *Storm Drainage Design Criteria Manual* (2016)
- Lighthouse Planning & Design - Marsh Creek Design (2018)
- Marsh Creek Flood Water Diversion Project, *Marsh Creek Watershed Assessment, Evaluation and Improvements, Saint John, New Brunswick* (2008)
- SJ Energy Sustainability Policy (2017)

ACAP Adaptation Initiatives:

- *Climate Change Impacts and Adaptation* (2008)
- *Coastal Hazards Characterization* (2016)
- Urban Forestry Plan (2017-2019)

Provincial Policies and Adaptation Initiatives:

- New Brunswick's Climate Change Action Program, *Transitioning to a Low Carbon Economy* (2016)
- *Flood Risk Reduction Strategy for New Brunswick* (2014)
- *A Coastal Areas Protection Policy for New Brunswick* (2019)
- A Water Strategy for New Brunswick 2018-2028 (2017)
- New Brunswick Emergency Measures Organization
- New Brunswick Lyme Disease and Other Tick-borne Disease Strategy (2018)

Recommendations:

Municipal Plan, *Plan SJ* (2011)

1. The Municipal Plan was completed by the City of Saint John in 2011 and no comprehensive review was completed after five years. Annual reporting on the plan was likely completed as a verbal update during council meetings. The City of Saint John should complete a comprehensive review of the Municipal Plan to incorporate the Climate Change Adaptation Plan.
2. Detailed neighbourhood plans should include considerations for Climate Change adaptation.

Move SJ, Transportation Strategy

3. Future transportation routes should encourage active transportation.

Asset Management

4. Climate Change should be factored into the assessment criteria for the SOTI risk assessment under asset management plan.
5. Stormwater assets were given a letter grade of "C" which means infrastructure is in a fair state of repair, showing signs of deterioration and will require attention in the near future. Green infrastructure should be implemented where applicable to extend the life of stormwater infrastructure.
6. Asset management does not include green infrastructure as an asset. Completing a green infrastructure inventory can identify assets that can be maintained in the future that will provide ecosystem services.

Flood Risk Area By-Law

7. The Flood Risk By-Law only applies to flood risk areas along Marsh Creek and its tributaries. The Flood Risk By-Law should be expanded to other flood risk areas throughout the City (i.e. along the Wəlastəkw (Saint John River) and Kennebecasis River).
8. The Flood Risk By-Law should state minimum elevations for floodproofing. Climate Change should also be a consideration when determining flood risk areas.

Stormwater Management

9. The City of Saint John should develop incentives to encourage the use of green infrastructure and stormwater best management practices.
10. Update IDF curves to consider an increase in precipitation due to Climate Change.

Marsh Creek Flood Water Diversion Project

11. Recommendations made in the 2009 Terrain Marsh Creek Diversion Project should be reviewed to increase the storage capacity of the Courtenay Forebay and to assess the feasibility of increasing the height of the causeway to protect from sea level rise and storm surge.

ACAP Coastal Hazards Characterization

12. Coastal erosion should continue to be monitored to identify solutions moving forward.

Provincial Adaptation Initiatives

13. Collaborate with provincial government partners for support in achieving the goals outlined in the New Brunswick Climate Change Action Plan.
14. Continue to monitor outputs from the New Brunswick Flood Risk Reduction Strategy.
15. Continue to monitor alerts and advisories from the New Brunswick EMO.

Appendix F. Action Register

The action register recommends actions that can work to achieve adaptation objectives for the City of Saint John. The table below describes each action including the departments and partnerships involved, the completion target, and current policies and initiatives that support the action. The City of Saint John should incorporate the Climate Change Adaptation Plan into the next iteration of the Municipal Plan or during the next comprehensive review.

Time Frames:
Short Term: 2021-2023
Medium Term: 2023-2025
Long Term: 2026-2031+
Ongoing: refers to an action that is already being completed and should continue to be implemented.

