Community Vulnerability Assessment of Climate Change and Variability Impacts in Charlotte County, New Brunswick

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Community Vulnerability Assessment of Climate Change and Variability Impacts in Charlotte County, New Brunswick

2014
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St. Croix Estuary Project Inc.

SCEP is dedicated to the continual improvement of environmental quality of the St Croix estuary ecosystem, in full collaboration with and in support of, healthy and prosperous coastal communities. SCEP's goal is to engage local and regional decision-makers and citizens in working together to better understand, sustain and improve the environment at local and regional scales through research & monitoring, application of scientific data, education and action.

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Eastern Charlotte Waterways Inc.

Eastern Charlotte Waterways Inc. (ECW) is a not-for-profit, environmental resource and research centre, collaborating with like-minded organizations to promote community well-being through sound environmental health. This is accomplished by facilitating projects that integrate common social, economic and environmental concerns.

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ACASA	Atlantic Climate Adaptation Solutions Association
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
CAO	Chief Administrative Officer
CCCVA	Charlotte County Community Vulnerability Assessment
CD	Chart Datum
CGVD	Canadian Geodetic Vertical Datum
cm	centimetre(s)
CSO	Combined Sewer Overflow
CVAT	Community Vulnerability Assessment Tool
DEM	Digital Elevation Model
DFA	New Brunswick Disaster Financial Assistance Program
DFO	Department of Fisheries and Oceans
DOTI	Department of Transportation and Infrastructure
DTW	Depth to Water
ECW	Eastern Charlotte Waterways Inc.
EMO	Emergency Measures Organization
ENGO	Environmental Non-Governmental Organization
GIS	Geographic Information System
GPS	Global Positioning System
ha	hectare(s)
HHWLT	Higher High Water Large Tide
HMSC	Huntsman Marine Science Centre
HST	Harmonized Sales Tax

IISD	International Institute on Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
km	kilometre(s)
km/h	kilometres per hour
LiDAR	Light Detection and Ranging
LSD	Local Service District
m	metre(s)
m^2	metres squared
m^3	cubic metres
mm	millimetre(s)
MOU	Memorandums of Understanding
MSL	Mean Sea-Level
ND	no date
NOAA	National Oceanic and Atmospheric Administration
RAC	Regional Adaptation Collaborative
RCMP	Royal Canadian Mounted Police
RCP	Representative Concentration Pathway
RP	return period
RSC	Regional Service Commission
SARA	Species At Risk Act
SCEP	St. Croix Estuary Project Inc.
SOP	Standard Operating Procedures
SRES	Special Report on Emissions Scenarios
SWNB	Southwestern New Brunswick
UNFCCC	United Nations Framework Convention on Climate Change
WAM	Wet Areas Mapping

CONTRIBUTORS

Working collaboratively with five municipalities throughout Charlotte County, New Brunswick, this Project could not have been completed without the participation of dedicated the residents from each community who formed the working groups. The working groups were made up of residents from each of the represented municipalities of Charlotte County who volunteered their time to participate in the community engagement process by attending a collective, County-wide meeting in addition to four to five meetings held in their respective communities.

This work was also completed with contributions from:

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EXECUTIVE SUMMARY

In recent years, the southwestern region of New Brunswick has experienced multiple and significant hydro-meteorological hazards including floods, blizzards, and ice storms. These events have caused health impacts, physical and infrastructure damage, loss of household savings, temporary loss of services resulting in economic disruption, and environmental damage. These hazards have impacted the communities of Charlotte County to varying degrees and proactive initiatives to adapt to future impacts have been lacking. Two local environmental non-governmental organizations (ENGOs), the St Croix Estuary Project Inc (SCEP) and Eastern Charlotte Waterways Inc (ECW), organized the Charlotte County Community Vulnerability Assessment (CCCVA) during 2013. The purpose of this initiative was to enable the participating communities to share knowledge and concerns relative to climate change, as well as to develop and share down-scaled information on such topics as socioeconomic systems, sea-level rise, and inland flooding. With this information, the CCCVA process was able to help shape recommendations for reducing the vulnerability of the participating Charlotte County communities to future climate related hazards.

The CCCVA process worked to determine which community elements are most sensitive to environmental and climatic changes and to start the development of efforts that focus on building resilience. This was accomplished by utilizing a community level advisory and engagement process to allow local stakeholders to identify locations, groups, and processes that are most susceptible to climate change hazards and impacts, based on past experience and new local projections for climate change. The working group members selection was purposive, an accepted method in qualitative research design, (more details available in the methodology section).

The long term objective of the CCCVA and resultant climate change adaptation planning is to increase the resilience of five Charlotte County communities to the impacts of climate change and variability. This report reflects the discussions, perceptions, and potential actions of five Charlotte County communities regarding their concerns for climate hazard impacts and community vulnerabilities in order to proactively increase their resilience.

The development of a regional all-hazards plan was the strongest recommendation shared by all of the working groups. However, the severe hazards and associated impacts that have previously occurred in Charlotte County must be addressed in the planning process, with consideration being given to any possible adaptations that could contribute to minimizing future impacts. Attention must be paid to those hazards with a high likelihood of reoccurrence to make certain that they are thoroughly planned for. Hydraulic studies were recommended in St. Stephen and St. George, the communities which have experienced significant inland flooding. It was suggested that a more detailed understanding of these areas would allow building and infrastructure issues to be addressed through mitigation. In Blacks Harbour and Grand Manan, climate related hazards had not posed a significant threat in the past, but were of concern into the future. These working groups indicated that their foremost concern focused on impacts which posed a risk to crucial industry, thus, economic diversification studies were recommended. The Town of St. Andrews was most concerned with communicating to, and gaining feedback from, their citizenry in order to formulate

a place-based response to future challenges, as the CCVA results are not, and do not purport to be representative of the views of the entire citizenry of these communities. Rather, the results suggest potential ways forward in terms of priority setting and developing locally-based climate change adaptation plans.

Unaware of any methodology that can provide 'verified' social and economic risks; the CCCVA provided instead, perceived social and economic risks. Throughout the initiative, however, we were able to develop science-based flooding and sea-level rise risk projections. This project was action oriented, there was no intention on completing a survey of risk perceptions. Our results provide a solid platform for the communities to build upon to plan for climate change.

The recommendations from the community working groups that participated in the CCCVA are expected to support long term strategic resource management and policy development, build community resilience, and strengthen adaptive capacity as part of climate change adaptation planning process. The CCCVA process has illustrated that one of the main factors which influences a community's ability to respond to new and potential circumstances is access to information. In the coming months and years, increasing the adaptive capacity of Charlotte County municipalities will also depend on the ability to clearly communicate information, the development of methods to effectively implement policy, and the resources required to support these efforts.

1. BACKGROUND

Climate change adaptation has become widely accepted as an issue of importance for municipal planning within local governments. Climate change adaptation literature insists that *adaptation is local*, as the impacts of climate change are geographic in their variability and must be addressed by 'place-based' approaches (Measham *et al.* 2011). As such, "adaptation science and practice have promoted the concept of community-based adaptation, which is locally focused, participatory, and draws on the normative preferences and knowledge of local people" (Measham *et al.* 2011).

In many fields, including sociology, anthropology, rural development, and food security, local vulnerability is determined using variations of participatory assessments of community conditions. These methods allow for the recognition of numerous motivations including political, cultural, economic, institutional, and technological sensitivities. These experience-based approaches recognize the interaction of the community's various exposures and its level of adaptive capacity over time. The concepts of vulnerability and adaptive capacity are central to climate change adaptation planning (Smit & Wandel 2006). Therefore, this project was designed to identify vulnerable areas and build adaptive capacity in participating municipalities.

Anticipating the effects of climate change and taking adaptive action is a fiscally responsible and effective strategy to manage climate change risk and reduce vulnerability at the local level. Adaptation planning at the municipal level must include the identification of the physical, social, economic, and environmental risks that result from climate hazards; and the development and implementation of strategies to reduce the impact of those hazards. Increasing the adaptive capacity of communities to respond to these vulnerabilities will lead to effective adaptation planning for the long term.

In November 2013, the International Institute for Sustainable Development (IISD) released a report entitled *Climate Change Adaptation and Canadian Infrastructure* which comments:

> In recent years, many government, private sector, and civil society actors in Canada have taken actions to address the cause of climate change (mitigation); but in comparison, limited efforts have been made to address the present and future negative impacts of climate change and to maximize potential benefits (adaptation). There is a pressing need to shift towards forward-looking, long-term planning and investment decision-making that strengthens adaptive capacity and builds resiliency across a number of sectors.
>
> New Brunswick's *Climate Change Action Plan* (2007 – 2012), [which is being renewed for the 2013–2020 period,] similarly included plans to enhance provincial adaptation planning with special emphasis on coastal regions. Key actions include incorporation of vulnerability considerations into cross-governmental decision making, and the implementation of a regulatory framework to help protect the coastal environment, infrastructure, and public and private property… [Established in 1990, the province's] *Environmental Trust Fund*… has funded some 50 projects related to mapping vulnerabilities and engaging stakeholders in adaptation planning (Government of NB 2012).

Many of these Environmental Trust Fund projects were undertaken as part of the Regional Adaptation Collaborative (RAC) Program. The RAC Program includes projects in New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador that prepare and adapt communities to the impacts of climate change and variability. RAC projects were administered through the Atlantic Canada Adaptation Solutions Association (ACASA) and served as guidance for the Charlotte county project. The Charlotte county project is the beginning of a long-term strategic community planning effort in the area and was developed by two local environmental non-governmental organizations (ENGOs), the St. Croix Estuary Project (SCEP) and Eastern Charlotte Waterways Inc. (ECW) for five municipalities, St. Stephen, St. Andrews, St. George, Blacks Harbour, and Grand Manan. These participating municipalities took part in a community-level advisory process that identified their vulnerabilities to climate related hazards and fostered building adaptive capacity.

1.1 Climate change adaptation projects in New Brunswick

The Charlotte County Community Vulnerability Assessment (CCCVA) was designed in consultation with various stakeholders as well as ACASA representatives. The collaboration of ACASA with local ENGOs, academia, climate change consultants, and various levels of government has enabled multiple climate change adaptation projects throughout New Brunswick. These projects, including the CCCVA, worked to develop and test tools and methodologies regarding adaptation measures. The resultant outcomes guide land use practices throughout New Brunswick, help to protect the province's valuable infrastructure, and identify pertinent social, economic, and governance issues (ACASA 2013). Figure 1 highlights six of these projects undertaken from 2009–2012 throughout New Brunswick. Each project is further detailed in the sections that follow.

The Provincial government has also started new work, shared at a stakeholders meeting January 2014 based on direction from the 2012 Speech from the Throne, "Recognizing the continuing risks associated with extreme weather events and climate conditions, your government will begin a collaborative effort to develop a province-wide Flood Risk Reduction Strategy. This strategy will build on past experiences including the flood event in the Perth- Andover-Tobique area earlier this year. It will benefit all areas of the province in reducing risk to life and property in the future." This initiative is now in its second phase, progressing on draft objectives and actions.

1.1.1 Acadian Peninsula coastal erosion and sea-level rise project

This project modelled future erosion and sea-level rise, and mapped risks to infrastructure in the communities of Shippagan, Le Goulet, and Bas-Caraquet (ACASA ND). The primary aim of the project was to guide community working groups from each municipality through a reflective exercise designed to generate recommendations for their respective municipal councils (Aubé & Kocyla 2012). The purpose of this project was to provide the participating communities with planning and decision-support tools to effectively address the issues of coastal flooding and erosion (Aubé & Kocyla 2012).