A **benefit-to-cost ratio** was determined to identify the funding sources and ancillary benefits of each task. Actions rated **high** have the most resources available and should be implemented as soon as possible. **Medium** actions have a medium benefit to cost ratio and should be implemented during routine maintenance or reviews or when the urgency of the climate impact increases. Actions rated **low** have an unknown cost to benefit ratio and resources to support implementation have not been identified (District of North Vancouver, 2017).

Objective 1: Integrate Climate Change impacts into community planning

Climate Change Impacts Addressed: Increased precipitation, sea level rise, extreme weather					
Action	**Benefit to Cost Ratio**	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
1. Ensure the Planning and Advisory Committee consults SLR projections and coastal development protocols established by GNB (2019) when considering new development applications along the coastal zone.	High	Growth & Community Services	Short term	High risk	A Coastal Areas Protection Policy for New Brunswick (2019) Plan SJ (2011) NE-26 NBCCAP (2016)-89 City of Saint John Flood Risk By-law (2005) CP-11
2. Set development standards and zoning to restrict development in coastal areas and near flood-prone areas. Account for 1 in 100-year storm/flood events.	High	ACAP/Growth & Community Services (Infrastructure Development)/ Develop SJ	Medium term	High risk	ACAP SJ (2016) - *Coastal Hazards Characterization* NB Flood Risk Reduction Strategy (2014) Objective 2, Actions 4, 7 The City of Saint John Flood Risk Area By-law (2005) Storm Drainage Design Criteria Manual (2016)
3. Expand the Flood Risk Area By-Law boundaries to include coastal and inland flood risk areas (i.e. St. John River, Kennebecasis River) identified in flood risk maps.	High	NB EMO/ Growth & Community Services	Medium term	High risk	NB Flood Risk Reduction Strategy (2014) Objective 1, Action 1-3 NBCCAP (2016)- 96 Plan SJ
4. Establish an interdepartmental Climate Change Adaptation Committee (Climate Committee) to participate in decision making and ensure actions are being implemented with the City of Saint John's Climate Change Adaptation Plan.	High	Growth & Community Services	Short term	Medium-high risk	
5. Review and continue to develop Neighbourhood Plans by working alongside neighbourhood associations, community	Medium	Growth & Community Services/ ACAP /Recreation and	Medium term	Medium-high risk	

members and leaders. The Plan can provide suggestions for green infrastructure sites and focus on priority areas of sustainability: economic, cultural, environmental and social.		Community Development			
6. Prepare and adopt a Municipal Emergency Response Plan and Policy that includes actions for emergency preparedness to Climate Change impacts.	High	EMO/Growth & Community Development	Long term	Medium-high risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 10
7. Update Development Standards Manuals to include low impact development (LID) into development/ planning process. Encourage LID throughout the community.	Medium	Asset Management/ Growth & Community Services (Building Inspection) Transportation & Environment	Ongoing - long-term	Medium risk	Plan SJ (2011) NE-35 NBCCAP (2016) 63, 71 Asset Management Policy A By-Law Respecting Drainage in the City of Saint John (2016) Storm Drainage Design Criteria Manual (2016)

Objective 2: Reduce shoreline erosion & promote natural infrastructure

Climate Change Impacts Addressed: Sea level rise, reducing land loss, erosion and infrastructure damage					
Action	**Benefit to Cost Ratio**	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
8. Conduct a study to identify high risk infrastructure that may require relocation in high erosion areas of the City.	High	Asset Management/ ACAP/ Saint John Energy/ Transportation & Environment/ Saint John Water	Ongoing - long term	High risk	NB Coastal Areas Protection Policy (2019) ACAP Coastal Hazards Characterization Report (2016) Asset Management Policy Climate Change Vulnerability Assessment (Complete May 2020)
9. Monitor coastline properties with high rates of erosion (i.e. Red Head Road, Sand Cove Road, Bayshore Beach, Sheldon Point Road, and Lorneville Cove, Courtenay Bay Causeway).	High	Transportation & Environment/ ACAP/Saint John Water	Ongoing-long term	High risk	NB Coastal Areas Protection Policy (2019) ACAP Coastal Hazards Characterization Report (2016)
10. Identify areas where possible **non-structural** protection can minimize storm surge inundation. (i.e. wetland restoration, dune building or beach nourishment). Identify stakeholders that will need to participate in implementing protection.	High	Asset Management/ ACAP	Long term	High risk	NB Coastal Areas Protection Policy (2019) ACAP Coastal Hazards Characterization Report (2016) Asset Management Policy Climate Change Vulnerability Assessment (Complete May 2020)
11. Identify areas where possible **structural** protection can minimize storm surge inundation of City infrastructure (i.e. seawall). Identify stakeholders that will need to participate in implementing protection.	High	Asset Management/ ACAP	Long term	High risk	NB Coastal Areas Protection Policy (2019) ACAP Coastal Hazards Characterization Report (2016) Asset Management Policy Climate Change Vulnerability Assessment