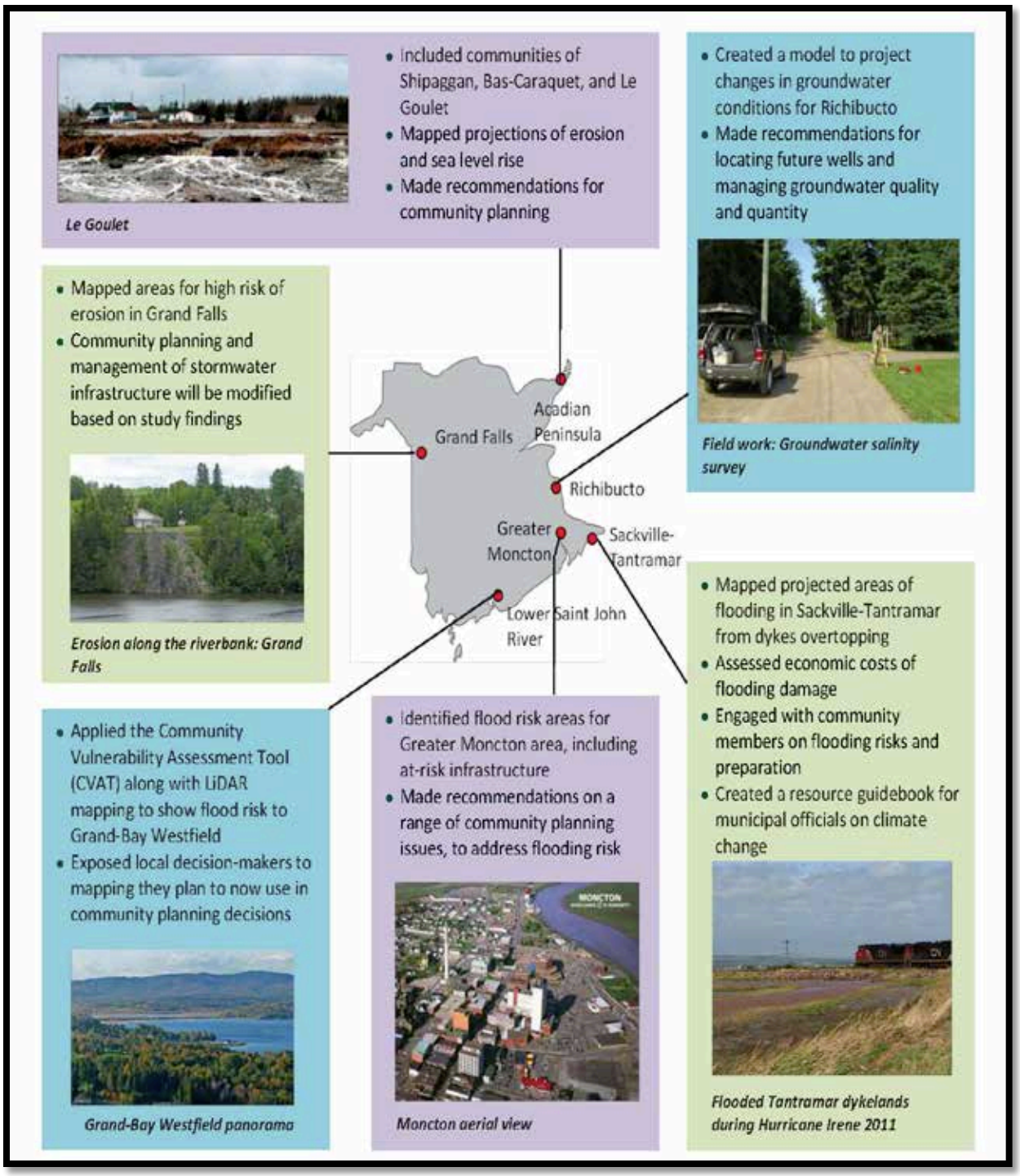


FIGURE: 1 ANNOTATED MAP OF CLIMATE CHANGE ADAPTATION PROJECTS IN NEW BRUNSWICK (SOURCE: ACASA 2013).

1.1.2 DYKELANDS INFRASTRUCTURE ASSESSMENT-TANTRAMAR

This project addressed property and agricultural lands vulnerable to flooding and erosion in the Tantramar Dykelands, specifically examining dyke flood protection structures. It used digital elevation models (DEMs) to project future sea-level rise, predict flooding scenarios, and map the at-risk infrastructure in the Town and Sackville and the surrounding agricultural areas. Based on the logistic regression model created, sections of the dyke which were exhibiting unusually high rates

of erosion were identified. The results of the project analysis have been used to identify sections of the dyke which will require the greatest long term financial investment to maintain (ACASA ND).

1.1.3. GRAND FALLS EROSION ASSESSMENT PROJECT

This project evaluated the erosion rates in Grand Falls, New Brunswick. It provided the community with recommendations regarding municipal infrastructure and identified areas at risk of erosion in the nearby Saint John River, Little River, and the Falls Brook. The project determined that these areas are causing instability problems for town infrastructure and public safety by eroding into the terrain and altering local topography. This project identified the flow of the rivers as the strongest force of erosion, with erosion rates significantly intensified by the removal of shoreline vegetation, poor stormwater runoff management, and inappropriate filling (ACASA ND).

1.1.4 GREATER MONCTON INFRASTRUCTURE ASSESSMENT PROJECT

This project addressed the inland flooding and wastewater management issues being caused by heavy precipitation events in the Greater Moncton Area. Environmental consultants with AMEC, an engineering and project management company, were contracted to develop a flood risk assessment for the area using current sewage and wastewater infrastructure, future sea-level rise, and climate change scenarios. The resulting planning tool assisted the preparation of impacted communities, providing them with information related to the identification of vulnerable infrastructure and recommend adaptation measures in order to make necessary changes to municipal plans and infrastructure programs (ACASA ND).

1.1.5 LOWER SAINT JOHN RIVER PROJECT

The need for this project arose from flooding issues along the Saint John River system. It provided information on tidal prediction and land use management in relation to flood prone and wet areas. This project used DEMs and wet areas mapping (WAM) to help the community of Grand Bay – Westfield implement appropriate planning mechanisms for flood events. It assessed the CVAT process, establishing its appropriateness for use throughout the province (ACASA ND).

1.1.6 RICHIBUCTO SALTWATER INTRUSION PROJECT

In response to seawater affecting the quality of groundwater in the Town of Richibucto, the University of New Brunswick carried out a modelling study to evaluate current saltwater intrusion in municipal wells and to make recommendations for management. In 2010 and 2012, case studies and field work were undertaken to investigate the occurrence of saline groundwater and how seawater intrusion into sandstone aquifers could be affected by projected climate change into the future (ACASA ND).

1.2 THE CLIMATE OF CHARLOTTE COUNTY

The climate of Charlotte County is dominated by the tempering airflow of the Atlantic Ocean's Bay of Fundy and can be described as a *moderate maritime climate*. It features cool summers and mild winters, extensive periods of fog, and strong autumn and winter winds. The water in the Bay of Fundy has a much higher heat capacity than soil and rock maintaining a smaller temperature range than continental climates. The proximity to the ocean causes increased humidity, resulting in greater amounts of precipitation in the coastal climate.

1.2.1 FOG

Fog occurs frequently during the spring and summer months because of the difference in temperature between the Bay of Fundy water and the air above it. Fog is most common during mild weather that features southerly breezes with low velocity. These cause offshore banks of fog to move inland. During the summer it is common for the continental air mass to force fog banks out of the bay during the day, but they generally return quickly at sunset (MacKay 2011).

1.2.2 WIND

The predominant winds in the Charlotte County area are southwesterly in summer and northwesterly in winter. Winter winds are often strong and characterized by clear weather. Summer winds are usually gentle but are generally accompanied by fog and precipitation. The average wind speed is approximately 38 kilometers per hour (km/h) during the winter but closer to 19 km/h during the summer. Occasionally, strong storms or hurricanes of tropical origin occur during the late summer, but most move offshore or strike the coast of the United States to the south (MacKay 2011).

1.2.3 TIDES

Tides result from the rise and fall of sea levels caused by the combined effects of the rotation of the Earth and the gravitational forces exerted by the moon and the sun. Charlotte County lies at the entrance to the Bay of Fundy, where the mean tidal range is approximately six meters (m). At its apex in Nova Scotia's Minas Basin, the Fundy tides are the world's largest. Strong tidal currents maintain cold water temperatures and drive the mixing of freshwater from the river systems with saline water from the ocean. This vigorous tidal exchange is largely responsible for the exceptionally productive and diverse ecosystems of the coastal marine environment. The tide is semi-diurnal and is delayed each day by approximately 50 minutes (Larsen *et al*. 2004).

1.2.4 HEAVY PRECIPITATION EVENTS

Charlotte County has experienced a number of extreme storm events in recent years including intense rainfall, storm surges, freezing rain, and blizzards. These have had various impacts throughout the county.

There are three weather monitoring stations in Charlotte County. The province's Department of Natural Resources operates a station in Brockway. Environment Canada maintains reporting stations at the St. Stephen airport and Point Lepreau, a peninsula in the Bay of Fundy separating

Saint John County and Charlotte County. In the 37 year period of record for the St. Stephen weather station there is an increasing trend in the number of large precipitation events. These events are predominantly large rainfall events during the summer to early winter seasons. The threshold of a *significant* event, for the purpose of this report, is greater than 50 millimetres (mm). This is the threshold for Environment Canada to issue a Heavy Rainfall Warning (Daigle 2014). Figure 2 graphs the annual number of these significant rainfall events measured at the St. Stephen airport since 2003. The increase in the number of these events is consistent with predictions made by climate change science. As the temperature of the air rises its capacity to hold moisture increases, resulting in a greater frequency of heavy precipitation events (Daigle 2014). There were five such events in 2013, including a rainfall event of 163mm recorded on July 26, which is similar to the event on December 13, 2010 which amounted to 166.4mm. Both these events greatly impacted the Charlotte County area, particularly the areas of St. Stephen and St. George.

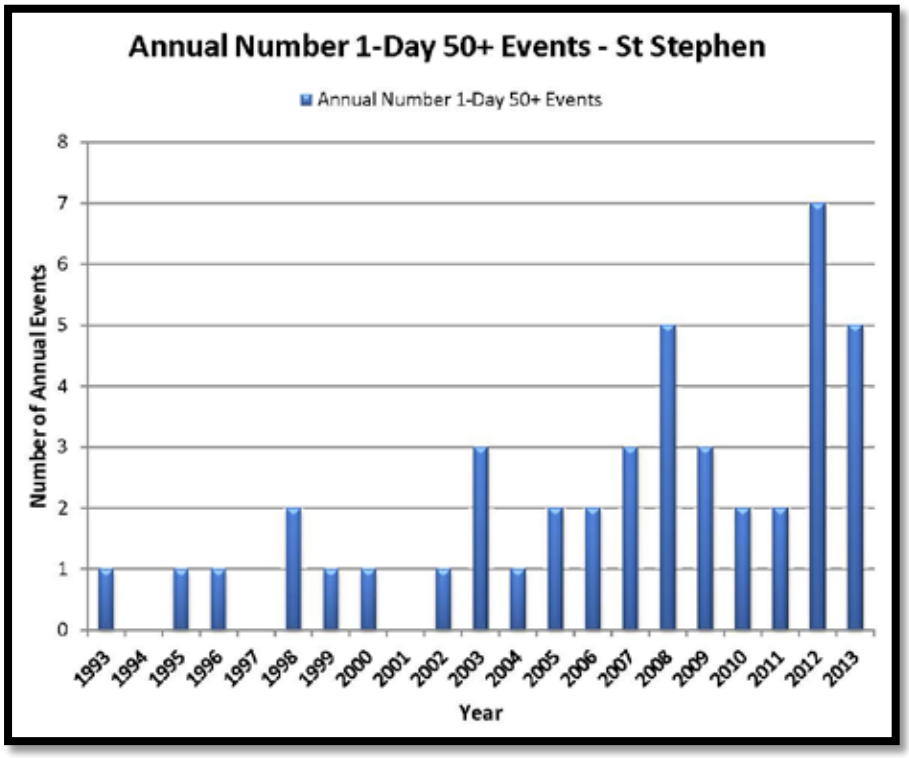


FIGURE 2: ANNUAL NUMBER OF DAYS THAT PRECIPITATION WAS 50MM OR GREATER, INCLUDING SNOW WATER EQUIVALENT AND RAIN COMBINED, AT THE ST. STEPHEN AIRPORT (SOURCE: DAIGLE 2014).

1.2.4.1 The Great Ice Storm of 1998

In 1998, between January 5 and 10, a series of five successive systems combined to form the *Great Ice Storm of 1998*. Freezing rain, heavy snow, and a drastic drop in temperature caused significant damage throughout Charlotte County, crippling electric utility infrastructure, leaving thousands of homes and businesses without power for days (Kerry *et. al* 1999). Throughout Ontario, Quebec, and the Maritime provinces, the storm resulted in over 25 fatalities, a shutdown of activities in major centres, and the largest deployment of Canadian military since the Korean War (Kerry *et. al* 1999).

1.2.4.2 November 5, 2010

On November 5, 2010, the Town of St. Andrews experienced strong winds accompanied by an extreme high tide and 45mm of rain. This caused a storm surge which inundated the coastal homes on Patrick Street and cast seaweed onto rooftops. The extent of flooding is illustrated in Figure 3. Seaweed was also found on the cannons near the Blockhouse and on the third row of camp sites at the Kiwanis Oceanfront Campground. Roads were temporarily closed as debris was left behind when the waves crashed over the armour stone. The storm surge caused damage to the seawall and the town's wharf. Dramatic coastal impacts also forced road closures on Beach Road in nearby Beaver Harbour.