12. Include natural assets (i.e. forests, wetlands, stormwater retention areas) in the Asset Management Plan. Identify & inventory natural assets using GIS.	High	Asset Management/ ACAP Saint John Parks & Recreation/Saint John Water/ Transportation & Environment /GIS	Medium Term	Medium-high risk	NBCCAP (2016)- 59, 89 ACAP Tree Inventory Report

Objective 3: Protect natural spaces, local habitats & migration routes

Climate Change Impacts Addressed: Increasing temperatures, loss of cool waterways, ocean acidification, and increased invasive species. Sea level rise resulting in coastal squeeze, land loss.					
Action	**Benefit to Cost Ratio**	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
13. Raise awareness of coastal squeeze among residents and policymakers and develop demonstration projects on City properties to illustrate adaptation options.	Medium	ACAP/ Parks & Recreation/ Communications	Medium term	Medium-high risk	NBCCAP (2016)- 95
14. Monitor and restore existing wetlands to maintain storm buffers. Prioritize areas based on their vulnerability to SLR projections.	Medium	Transportation & Environment/ ACAP/ DELG	Long term	Medium-high risk	NB Coastal Areas Protection Policy (2019) Plan SJ (2011) NE-23 NBCCAP (2016)- 59, 89
15. Identify and monitor critical habitats of at-risk cold-water species experiencing stress from increased temperatures.	High	ACAP/ Saint John Water	Ongoing	Medium risk	NBCCAP (2016)- 90 Robertson Lake Monitoring (ACAP)
16. Develop a city-wide Urban Forest Management Plan that addresses Climate Change impacts.	High	Parks & Recreation /ACAP	Long term	Medium risk	NBCCAP (2016) -89, 90 NB Lyme Disease and TBD Strategy (2018)
17. Build awareness about invasive species to the public through public service announcements.	Medium	Parks & Recreation/ ACAP/ CFIA	Ongoing	Medium risk	NBCCAP (2016)- 67
18. Identify species and habitats that will be impacted by changing ocean acidification from increasing water temperature.	Low	ACAP	Medium term	Low risk	
19. Evaluate and monitor sediment loading and contamination in streams as a result of stormwater runoff during floods and heavy rainfall events.	Medium	Transportation & Environment/ ACAP/ DELG	Ongoing-long-term	Low risk	Rebirth of Water NB Water Strategy 2018-2028 -Goal 3

Objective 4: Provide public education on how to deal with the impacts of Climate Change