1.2.4.3 December 12 – 15, 2010

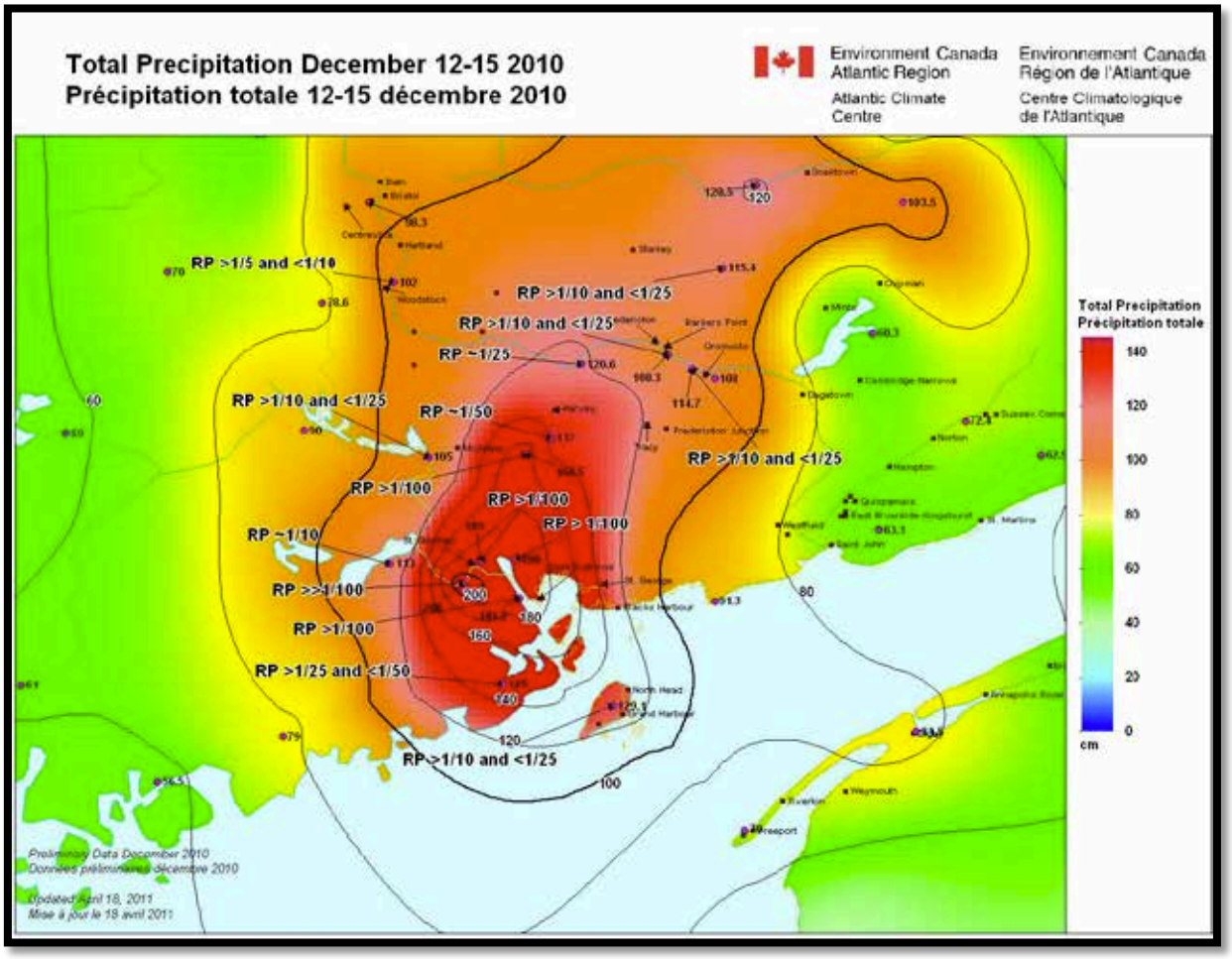
On December 12, 2010 a large, low pressure system moved over southern New Brunswick bringing heavy rains to Charlotte County. At the St. Stephen airport 166.4 millimeters (mm) of rain fell on December 13, however, the resultant flooding continued until December 15 in multiple locations throughout Charlotte County. The most substantial impacts took place in and around the communities of St. Stephen and St. George as homes and businesses were destroyed by flood waters. The groundcover snow had started to melt the previous week, saturating the ground, and exacerbating the impacts of the rainfall. In St. Stephen, there was massive flooding in the upper King Street area (see Figure 4) when the Billy Weston Brook exceeded its banks near the Charlotte Mall shopping centre. The water elevation in St. Stephen was estimated at approximately 13.2 metres (m) based on eyewitness reports, high water marks, and photographs verified by municipal officials (Daigle 2014).

FIGURE 4: ST. STEPHEN, DECEMBER 13, 2010 (SOURCE: ST. CROIX COURIER).

In St. George, the Magaguadavic River exceeded its banks in multiple locations causing extensive flooding both in the downtown area and upstream beyond Lake Utopia. The flood elevation level

was established through eyewitness accounts and photographs taken at the height of the event and verified by the local EMO coordinator. The peak water level was estimated at 20.8m in the downtown area and at 21.4m between Highway 1 and the Canal Road bridge area.

Figure 5 shows the intensity and return period (RP) of the December 12–15, 2010 precipitation event. Also referred to as the *recurrence interval*, the RP is an estimate of the likelihood of a specific amount of precipitation occurring for a specified area. The RP is a statistical measurement based on historic data that denotes the average recurrence interval of a particular sized event over an extended period of time. For example: RP >1/100 refers to an amount of precipitation that is greater than the 1 in 100 year precipitation event. In any given year there is a 1 in 100, or 1% chance, that a precipitation event of a certain amount will occur. The occurrence of a 1 in 100 year precipitation event does not preclude a similar event from occurring within one hundred years' time, rather in any given year there is a 1% chance that the area will experience that amount of precipitation, regardless of when the last similar event occurred.



1.2.4.4 July 21 - 28, 2013

Between July 21 and 28, 2013, over 240mm of precipitation fell on the Town of St. Stephen. On July 26, approximately 163mm of precipitation fell in a 24 hour period. Businesses and homes were flooded and the railway line over the Billy Weston Brook, which serves as the drainage point for over 1500 hectares (ha), was almost completely washed away for a second time in less than three years. Route 1, Highway 3, Route 760, roads in adjacent LSDs, and various streets throughout St. Stephen were covered in flood water, impeding road access. Flood issues were worsened as the rain was accompanied by a high tide. In St. Stephen, the high tide waters prevented the stormwater runoff from making its way into the St. Croix River causing surcharging. In St. George, the local EMO coordinator commented that the Magaguadavic River was rising by approximately eight centimeters (cm) per hour due to a local rainfall of approximately 100mm. In St. Andrews, 98mm of rainfall was recorded, with few reported impacts.

1.2.4.5 December 22, 2013 – January 3, 2014

In late December 2013, a series of intense storm events comprised of freezing rain, ice pellets, extreme wind chill temperatures, and snow storms impacted Charlotte County for an extended period. The first and most intense storm hit on December 22, 2013 and lasted for 24–36 hours. It was estimated that 50,000 residences were without power across the province of New Brunswick (NB Public Safety Dept. 2013). The St. Croix Courier reported that approximately 13,300 residences in the Charlotte County region had power interruption. In Charlotte County, some rural homes did not have their power restored for up to twelve days. Impassable road conditions, businesses closures, violent wind gusts, fallen

FIGURE 7: ICE BUILDUP IN ST. ANDREWS, DECEMBER 2013 (SOURCE: SUBMITTED PHOTOGRAPH).

FIGURE 8: ICICLES ON CLOTHES LINE DURING ICE STORM, DECEMBER 25, 2013, ST. ANDREWS (SOURCE: GREGOR REID).

trees, and the extended power outages impeded traditional celebrations and business operations during the holidays. Even though a "state of emergency" was not declared in the county, the impacts of the storm were considered by some to be worse than those during the Great Ice Storm of 1998. The Provincial Emergency Measures Operations Centre was activated and the New Brunswick Emergency Measures Organization (NBEMO) deployed the Red Cross to assist with the establishment of warming centres throughout the affected areas (NB Public Safety Dept. 2013).

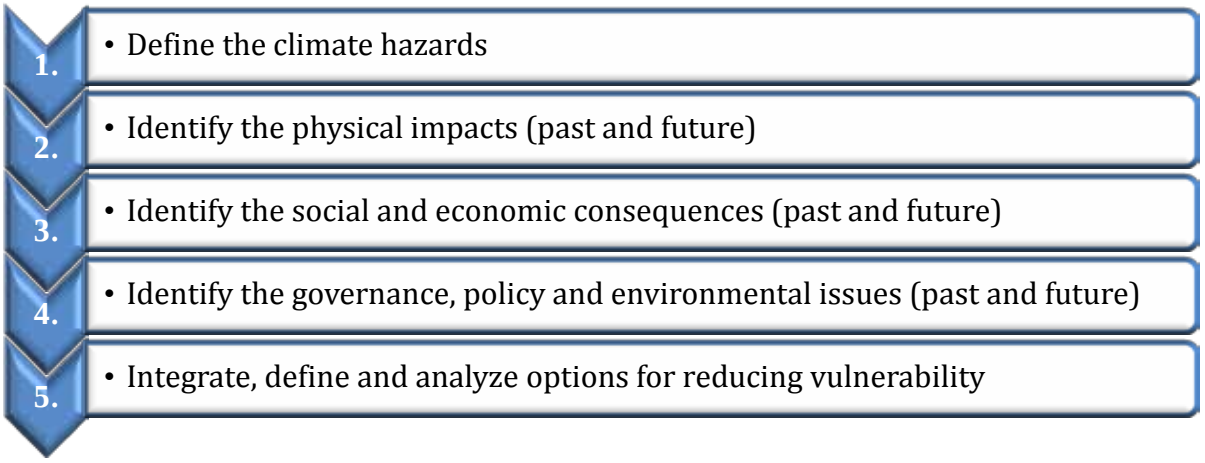
2. METHODOLOGY

The CCCVA project incorporated proven vulnerability assessment methods with community concerns to identify local vulnerabilities and define options for local adaptation. The methodology of this project was based on the CVAT developed by the National Oceanic and Atmospheric Administration (NOAA). During the RAC program, it was modified for use in rural communities by the Department of Geography at Memorial University in Newfoundland and Labrador (Leone Pippard & Associates 2012). The CVAT process has also been recognized by the United Nations Framework Convention on Climate Change (UNFCCC). A description of the UNFCC's modified CVAT method is available on their website under the title *Compendium on methods and tools to evaluate impacts of*, *and vulnerability and adaptation to*, *climate change*. The methodology used in this project was also guided by the book *From Vulnerability to Resilience, A framework for analysis and action to build community resilience* by Katherine Pasteur, 2011. Pasteur outlines the Vulnerability to Resilience (V2R) method, which provided valuable input on disaster risk reduction methods that were successfully integrated into the CCCVA for use in Charlotte County.

This project's primary action was a series of facilitated consultations with community members, designed to identify local climate hazards and the associated impacts. The community members were formed into working groups in each participating municipality and each working group was guided through a five step process, outlined below in Table 1. Initially, the working group members, in addition to the local public and media, were addressed by New Brunswick leaders in climate change and social science during a general meeting on September 24, 2013. A full description of this meeting is found in section 2.3.

Through autumn of 2013, four to five working group meetings were held in each of the five participating municipalities, as outlined in sections 2.4 – 2.8. Meeting on a bi-weekly basis, the working group members took part in an interactive community mapping exercise to identify physical, social, economic, and environmental climate hazard impacts. This process captured the complex network of factors that exist and operate on varying spatial and temporal scales, giving rise to vulnerability. It is these complex interactions between physical, social, economic, and environmental factors that affect the ability of individuals and communities to prepare for, cope with, and recover from climate related hazards (Thomalla *et al.* 2006). Throughout the process, background information and scientific research was provided to the working groups to prompt discussions, assist with mapping activities, and develop recommendations for future climate change adaptation planning.

TABLE 1: STAKEHOLDER ENGAGEMENT PROCESS USED IN THE CCCVA.



2.1 SELECTION OF THE WORKING GROUP MEMBERS

The working groups for each of the participating Charlotte County municipalities were made up of community members that aimed to represent a diverse range of stakeholders. Local knowledge is considered a key source of information on changing climate conditions. Residents have knowledge of changing weather and climate patterns that can be integrated with observations made by climatologists to better understand the changing climate of a community (Vodden 2012).

In each municipality, first contact was made with the municipal council. Each council was presented information on the project and asked to pass a motion of support for the effort. The municipalities were required to provide a meeting space for working group meetings, background information, and appoint a council member to serve as liaison. This liaison worked with project staff to assemble the working group in their community. It was established that 6 – 8 working group members were required for each municipality, however, in larger communities, more participants were expected. Working group members were also recruited through the media and through direct contact with citizens who showed interest or were recommended by their peers.

2.2 LiDAR

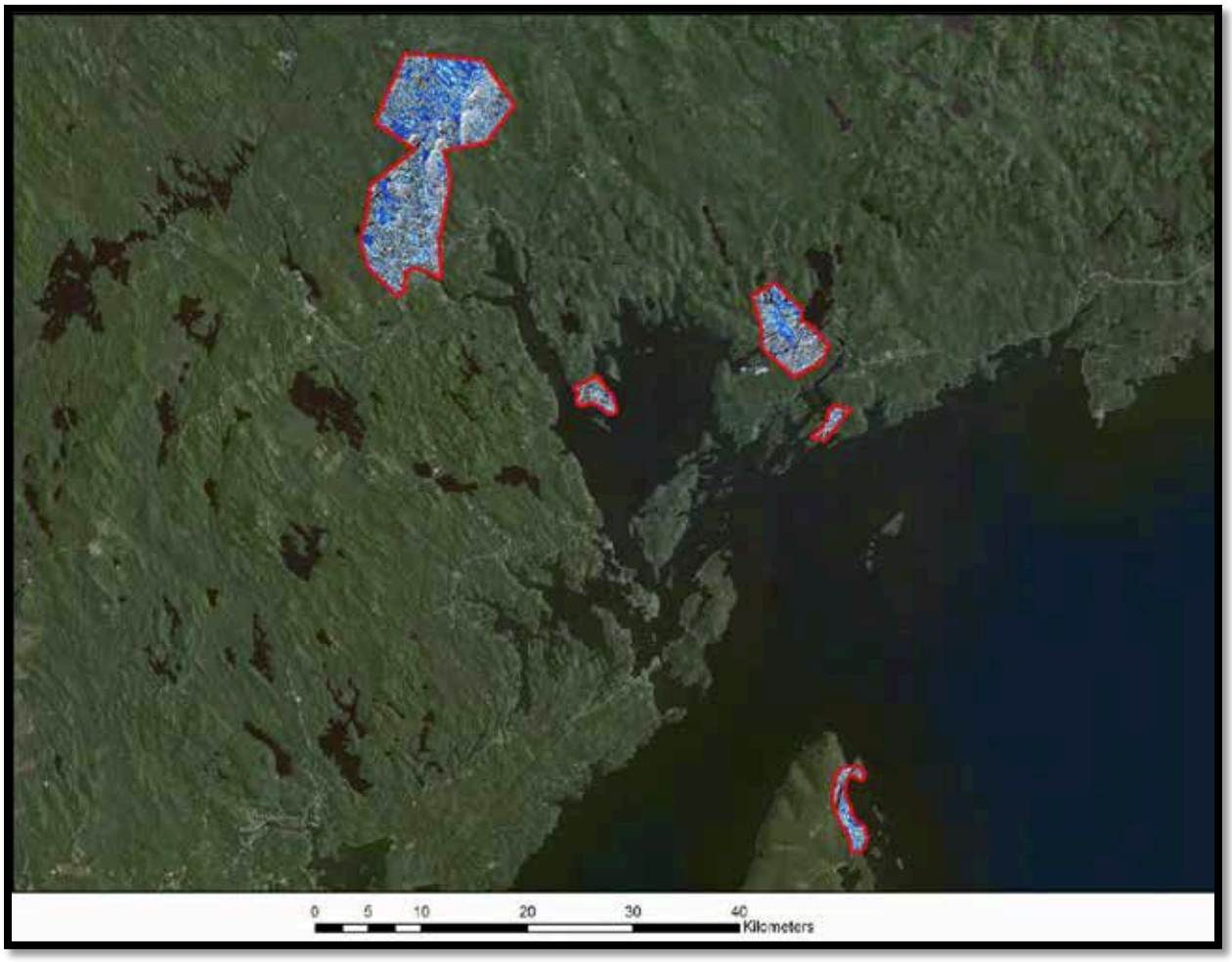


FIGURE 9: LIDAR COVERAGE FOR THE CCCVA.

LiDAR (Light Detection and Ranging) was first used in New Brunswick in 2004. It generates terrain elevation models of a selected area. The technology requires scanning a laser combined with both GPS and inertial technology to create a three dimensional set of points, referred to as a point cloud. It can detect changes in elevation to within 15 centimetres (cm). For the CCCVA LiDAR imaging was sourced from Leading Edge Geomatics in Fredericton and analyzed by Mr. Réal Daigle of R.J. Daigle Enviro and Dr. Paul Arp from the University of New Brunswick. Mr. Daigle used the LiDAR information to create Digital Elevation Models (DEMs), which were analyzed to create sea-level rise projections (see section 2.2.1). Dr. Arp created DEMs and depth to water maps, also referred to as wet-areas mapping (WAM) (see section 2.2.2). This information was provided to working group members, helping them to assess the threat of sea-level rise and depth to water for each municipality. The accessed LiDAR coverage areas of Charlotte County are illustrated in Figure 9.

2.2.1 SEA-LEVEL RISE

The Director of R.J. Daigle Enviro, Mr. Réal Daigle, utilized LiDAR data and Intergovernmental Panel on Climate Change (IPCC) scenarios to create projections of future sea-level rise for coastal Charlotte County. Mr. Daigle has over 30 years of experience as a meteorologist and project manager for Environment Canada, and has consulted on several sea-level rise and storm surge climate change projects throughout Atlantic Canada. Mr. Daigle made his projections using the most recent information provided by the IPCC Fifth Assessment Report (AR5) which includes information on sea-level rise estimates. The estimates of sea-level rise are higher than those published in the 2007 IPCC Fourth Assessment Report (AR4). The sea-level rise estimates in the AR5 also now include dynamical modelling of accelerated ice sheet (Greenland and West Antarctic) melting.

The sea-level rise estimates provided in this report are based on the AR5 information using the highest emission scenario known as Representative Concentration Pathway (RCP) 8.5. RCP 8.5 is based on the absence of any significant global policy for the reduction of greenhouse gas emissions. Mr. Daigle's projections also include regional subsidence, the downward motion of the Earth's surface relative to sea-level. Recent research by Natural Resources Canada (report in progress) which is based on precise Global Positioning System (GPS) calculated vertical movements of the Earth's crust state that determined the subsidence of St. Stephen and St. Andrews is near the zero-line, and that Blacks Harbour and Grand Manan are subsiding by four and six centimeters (cm) per century respectively (Daigle 2014). In Table 2, the anticipated change in relative sea-level has been calculated for the communities participating in this project, with the exception of St. George, which is not directly subject to sea-level rise.

In order to calculate sea-level rise, a reference, or baseline, must be established from which to determine heights or depths. This baseline is known as tidal datum or chart datum (CD). A CD is a ship navigation reference level that is representative of the lowest tide level for a given area and phase of the tide, as such, the CD varies for each community. It is used as a baseline from which local water levels can be measured (NOAA 2013). The regional tidal datum, inclusive of Charlotte County, is referred to as "CGVD28" and does not vary for each community. CGVD28 is a geodetic reference level that closely represents elevations above Mean Sea Level (MSL). In order to represent coastal water levels using the Geographic Information System (GIS) software, CD elevations must be calculated in terms of CGVD28 elevations. Mr. Daigle used the CGVD28 baseline in order to calculate the average of the maximum annual predicted tide over the 19 year tidal cycle for each community. This is referred to as the Higher High Water Large Tide (HHWLT). The 19 year tidal cycle for each community was provided to the working groups and is located under Meeting # 3 for each community.

TABLE 2: CALCULATIONS OF SEA-LEVEL CHANGE FOR SELECT CHARLOTTE COUNTY COMMUNITIES.

Anticipated change in relative sea-level (m)						
Location	**Global sea-level rise (2100)**	**Vertical motion (2100)**	**Total change (2025)**	**Total change (2055)**	**Total change (2085)**	**Total change (2100)**
St. Stephen	0.88 ± 0.24	0.00 ± 0.05	0.13 ± 0.03	0.35 ± 0.11	0.68 ± 0.21	0.88 ± 0.29
St. Andrews	0.88 ± 0.24	0.00 ± 0.05	0.13 ± 0.03	0.35 ± 0.11	0.68 ± 0.21	0.88 ± 0.29
Blacks Harbour	0.88 ± 0.24	0.04 ± 0.05	0.14 ± 0.03	0.37 ± 0.11	0.71 ± 0.21	0.92 ± 0.29
Grand Manan (North Head)	0.88 ± 0.24	0.06 ± 0.05	0.15 ± 0.03	0.38 ± 0.11	0.73 ± 0.21	0.94 ± 0.29

Mr. Daigle's sea-level rise projections are referred to as *extreme total sea-level flooding scenarios*. They incorporate the mean value of the HHWLT for each community, local crustal subsidence, anticipated global sea-level rise, and a storm surge return period component. A storm surge is the difference between the observed water level and the predicted astronomical tide. The magnitude of a storm surge depends on the nature of the meteorological event responsible for reduced atmospheric pressure and the strength of the winds associated with a particular event. This equation is represented in Figure 10. The extreme total sea-level flooding scenarios have been calculated to represent the worst-case flooding scenario in which a storm surge event would occur during a high portion of the tide cycle. In the opposite case where a storm surge event coincides with the low portion of the tide cycle, the chance of flooding is eliminated. The return period statistics have been calculated to represent the relative probability that a given storm surge value, also defined as *surge residual*, would coincide with the higher portion of the tide cycle. Because of the nature of the Bay of Fundy's "semi-diurnal" tide cycles, the duration of the high tide peak is short lived (changes of over 1m per hour) and hence the risk of flooding is reduced. As a result, the 1 in 100 year storm surge component for the Charlotte County coastal areas is 0.94m. Therefore there is a 1% relative probability of a storm surge event will reach 0.94m in any given year. This value is the same for each of the Charlotte County communities participating in this project as the storm surge value has been derived from the Saint John tide gauge statistics.

The flooding scenarios have been reproduced in the form of elevation contours (rounded to the nearest tenth of a metre) on LiDAR derived DEMs for the communities of St. Stephen, St. Andrews, Blacks Harbour, and Grand Manan. The resulting flooding scenario maps are included in Meeting #3 for each of the communities. The included extreme total sea-level flooding scenario maps prepared for each affected community are based on a 1 in 100 year flood event and are marked with colour-coded lines representing the extent of flooding for the years 2010, 2025, 2055, 2085, and 2100. For the additional extreme total sea-level flooding scenario maps (1 in 1 year, 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, and 1 in 50 year) produced by Mr. Daigle, please see attached memory stick.

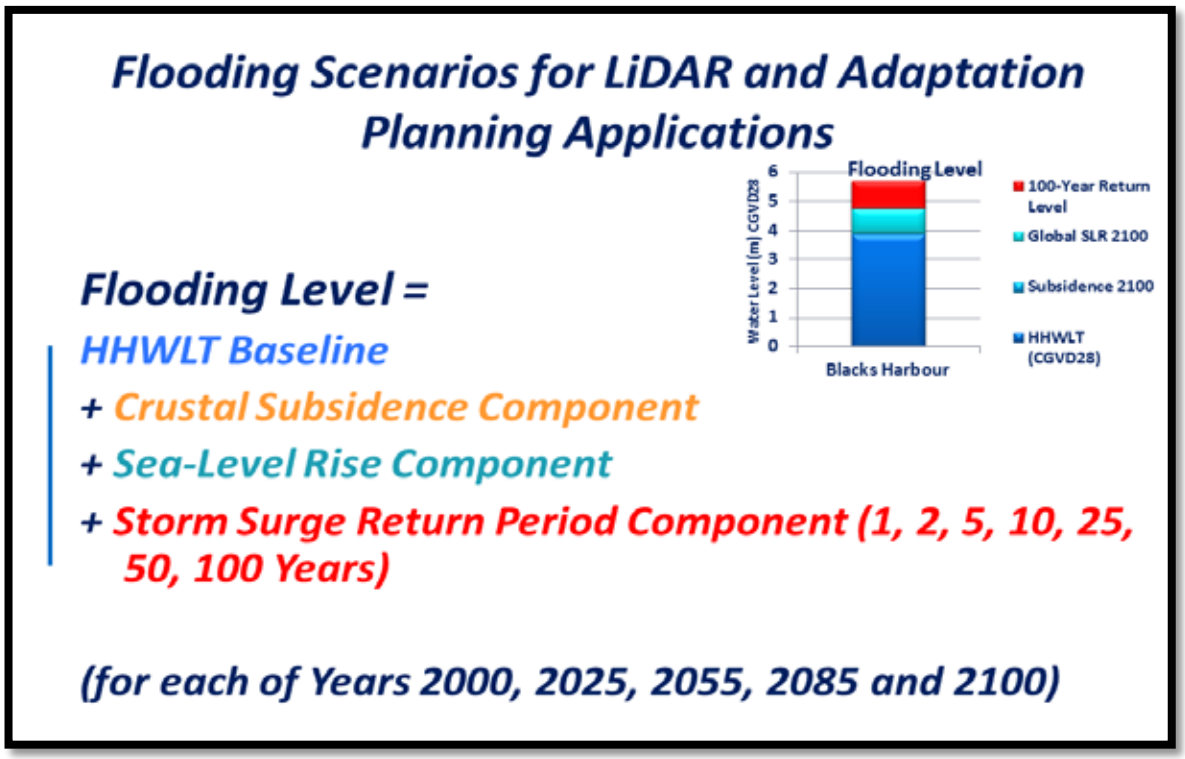


FIGURE 10: MR. DAIGLE'S METHOD OF CALCULATING THE EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS.