Climate Change Impacts Addressed: Increased temperatures resulting in extreme heat, forest fires. Increased rainfall and SLR resulting in land loss/flooding. Increased storms resulting in power outages.					
Action	**Benefit to Cost Ratio**	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
20. Update EMO website to communicate future risk from storm surge and sea level rise. Include messaging in public advisories when applicable.	High	Communications/ ACAP/ ECCC/ EMO	Short term	High risk	NBCCAP (2016)- 95
21. Engage developers and residents in identified risk areas to discuss adaptation options for their property.	High	Growth & Community Services/ Communications	Medium term	High risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 11.
22. Education about alternative technologies and passive energy systems to support residents during power outages.	Medium	Asset Management, Communications/ SJ Energy/NB Power	Ongoing-long term	Medium-high risk	Plan SJ (2011) NE-38,40, 44 NBCCAP (2016) 42 Community GHG & Energy Action Plan (2019)
23. Integrate climate impacts into public education for storm preparation. Make information available on EMO website, during Emergency Preparedness week and in development permits.	High	EMO/ Growth & Community Service/ Communications/ ACAP/ Saint John Energy	Short term	Medium-high risk	SJ Energy Vegetation Management Details (online)
24. Create an online database for information on adaptation including weather observations, erosion/ SLR rates and adaptation feedback (i.e. turnbackthetide.ca or sealevelrise.ca).	Medium	ACAP/ Communications	Ongoing - short term	Medium-high risk	
25. Education on green infrastructure and LID design to manage the impacts of Climate Change through pilot projects and workshops.	Medium	Communications/ Transportation & Environment/ ACAP/ BIA/ Heritage	Short term	Medium-high risk	NB Coastal Areas Protection Policy (2019) NBCCAP (2016)- 71, 63

26. Prepare a Forest Fire Plan for the Greater Saint John Area to provide awareness and education on avoiding forest fires and reducing health risks.	High	EMO/ Communications/ Parks & Recreation/ Fire Department/ Energy and Resource Development	Long term	Low risk	NBCCAP (2016) 103

Objective 5: Reduce the impact of Climate Change on human health

Climate Change Impacts Addressed: Flooding resulting in mental health impacts. High temperatures resulting in heat stress, increased insect populations and cyanobacteria outbreaks.					
Action	**Benefit to Cost Ratio**	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
27. Collaborate with NB Government to develop a public health and Climate Change communications plan.	High	Communications/ Public Health/ ACAP/ DELG	Medium term	Medium-high risk	NBCCAP (2016) 99,103 NB Lyme Disease and TBD Strategy (2018)
28. Organize public support sessions after flooding events to ease community stress and reduce mental health challenges.	High	EMO/ ACAP/ Public health	Short term	Medium-high risk	NBCCAP (2016) 102
29. Provide cooling shelters and drinking water during periods of prolonged very hot days.	High	Communications/ EMO	Short term	Medium risk	NBCCAP (2016)- 101
30. Continue to monitor nutrient loading in drinking water lakes to track bacterial growth and harmful algae blooms.	High	ACAP/Saint John Water	Ongoing-long term	Medium risk	Plan SJ (2011) NE -12 NB Coastal Areas Protection Policy (2019) NB Water Strategy 2018-2028-20
31. Establish partnerships with Regional Health Authorities and naturalist groups to encourage citizen science to increase tick surveillance.	Medium	Parks & Recreation/ Public Health/ ACAP/ Communications	Medium term	Medium-low risk	NB Lyme Disease and TBD Strategy (2018)
32. Continue to monitor precipitation, groundwater, and surface water to maintain sustainable drinking water yields.	High	Saint John Water/ ACAP	Ongoing-long term	Low risk	Plan SJ (2011) - Policy NE-12 NB Water Strategy 2018-2028- 18
33. Continue monitoring aquifers for saltwater intrusion from sea level rise and storm surges.	High	Saint John Water	Ongoing-long term	Low risk	NB Coastal Areas Protection Policy (2019) NBCCAP (2016)- 74
34. Continue routine monitoring to ensure safe drinking water quality after/during a flood or storm event. Educate residents on potential sources of well water contamination.	High	Saint John Water/ EMO	Ongoing	Low risk	NBCCAP (2016)- 104