2.2.2 INLAND FLOODING

Wet-areas mapping (WAM) was produced for the participating Charlotte County communities to better understand inland flooding issues. They were prepared under the direction of Dr. Paul Arp, a forestry professor at the University of New Brunswick who coordinates research at the Forest Soil Laboratory and at the Forest Watershed Research Centre. The development of the WAM involved a systematic calculation of local flow channels and associated wet areas using DEMs. Two DEMs were used to create the WAM figures: a Provincial DEM for New Brunswick, at a 10m resolution, and LiDAR generated bare earth DEM, at a 1m resolution. The bare earth DEM was used to ensure trees and structures do not disturb the calculations. The DEMs were used to determine the topographic depth-to-water index (DTW), which projects how far the water table is located below the ground surface using open water surfaces such as lakes, rivers, streams and shores as DTW = 0 reference locations. These waterways are referred to as *flow channels,* see Figures 12 and 13 below. The elevation rise from the nearest open flow channel is calculated from the DEMs and used to estimate the local soil drainage conditions.

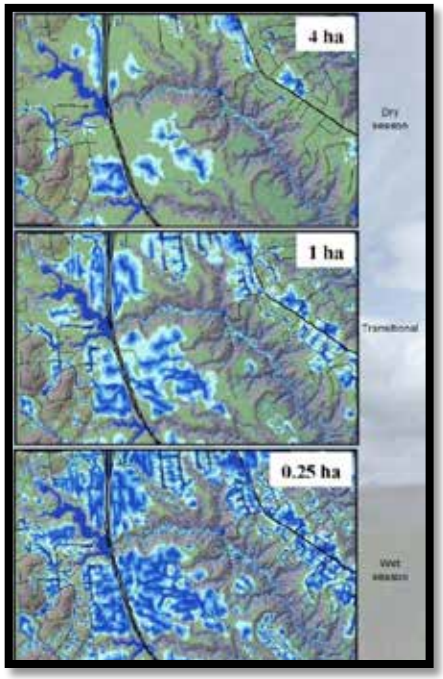


FIGURE 11: VARYING FLOW RATE INITIATIONS USED TO DESCRIBE GROUND SATURATION (SOURCE: ARP 2013).

To map the expansion and contraction of flow channels and the resulting wet-areas, the appropriate season and weather variables must be selected. Seasons produce variety in flow channels and ground saturation. The seasonal conditions are assigned a flow rate initiation value. Flow rate initiation is the

amount of land that must be drained to create a flow channel. In the late summer season, when the ground is dry, the flow rate initiation selected is 4ha, but during the spring freshet, when the ground is saturated, the flow rate initiation selected is 0.25 ha, see Figure 11 above. The difference in flow rate initiation means that in the spring there are many more flow channels therefore less land is required to initiate flow. For the CCCVA, a 4ha flow rate initiation was used simulating conditions at end of summer, when the ground is dry. WAM assumes all flow channels to carry water once the above-slope water-contributing areas exceed 4 ha, to approximate the general stream flow conditions. The WAM figures that were presented to the working groups can be found in their respective results sections. For 0.25ha initiation, please see attached memory stick.

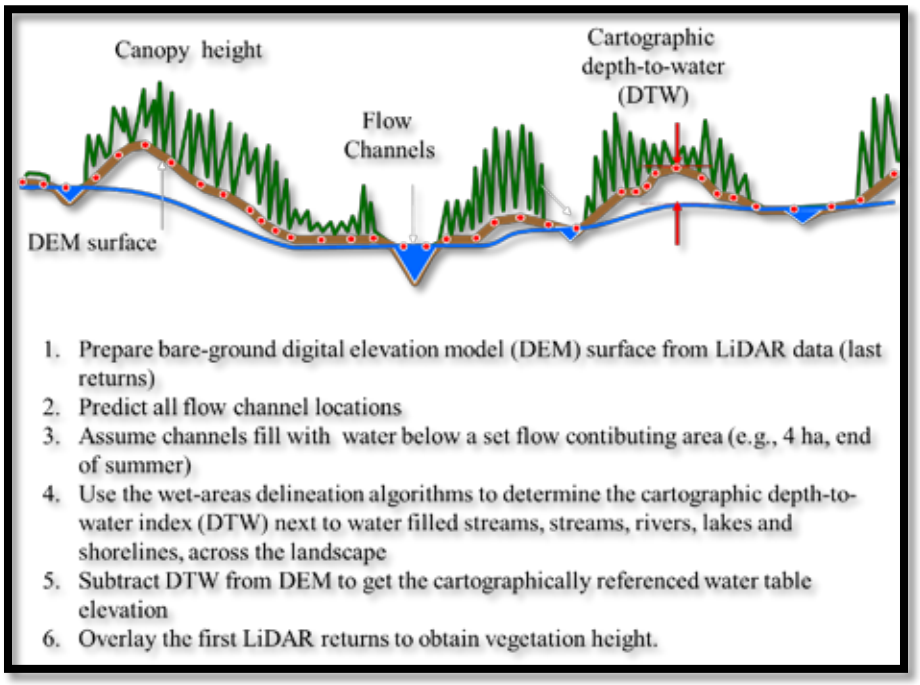


FIGURE 12: METHOD USED IN DETERMINING THE CARTOGRAPHIC DTW INDEX ACROSS LANDSCAPES (SOURCE: ARP 2013).

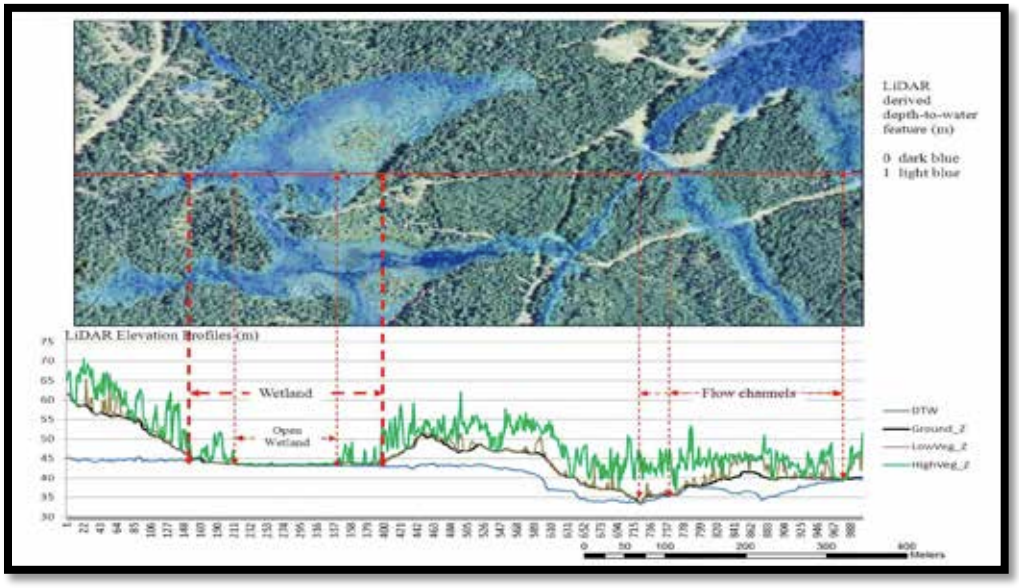


FIGURE 13: WETLAND DELINEATION IN RELATION TO DTW INDEX TOP AND SIDE VIEWS (SOURCE: ARP 2013).

2.3 CHARLOTTE COUNTY GENERAL MEETING

During the assemblage of the working groups for each municipality, a general meeting was held for the greater Charlotte County region. The meeting was attended by committed working group members, potential working group members, government officials, the media, and the public. This meeting introduced the CCCVA and provided scientific background information regarding climate change and the impacts that have been experienced throughout Charlotte County. The facilitators of the project, SCEP and ECW, were introduced and provided an overview of how they would perform their role, including the provision of knowledge and expertise from outside sources, and by leading the working groups in discussions and mapping exercises. Additionally, SCEP and ECW explained how their role as facilitators would include working alongside the members of the community working groups to ensure that their input would be used effectively to communicate existing concerns, how communities felt their energies could be best directed, and how recommendations could be appropriately incorporated into long-term planning strategies.

FIGURE 14: GENERAL MEETING IN ST. GEORGE SEPTEMBER 24, 2013.

The objectives of the CCCVA for each participating community were identified:

- assess physical, social, economic, and environmental climate hazard impacts
- discuss governance and policy issues relating to climate change and disaster management
- increase resilience to progressively withstand and recover from climate hazard impacts
- make recommendations for future adaptation to climate change and variability
- discuss resource and land use over the long term, under new environmental conditions
- increase awareness of the expected impacts of climate change and variability and how these impacts can be reduced or avoided

Based on these objectives, the working groups were asked to:

- increase their knowledge of climate change and variability and the associated impacts
- identify and prioritize climate related hazards
- identify and prioritize recommendations for future climate change adaptation
- communicate working group discussions to their respective communities

It was explained that the desired outcome of the CCCVA is increased resilience to the impacts of climate change in the participating communities, and that a resilient community is one that takes intentional action to enhance its capacity to respond to change.

To offer expert knowledge and to provide background information on climate change and the associated impacts in Charlotte County, presentations were delivered by Ms. Colette Lemieux, the climate change engagement and mainstreaming coordinator of the Climate Change Secretariat, New Brunswick Department of Environment and Local Government. Her presentation focused on climate change and climate change adaptation in New Brunswick and the concept of increasing resiliency. A presentation was also delivered by Mr. Réal Daigle, a meteorologist and climate change consultant with R. J. Daigle Enviro regarding climate change scenarios and climate change impacts, including coastal flooding in New Brunswick. From Environment Canada, Mr. Rick Fleetwood, a regional climatologist, discussed heavy precipitation events and flooding in New Brunswick and, specifically, Charlotte County. A survey was distributed at this meeting to collect information on the personal impacts of climate hazards, future concerns regarding climate hazard impacts in Charlotte County and any organizational action or attention to climate change/climate change adaptation. A copy of the survey is included as Figure A1 of the Appendix. The following sections (2.4 – 2.8) include the general methodology. Section 3 starts the description of specific methodology applied at the community level.

2.4 MEETING # 1: IDENTIFICATION OF CLIMATE HAZARDS AND IMPACTS TO INFRASTRUCTURE AND PHYSICAL STRUCTURES

Meeting # 1 was inclusive of the first two steps of the project process, as outlined in Table1. Definitions of the major terms to be used throughout the meeting process and a brief description of climate change, the IPCC, and climate change scenarios was provided to the working groups. The working groups then identified the climate hazards that they thought most pertinent to their community. Working group members were then asked to identify their home on the printed community map using numbered yellow sticker dots. This was done to encourage participation and to understand the distribution of working group members throughout the municipality. Next, using the community map, the working group members were asked to identify the physical impacts of each climate hazard that both have occurred and/or were of future concern. Working group members placed red sticker dots on these locations. A descriptive list of the numbered dots placed on each community map representing physical impacts can be found in the Appendix, in the red table under Meeting # 1 for each municipality.

Identifying infrastructure that has been or could be vulnerable due to the impacts of climate hazards is important for the creation of anticipatory adaptation measures. Identifying critical infrastructure and physical structures throughout the community allows for long term, strategic

planning for projected impacts. The *Climate Change Adaptation and Canadian Infrastructure* report from the IISD states that, "climate change has the potential to substantially affect the effectiveness and lifespan of infrastructure in Canada, particularly transportation, buildings, marine and water management infrastructure. The exposure and vulnerability of these different types of infrastructure varies greatly. Collectively, though, substantial economic costs have already been attributed to the impact of climate hazards on such infrastructure, and these costs are only expected to increase in the future. Adaptive measures can be taken to limit costs and strengthen the resiliency of infrastructure." By identifying past and potential future climate impacts to physical structures, the cost to repair or maintain municipal infrastructure can be reduced or avoided. In July 2013, the Department of Transportation and Infrastructure (DOTI) reported repair estimates of approximately $750,000 throughout Charlotte County due to the July 26, 2013 flood event. During this meeting, in the communities which have experienced less obvious climate hazard impacts to infrastructure and physical structures, working group members instead, identified critical structures and infrastructure.

2.5 MEETING # 2 IDENTIFICATION OF IMPACTS TO SOCIAL AND ECONOMIC SYSTEMS

In Meeting #2 the working group members were provided with the demographic statistics of their community, as reported in the 2011 census. The information provided was incorporated to identify the sensitivity, adaptive capacity, and vulnerability to climate hazards of the social and economic systems throughout the municipalities. Particularly in coastal zones, the effects of climate change have the potential to greatly impact social and economic systems due to increasing rates of coastal erosion, inundation and sea-level rise. Influences could be felt in economic sectors such as tourism, fisheries and aquaculture, agriculture, financial services, and social processes such as freshwater quality and supply, and human health. In a report by the Tyndall Centre for Climate Change Research entitled *Socio-economic futures in climate change impact assessment: using scenarios as 'learning machines',* the authors comment that "climate impact assessment requires a clear picture of two intimately interrelated processes: socio-economic change and climate change" (Berkhout, Hertin & Jordan 2001).

Working group members placed blue sticker dots on the community maps to mark social and economic impacts. These included the closure of businesses and schools, disruption of access to goods and services, the location of vulnerable individuals or groups, and the economic sectors that

have been or could be impacted. In municipalities where the selected climate hazards had not yet caused significant impacts, the working group members were asked to identify areas of economic and social activity in the community. A list of the numbered dots placed on each community map representing social and economic impacts and their description can be found in the Appendix in the blue table under Meeting # 2 for each municipality.

2.6 MEETING # 3 IDENTIFICATION OF THE GOVERNANCE AND POLICY ISSUES

In Meeting #3, the working groups were given information on governance and policy making structures in New Brunswick and asked to examine how climate hazards could be included in the policy and decision making process for adaptive planning in their community. As arbiters of policy implementation, government officials play a large role in the climate change adaptation process. They shape conditions that can alter adaptive capacity and vulnerability through policy and the decision making process (Smit & Wandel 2006). Government action for responding and adapting to the projected impacts of climate change requires modifications in how economic development, tourism, and social programs are managed. Inherent in community based adaptation planning is the role of local initiatives relative to transformations of geo-political-economic systems (Smit & Wandel 2006). Project facilitators guided working group discussions on how governance and policy could help to minimize the impact of climate related hazards on their community. The working group members discussed the local government response to previous climate hazard events, and the effectiveness of those responses. They also discussed how all levels of government are addressing the threat of future climate hazard impacts, suggesting governance factors that should be considered.

2.7 MEETING # 4 IDENTIFICATION OF ENVIRONMENTAL IMPACTS

Climate related hazards have the potential to affect a wide range of ecological systems including forests, grasslands, wetlands, rivers, lakes, and marine and coastal environments. Ecological processes can also be affected such as waste assimilation, nutrient cycling, and storm buffering. Climate hazard repercussions on the natural environmental are varied and may lead to greater burdens on the built environment. An example of this is coastal erosion, which can lead to impacts on nearby businesses, homes and infrastructure. Hard engineering options, such as the use of armour stone for shoreline protection, can be expensive and have a high level of influence on the landscape, but can serve as an immediate protection measure for the short term. However, soft engineering options, such as re-vegetation initiatives, can be less expensive, more ecologically sensitive, and offer longer term options for shoreline protection, if they can be established. Additionally, the ecosystem services that the environment provides must be protected and considered in long term planning strategies where they are at risk due to climate hazards.

The working group members in each participating municipality were asked to identify environmental impacts of climate hazards with green sticker dots on the community maps. These dots represented past effects on the environment and those of concern in the future. A list of the numbered dots placed on each community map representing the climate related environmental impacts and their description can be found in the Appendix in the green table for each municipality. The working group members discussed environmentally sensitive areas that have been or could be

affected by the climate hazards, environmental areas in need of protection, and areas that act as environmental buffers and could serve to protect their community during certain climate hazard events.

2.8 MEETING # 5 INTEGRATION, DEFINITION AND ANALYSIS OF OPTIONS TO REDUCE VULNERABILITY

In the final meeting, the working groups were asked to identify the most vulnerable areas of their community to climate related hazards and these were marked on a satellite image of their community. The groups were asked to identify these areas using the information presented throughout the meetings, the sticker dot clusters that could be seen on the community maps, and their personal experience. As vulnerability and adaptive capacity are unevenly distributed, socially and physically, the selection of the most vulnerable areas was of high interest within the working groups. The selections underscore the most critical needs for adaptation to climate change in the community. Once the most vulnerable areas were agreed upon, the working groups were asked to discuss how they felt they could incorporate what they had learned throughout the project process into the development of sound options for reducing the vulnerability. Working groups were engaged in an open discussion of options for further action, shaping a vision for climate change adaptation planning and analyzing how their specific issues could be addressed to reduce vulnerability. The recommendations proposed by the working groups were developed with the intention of facilitating further discussion with the larger community. Additionally, to serve as a starting point for aiding local governments in evaluating adaptation options that integrate the present and futures risks and opportunities. At the conclusion of Meeting #5 the facilitators thanked the group members for their assistance and discussed meeting once again to verify the results and conclusions contained in the final report.

3. MUNICIPALITIES

Charlotte County is located in southwestern New Brunswick (see Figure 17). It covers an area of 3,424 square kilometers (km^2). The population of the county, based on the 2011 Statistics Canada National Household Survey, was approximately 26,000. Charlotte County is inclusive of six municipalities including two island communities, Grand Manan and Campobello, as well as Blacks Harbour, St. Andrews, St. George, and St. Stephen.

Located on the International Boundary between New Brunswick, Canada and Maine, United States of America, Charlotte County extends north toward Fredericton and east toward Saint John. The St. Croix River serves as the lower part of the International Boundary and is designated as a Canadian Heritage River. Beyond the St Croix watershed, Charlotte County is also defined by the Magaguadavic and Digdeguash watersheds. St. Croix Island, in the St. Croix River, was the sight of settlements established by French explorers Samuel de Champlain and Sieur De Monts in 1604. With the help of the Passamaquoddy people, they were able to survive the winter. In 1784, the United Empire Loyalists arrived following the American War of Independence, joining the original settlers of the area (Town of St. Stephen 2010). Settlement throughout Charlotte County was

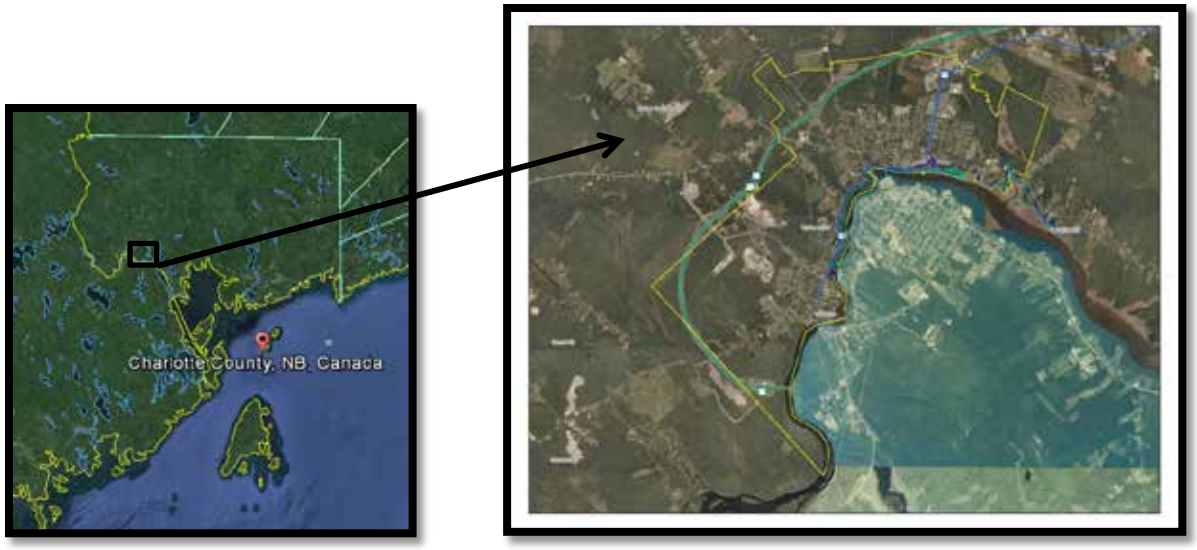
encouraged by the government following the war to deter possible American expansion into the area (SGAHAM 2009).

Previously in New Brunswick, governed areas were distinguished using parishes and counties however; local governance in New Brunswick is undergoing a substantial change. The province is redefining the local governance system, implementing the use of Regional Service Commissions (RSCs). Currently, residents receive services either from a local government (city, town, village, or rural community) or the provincial government (Local Service Districts (LSDs)). Some services are delivered by municipalities or rural communities themselves, while others are acquired or arranged for from service providers, including commissions, local volunteers, other municipalities, the private sector, and in the case of RCMP services, from the federal government. The provincial government has recognized that this approach to service delivery is inefficient and does not capitalize on the collective strength of neighbouring communities.

RSCs have been established throughout New Brunswick to enable communities to communicate with one another, to plan and prioritize from a regional perspective, collaborate on projects, cost-share on service delivery, make mutually-beneficial decisions on investments, and share expertise. Twelve RSCs have been established throughout the province. Charlotte County, as well as a small part of York County, has been included in RSC 10.

3.1 St. Stephen

St. Stephen is located at the estuary of the St. Croix River and the coast of Passamaquoddy Bay, see Figure 18 below. It covers an area of approximately 13.45km^2. The Town of St. Stephen was officially incorporated in 1871. In 1973 the municipalities of Milltown and St. Stephen were amalgamated and designated as the Town of St. Stephen (Government of NB 2014). The St. Croix River acts as the International Boundary, separating the towns of St. Stephen, New Brunswick and Calais, Maine. The two communities are connected at three international border crossings, Ferry Point International Bridge, the Milltown International Bridge, and the International Avenue Bridge (Town of St. Stephen 2010). St. Stephen is also home to Canada's oldest candy company, Ganong Bros. and has been deemed "Canada's Chocolate Town" (Town of St. Stephen 2010). The population of St. Stephen was approximately 4800 in 2011.



3.1.1 MEETING # 1

In Meeting # 1, the working group was first presented with an outline of the project process, an explanation of the major terms used throughout the meeting process and a brief description of climate change, the IPCC, and climate change scenarios. The working group members were given a summary of their survey responses, and were asked to identify the climate hazards that they would like to discuss throughout the course of the meetings. The Town of St. Stephen and nearby area was significantly impacted by both the December 2010 and July 2013 heavy precipitation events and, as such, the working group members decided that the climate hazards that they would like to discuss were *flooding* and *sea-level rise*. They indicated that they would also like to discuss *increased frequency of days over 30^{0}C*.

FIGURE 19: HIGH TIDE IN ST. STEPHEN (SOURCE: KRISTIE SIGNER).

It was discussed that St. Stephen has an aging infrastructure system and one of the main climate hazard impact concerns from the survey was *damage to public infrastructure*. The community has suffered with storm water management issues due, in part, to the use of Combined Sewer Overflows (CSOs) which direct both sewage and storm water runoff. CSOs in St. Stephen have been a source of complaint during flood events as extreme high tides have prevented the combined sewage and storm water overflow from entering the St. Croix River. Surcharging of the system has occurred in the downtown area of St. Stephen and was identified by the working group as a health and safety concern. Lines designated for only sanitary sewage have been impacted by inflow and infiltration of storm water which can cause back-

ups in residential basements during extreme precipitation due to increased loading. Many of the lines designated for storm water use have also been impacted causing capacity over-topping and overland flooding issues.

Many of the St. Stephen working group members had experienced significant damage during the recent heavy precipitation events and expressed acute concern during the discussion of physical and infrastructure impacts. They were eager to share their knowledge and identified areas of physical climate hazard impacts by marking the affected areas with red sticker dots on the community map, including information on the type and degree of impact. The impact numbers and descriptions are located in Table A1.1 of the Appendix under St. Stephen. The areas marked on the map were primarily past impacts of a physical nature. Also identified on the map, and in the accompanying table, were the 42 residential calls made to the local EMO during and after the 2010 and 2013 flood events. It was indicated by the working group that even though there were 42 calls reporting residential flooding to the local EMO, the number of residences impacted by flooding was much greater.

FIGURE 20: BILLY WESTON BROOK, ST. STEPHEN JULY 27, 2013 (SOURCE: ST. CROIX COURIER).

The working group identified the specific areas that had been repeatedly impacted by heavy precipitation. In some cases, studies had been undertaken or were planned to better understand how flooding impacts could be reduced or avoided. The municipality had commissioned studies at the Tan House Brook, the Bell subdivision, the area of West Street and Dow Street, and Thompson Avenue. The municipality has not undertaken a study of the Billy Weston Brook to date, in hope that a cost sharing arrangement can be made between the government and industry stakeholders. The working group felt strongly that the Billy Weston Brook and related infrastructure were contributing factors to flood impacts during the heavy precipitation events. In 2010, the flood waters from the Billy Weston Brook washed out the culverts behind Downey Ford and new culverts were installed. In July 2013, the fill supporting those culverts was removed to allow flood waters to flow freely, as seen in Figure 20. In the early 2000's, there was a railway trestle system in place at this location. The working group felt that the change from the trestle to the culvert system may represent a significant decrease in hydraulic capacity, and that the trestle was more effective for large volumes of water.