Objective 6: Support vulnerable groups to increase adaptive capacity

Climate Change Impacts Addressed: Extreme weather resulting in power outages & food shortages. Sea level rise/flooding displacing populations.					
	Benefit to Cost Ratio	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
35. Develop and distribute public surveys to determine the most effective mode of communication for vulnerable groups during flood or extreme weather events.	Low	Communications/ SJHDC/ ACAP/ Growth & Community Development	Short term	Medium-high risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 14
36. Assessment of emergency shelters to determine the level of preparedness (i.e. evaluating capacity, backup power sources, food and water storage).	Medium	EMO/ Red Cross/ Social Development		Medium-high risk	
37. Develop a collaboration between EMO and community groups to ensure the vulnerable populations have places of refuge during flood or storm events.	Medium	EMO/ Recreation and Community Development		Medium-high risk	NBCCAP (2016)- 95
38. Identify vulnerable populations (low income, seniors, single parents, infants) and create specific evacuation plans for vulnerable groups living in high risk areas.	High	ACAP/EMO/ Recreation and Community Development	Short term	Medium-high risk	NB Flood Risk Reduction Strategy (2014) Objective 1
39. Partner with community garden associations to organize operational structure of committees and promote workshops & events.	Medium	Parks & Recreation/ ACAP	Ongoing	Low risk	Plan SJ (2011) NE-36
40. Work to engage and prioritize dialogue with First Nations to discuss climate challenges and solutions being addressed in their communities.	High	Mayor & Council/ Aboriginal Affairs Secretariat/ DELG	Short term		UNDRIP (2008) - Article 19 NBCCAP (2016)- 6c

Objective 7: Increase resilience to flooding and sea level rise

Climate Change Impacts Addressed: Sea Level rise and increased precipitation resulting in land loss, infrastructure damage, storm surge flooding, winter precipitation events.					
	Benefit to Cost Ratio	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
41. Identify petroleum storage sites at risk of coastal flooding. Ensure storage is above flood level. **	Medium	EMO	Long term	High Risk	
42. Identify alternate evacuation routes to be taken when emergency routes are flooded. **	High	EMO	Short term	High Risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 10
43. Host public sessions annually (early spring) to review the risks of flooding and appropriate planning before, during and after a flooding event.	High	EMO/ NB EMO/ ACAP	Ongoing	Medium-high risk	NB Flood Risk Reduction Strategy (2014) Objective 1, Objective 3, Action 9
44. Increase the availability of flood risk mapping data for public access and learning. Collaboration with Saint John public library and community resource centers.	High	Growth & Community Development (GIS)/ EMO/ Communications	Short term	Medium-high risk	NBCCAP (2016)- 69 NB Flood Risk Reduction Strategy (2014) Objective 1, Action 3
45. Raise roadway elevations that are impacted by sea level rise, spring freshet and stormwater flooding. **	High	Transportation & Environment/DTI/ NB EMO	Long-term	Medium-high risk	NBCCAP (2016)- 72 Asset Management Policy
46. Recommendations #3, #4 and #5 made in the 2009 Terrain Marsh Creek Diversion Project should be reviewed to increase the environmental functionality of the Courtenay Forebay (see Appendix for action details).	Medium	Transportation & Environment/ ACAP/ DTI	Long term	Medium-high risk	NBCCAP (2016)- 89
47. Develop a communications plan for storm surge warnings to be effectively communicated to coastal residences and public centers.	High	EMO/ Communications	Ongoing	Medium-high risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 14

48. Increase awareness and incentivize installation of backwater valves for homes in flood areas. Note: this is a requirement for new developments.	Medium	Saint John Water/ Transportation & Environment/ Communications	Ongoing	Medium risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 11 Asset Management Policy
49. Use wet area mapping to plan and prioritize snow clearing around storm drainage systems (i.e. catch basins) to reduce flooding from winter precipitation and/or thaw events.	High	Transportation & Environment	Ongoing-long term	Medium Risk	Winter Management Plan for Streets and Sidewalks (2017) - Part 9
50. Develop a Food Security Plan for importing food and prioritizing distribution during extreme weather events.	High	EMO /Salvation Army/ Red Cross	Long term	Low risk	Plan SJ (2011) NE-36

** Refer to Sea Level Rise Impact Tables (See Appendix B of the Climate Change Adaptation Plan for Saint John)

Terrain Report Recommendations

"3. The triple culverts at the CN Rail crossing of Marsh Creek, at the entrance to the forebay, should be replaced with a bridge. This will reduce the water surface level in the lower Marsh Creek area next to the portions of Rothesay Avenue that currently experience frequent flooding. The estimated cost of this improvement recommendation is $1,000,000. This cost includes an allowance of 20% for engineering and contingency fees and 13% HST.