Other points that were raised by the working group in Meeting # 1:

- Road access issues during flood events were a major concern

- Border access due to State of Maine closures and flooding of the new border crossing at the traffic circle on the Maine side
- Major residential and commercial impacts throughout the community

3.1.2 MEETING # 2

In Meeting # 2, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercise from Meeting # 1. Abby Pond, a St. Stephen working group member, and the Executive Director of the St. Croix International Waterway Commission, provided information to the working group on how to identify social and economic impacts in their municipality. In her presentation, Ms. Pond presented information on the definition of socioeconomic impacts and the difference between disaster/risk management and adaptation. She also provided two examples of sample demographics, not represented on the working group, that should be considered when discussing socioeconomics including an elderly woman who lives alone in a historic home, and a young single mother who lives in an apartment. Following this, the working group members used blue sticker dots to mark areas on the community map where socioeconomic impacts have occurred or were of future concern with respect to the chosen climate hazards. The table outlining the number and description of the impact is located in Table A1.2 of the Appendix under St. Stephen.

The working group members in St. Stephen were very focused on discussing and addressing the social and economic impacts on the community. The economic and social impacts of the 2010 and 2013 flooding events were dispersed throughout the Town of St. Stephen and surrounding areas. Residents were displaced from their homes, businesses shut down, and access to services was restricted because of road closures. The working group members identified the clusters of senior living facilities and low income housing, recognizing that those groups may be more vulnerable to flooding and sea-level rise. It was noted by the working group that the economic impact of the flood events affected all levels of income earners. It was also noted that an increase in days over 30^0C will have a disproportionate effect on the older population of the community. Historical sites were also marked on the map, indicating that there were concerns for cultural heritage locations, and, consequently, the tourism industry. It was also noted that school closures had major socioeconomic repercussions because local schools are used as venues for community events and that there are some children who depend on school-based programs for their daily meals.

FIGURE 21: MEETING # 2 IN ST. STEPHEN (SOURCE: KIM REEDER).

The working group members were aware that low and fixed income earners are dispersed throughout the community and that their ability to recover from climate hazards may be further limited. The working group members acknowledged that they were intertwined with the socioeconomics of the town and that residents can often provide more help personally to those affected than the various levels of government can in the short term following a climate hazard event.

During the 2013 flood event, there were significantly fewer calls made to the local EMO than during the 2010 flood. The working group explained that some residents felt the town was unable to adequately respond and that it was their responsibility to deal with the impacts. There was confusion about insurance coverage with respect to flood impacts throughout the meeting. Issues mentioned include the variability of who is eligible for coverage, what types of coverage are available, and the cost. Additionally, some individuals who had insurance coverage, in full or part, have been threatened with the loss of coverage.

Other points that were raised by the working group in Meeting # 2 include:

- Communication before impact events (pre-planning as well as more imminent warnings) and during events was the major concern of the working group
- Facilities that offered social programs, seniors residences and multi-unit housing were identified on the map
- Recreational fields were an issue of concern and identified on the map
- There was a discussion of various buildings throughout the area that could be used as cooling centres in the case of days over 30^{0}C

3.1.3 MEETING # 3

In Meeting # 3, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises from Meeting # 1 and 2. The working group was then presented with information from Dr. James MacLellan, a Senior Research Scientist, and Project Leader for the New Brunswick Climate Change Research Collaborative, on how climate change adaptation is defined in simple systems. Dr. MacLellan discussed socioeconomic considerations and how statistical information on New Brunswick and St. Stephen can be considered with respect to climate change adaptation planning. The information presented by Dr. MacLellan included statistical information that was gathered from the 2011 Statistics Canada National Household Survey. He explained that community profiles, based on the census data, provided a snapshot of who lives in the community, their age,

FIGURE 22: QUEENSWAY STREET AT MILLTOWN BOULEVARD, ST. STEPHEN JULY 26, 2013(SOURCE: ST. CROIX COURIER).

income, profession, and sector in which they work and can help in deriving a general idea of what climate hazard impacts may be important to the community.

The census data provided by Dr. MacLellan indicated that the populations of the Town of St. Stephen and the St. Stephen Parish were each 4720 residents. St. Stephen has the highest population of any municipality that participated in this project and serves as the regional centre for Charlotte County with a diversity of services available. Dr. MacLellan's analysis of the local demographics indicated that, relative to provincial characteristics, the Town of St. Stephen had a high proportion of youth, with fewer residents in their 50's and in their 80's. Of the population dynamics presented, Dr. MacLellan commented that St. Stephen is a long established community with a percentage of third generation or greater residents which is substantially greater than the national average, but not as high as other Atlantic regions. St. Stephen is a relatively stable community in terms of mobility however parish residents are less mobile than the town's. The working group indicated that there had recently been an influx of residents moving from the parish into the town.

FIGURE 23: MEETING # 3 IN ST. STEPHEN (SOURCE: KIM REEDER).

Dr. MacLellan's analysis of the occupation by sector in St. Stephen revealed that it is largely diverse and relatively consistent with national and provincial statistics. In general, it is in line with a town that serves as a regional centre. As indicated in Figure 24, the manufacturing sector is important to the Town of St. Stephen and is far above national and provincial levels. The two major manufacturing operations are Flakeboard and Ganong Bros.

Dr. MacLellan commented that the income distribution pattern is consistent with the Atlantic region. House prices in the town and the parish are below the national, regional, and provincial averages with an even distribution of primary household maintainers. Additional information provided by Dr. MacLellan can be found in Figures A1.1 to A1.4 of the Appendix under St. Stephen.

Occupations by Sector (2011 NHS)

	CANADA	ATLANTIC CAN	NEW BRUNSWICK	CHARLOTTE County	St Stephen T	St Stephen P
Retail trade	11.6	12.4	11.9	9.7	14.5	13.3
Health care and social assistance	11.1	12.8	12.8	11.3	15.2	9.0
Manufacturing	9.2	7.6	8.6	16.3	16.6	21.9
Educational services	7.4	7.6	7.0	4.4	6.5	2.4
Public administration	7.2	10.3	10.2	7.0	6.5	8.6
Professional; scientific and technical services	7.1	4.5	4.2	2.3	2.8	0.0
Construction	6.9	7.5	7.5	9.4	8.6	9.5
Accommodation and food services	6.4	6.4	6.1	5.2	6.3	3.8
Transportation and warehousing	4.7	4.5	4.9	4.9	5.6	6.7
Other services (except public administration)	4.6	4.5	4.6	4.9	3.5	6.7
Finance and insurance	4.4	3.0	3.4	1.0	0.7	1.9
Wholesale trade	4.2	3.0	3.1	1.0	0.0	0.0
Admin. support; waste mngt $ remediation ser.	4.1	4.6	4.9	3.5	2.8	2.4
Agriculture; forestry; fishing and hunting	2.5	4.2	4.0	13.6	4.9	7.1
Information and cultural industries	2.4	1.9	1.9	0.6	1.6	0.0
Arts; entertainment and recreation	2.1	1.7	1.6	1.3	0.9	0.0
Real estate and rental and leasing	1.8	1.3	1.1	1.0	0.5	0.0
Mining; quarrying; and oil and gas extraction	1.5	1.5	1.2	0.3	0.0	0.0
Utilities	0.9	0.8	1.0	2.5	0.5	1.9
Management of companies and enterprises	0.1	0.1	0.1	0.0	0.0	0.0

FIGURE 24: OCCUPATIONS PERCENTAGE BY SECTOR COMPARISON FOR THE TOWN OF ST. STEPHEN AND THE ST. STEPHEN PARISH, VARIOUS CELLS WERE HIGHLIGHTED FOR DISCUSSION (SOURCE: DR. JAMES MACLELLAN).

Total number of private households by age group of primary household maintainers (NHS 2011 Stats Can) & Dwelling Value.

Home Maint (age Group)	CANADA	ATLANTIC CAN	NEW BRUNSWICK	CHARLOTTE County	St Andrews T	St Stephen T	St Stephen P
Under 25 years	3.4	3.5	3.6	2.9	9.4	4.4	0.0
25 to 34 years	14.4	12.4	12.7	9.9	4.7	10.9	6.6
35 to 44 years	17.9	16.6	16.7	16.8	11.8	17.4	24.3
45 to 54 years	22.7	22.0	21.8	21.4	18.8	20.5	25.7
55 to 64 years	19.2	21.0	20.9	21.5	19.4	20.0	21.7
65 to 74 years	12.2	13.7	13.4	13.6	12.4	9.1	11.2
75 years and over	10.2	10.9	11.0	13.8	24.1	17.9	7.9
Median value of dwellings ($)	280552	159687.5	139537	120010	190226	125051	120158
Aver. value of dwellings ($)	345182	179376.5	153484	142713	209749	126580	126294

FIGURE 25: TOTAL NUMBER OF PRIVATE HOUSEHOLDS BY AGE GROUP OF PRIMARY HOUSEHOLD MAINTAINERS AND DWELLING VALUE FOR THE TOWN OF ST. STEPHEN AND THE ST. STEPHEN PARISH (SOURCE: DR. JAMES MACLELLAN).

Following Dr. MacLellan's presentation, the working group was presented with information on sea-level rise for the St. Stephen area by Réal Daigle, a New Brunswick based meteorologist and climate change consultant with R. J. Daigle Enviro. Mr. Daigle began by describing the science that informs his analysis and included summaries of the IPCC Fifth Assessment Report (AR5) and the development and use of Representative Concentration Pathways (RCPs) that replaced the Special Report on Emission Scenarios (SRES) in the preceding Assessment Reports. The RCPs are greenhouse gas concentration trajectories that are used to model various climate change impacts such as sea-level rise. He presented the LiDAR-based DEM for the St. Stephen area, as shown in Figure 26.

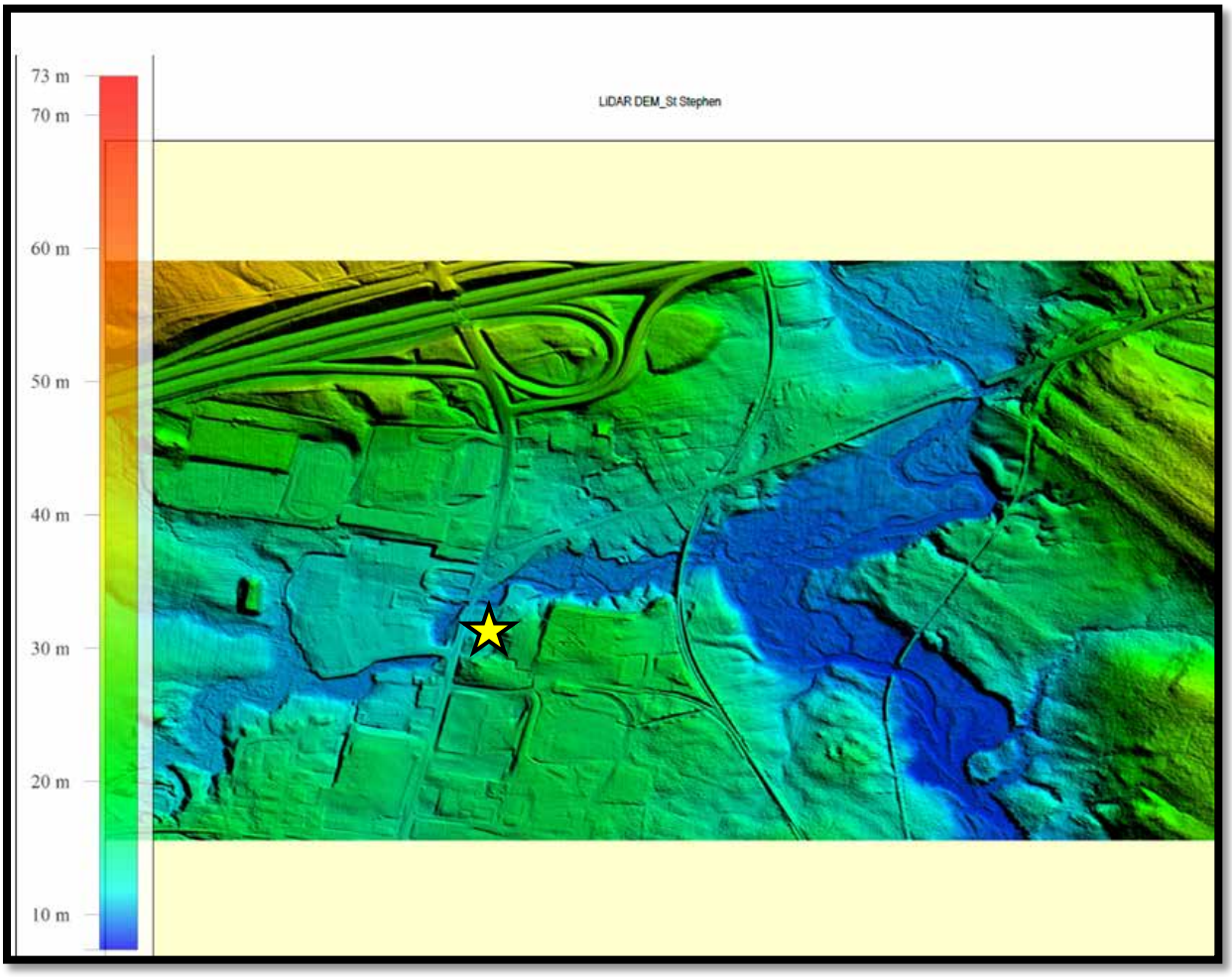


FIGURE 26: DEM FOR THE UPPER KING STREET AREA OF ST. STEPHEN IN THE VICINITY OF THE TRAFFIC CIRCLE. STARRED AREA IS THE APPROXIMATE LOCATION OF THE KING STREET IRVING (SOURCE: DAIGLE 2013).