4. Additional study of the Courtney Bay Causeway and its ability to act as an earth dam should be conducted. It is recommended that ultimately a higher levee be constructed to an elevation sufficiently high enough to hold back high tide plus a 2.0 m storm surge plus wave action. In the interim, it is advisable to set up an early warning system such that the Marsh Creek area could be efficiently and expeditiously evacuated should the need arise. Typically, storm surges are well predicted, and meteorologists and oceanographers are able to correlate the storm surge and its timing arrival with high tide. It is typical for these types of events to have many hours of warning in advance.

5. The City should provide for controls over future development in the Marsh Creek watershed. This would typically involve setting safe elevations that structures could be placed at and restricting any further impingement or encroachment on the Marsh Creek channel itself" (Terrain Group, 2008).

Objective 8: Increase resilience to extreme weather

Climate Change Impacts Addressed: Increased precipitation, increased temperatures, wind/ice storms					
	Benefit to Cost Ratio	**Lead Department & Partners**	**Completion Target**	**Risk Rating**	**Supporting Initiatives and Policies**
51. Promote residential emergency preparedness kits (minimum 72 hours up to one week) including backup generators, batteries and wind up radios.	High	Communications/ EMO	Ongoing	Medium-high risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 11
52. Create a voluntary signup for individuals requiring electricity to run healthcare equipment and requiring assisted evacuation.	High	EMO/ Communications/ SJ Energy	Ongoing Medium term	Medium-high risk	NB Flood Risk Reduction Strategy (2014) Objective 3, Action 9 & 10
53. Create a list of facilities (i.e. grocery stores, emergency centers and gas stations) that have backup power infrastructure.	Medium	EMO/ SJ Energy	Ongoing/ Short term	Medium-high risk	
54. Continue cyclical tree trimming around utility lines (completed by SJ Energy). Develop a 3-5-year inspection cycle to be implemented by the City to identify dead or diseased trees in streets or park spaces.	High	Parks & Recreation /SJ Energy	Ongoing	Medium-high risk	SJ Energy Vegetation Management Details (online)
55. Determine a percent increase on Environment Canada IDF curves to reflect future increase in precipitation for new infrastructure development and design.	High	Transportation & Environment/ Asset Management	Short-term/ongoing	Medium-high risk	NBCCAP (2016)- 72 & 75 Asset Management Policy
56. Develop a list of priority areas and core infrastructure that may be at risk of failure during mid-winter thaws and heavy rain on snow events.	High	Transportation & Environment/ Asset Management	Ongoing-long term	Medium-high risk	Winter Management Plan for Streets and Sidewalks (2017)
57. Install bioretention infrastructure in flood risk areas during capital upgrades *See at risk areas.	Medium	Transportation & Environment/ ACAP/Parks &	Medium-long term	Medium risk	NBCCAP (2016)- 63, 71,74, 89 City of Saint John 2016 State of the Infrastructure Report (2016).

		Recreation			Asset Management Policy
58. Identify response plans and solutions to ensure energy capacity will withstand heavy usage during extended periods of heat.	Medium	SJ Energy	Ongoing-long term	Medium-low risk	Heat pump rental program (Saint John Energy)
59. Formalize partnerships to ensure the distribution of clean drinking water during an extreme weather event.	High	EMO/Red Cross/ Salvation Army/ Public Health		Low risk	NBCCAP (2016)- 67

*Refer to Inland Vulnerability Maps (See Appendix C of the Climate Change Adaptation Plan for Saint John)

ACAP SAINT JOHN

Founded in 1992, ACAP Saint John is a community-based, non-profit organization that encourages communication, partnership and active involvement from all sectors of the community in managing the environment.

At its heart, ACAP has always been an environmental incubator, one that transforms and evolves our region's landscapes with the help of governments, companies and community collaborators. Our work is designed to be seen, felt and experienced throughout the environment – from our wetlands and coastlines to our streets and public spaces.

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