Mr. Daigle used the DEM to make projections of sea-level rise into the future incorporating information from the IPCC, the extreme high tide value (HHWLT), crustal subsidence, and varying storm surge return periods. The HHWLT is determined using the average of each of the annual maximum predicted tide values over a 19 year tidal cycle as shown in Figure 27. A further explanation of how Mr. Daigle made his calculations can be found in the Methodology section.

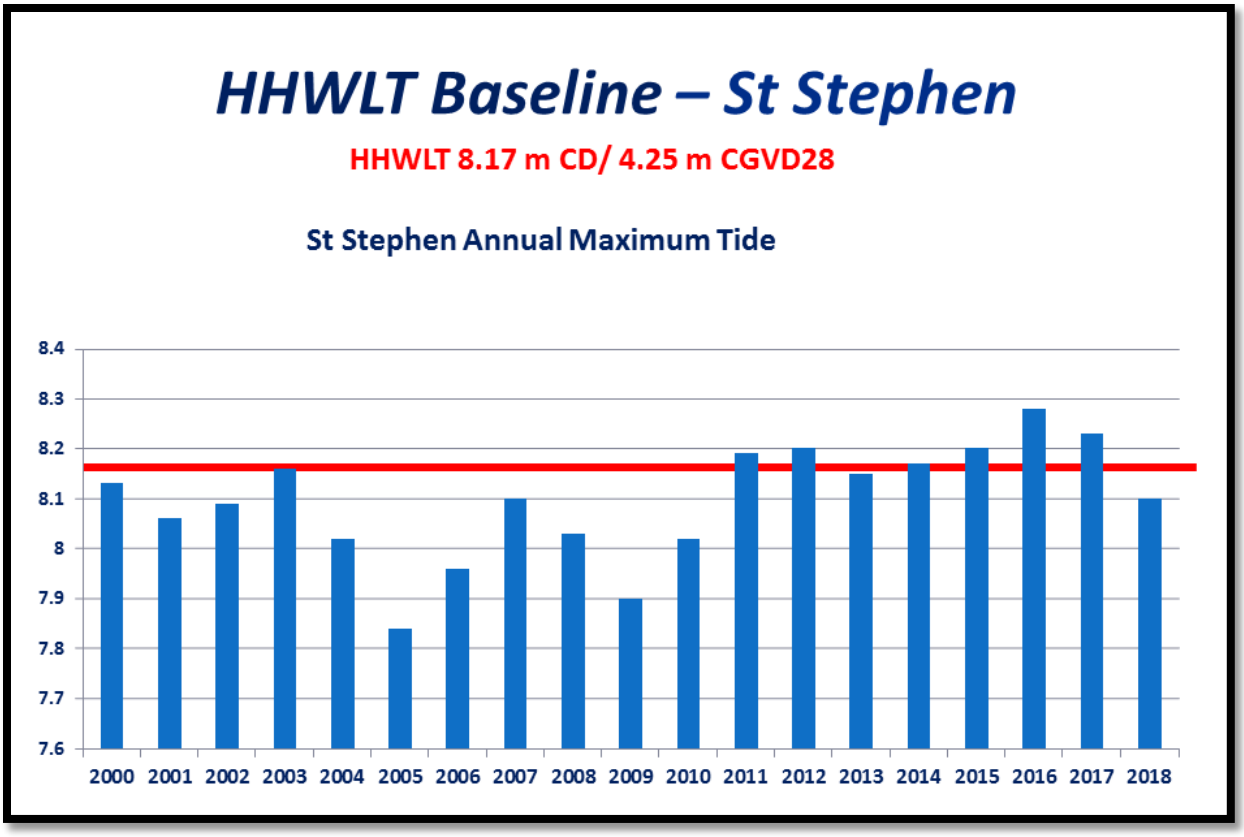


FIGURE 27: 19 YEAR TIDE CYCLE FOR ST. STEPHEN, THE RED LINE ILLUSTRATES THE AVERAGE VALUE OF THE HHWLT: 8.17M CD/4.25M CGVD28 (SOURCE: DAIGLE 2014).

Mr. Daigle developed extreme total sea-level flooding scenarios for St. Stephen; the value is given for the vertical height in meters from the CGVD28 baseline along with a margin of error for the estimates as shown in Table 3 below. Estimates of the anticipated changes in total sea-levels for the time frames of 2010, 2025, 2055, 2085 and 2100, represented in Table 3, are meant to represent the worst case flooding scenario resulting from the simultaneous occurrence of a significant storm surge event for the respective return-periods and a high astronomical tide (HHWLT) at a given location. Of note in Table 3, with an estimated sea-level increase of 0.88m by 2100, the present day 1 in 100 year flooding scenario (5.19m) becomes an annual event between 2055 and 2085.

TABLE 3: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR ST. STEPHEN (SOURCE: DAIGLE 2014).

Zone 11: St Stephen HHWLT 4.25 m (CGVD28)						
Return Period	**Surge Residual**	**Level 2010**	**Level 2025**	**Level 2055**	**Level 2085**	**Level 2100**
1-Year	0.47 ± 0.20	4.72 ± 0.20	4.85 ± 0.23	5.07 ± 0.31	5.40 ± 0.41	5.60 ± 0.49
2-Year	0.54 ± 0.20	4.79 ± 0.20	4.92 ± 0.23	5.14 ± 0.31	5.47 ± 0.41	5.67 ± 0.49
5-Year	0.64 ± 0.20	4.89 ± 0.20	5.02 ± 0.23	5.24 ± 0.31	5.57 ± 0.41	5.77 ± 0.49
10-Year	0.71 ± 0.20	4.96 ± 0.20	5.09 ± 0.23	5.31 ± 0.31	5.64 ± 0.41	5.84 ± 0.49
25-Year	0.80 ± 0.20	5.05 ± 0.20	5.18 ± 0.23	5.40 ± 0.31	5.73 ± 0.41	5.93 ± 0.49
50-Year	0.87 ± 0.20	5.12 ± 0.20	5.25 ± 0.23	5.47 ± 0.31	5.80 ± 0.41	6.00 ± 0.49
100-Year	0.94 ± 0.20	5.19 ± 0.20	5.32 ± 0.23	5.54 ± 0.31	5.87 ± 0.41	6.07 ± 0.49

The colour-coded lines on the map represented in Figure 28 are indicative of the extreme total sea-level flooding scenarios for a 1 in 100 year (1% chance of occurrence in any given year) storm surge return period for the years 2010, 2025, 2055, 2085 and 2100 along the St. Stephen waterfront. There is an additional line representing the year 2100 flooding scenario with the uncertainty factor. It should be noted that the aerial photograph used in Figure 28 does not represent the water level at high tide, however, the contours are not influenced by this.

For the additional extreme total sea-level flooding scenario maps for St. Stephen (1 in 1 year, 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, and 1 in 50 year) produced by Mr. Daigle, please refer to the included memory stick.

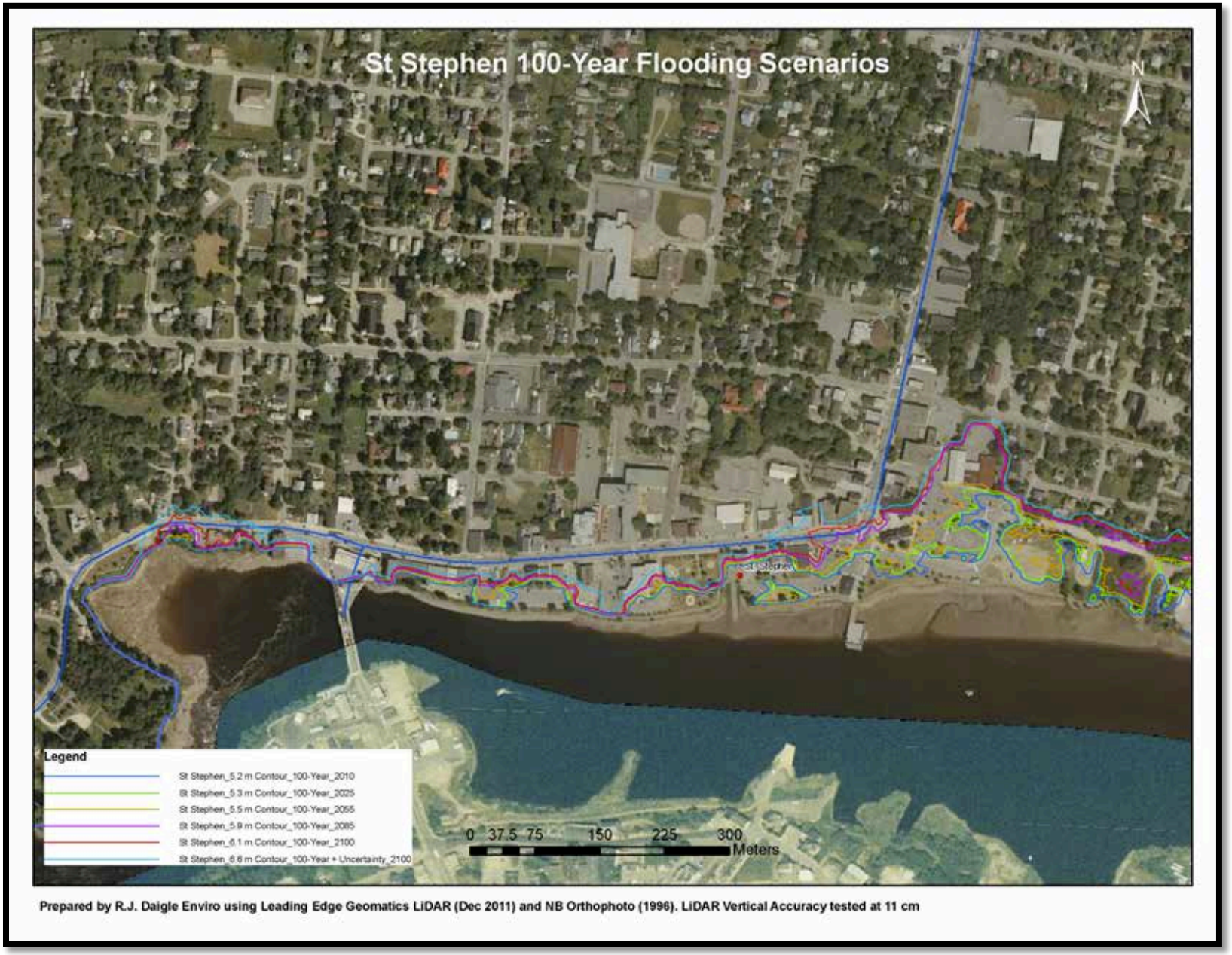


FIGURE 28: ST. STEPHEN EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR STORM SURGE RETURN PERIOD (SOURCE: DAIGLE 2014).

The working group indicated that the sea-level rise mapping presented by Mr. Daigle resembled the St. Stephen shoreline prior to the town infilling the land around the St. Croix River. It was discussed that when some buildings were constructed they sat on piers to allow for access of deliveries by boat directly into the buildings. Concerns were expressed regarding the hotel and civic centre under development along the shoreline, as well as historical buildings on the waterfront that will suffer impacts if an extreme precipitation event were to occur following the projected sea-level rise. It was noted that currently many buildings on Milltown Boulevard already suffer damage during extreme high tides.

After the presentations, the working group engaged in a discussion regarding local governance and policy. It was mentioned that in 2013 the Town of Calais, Maine declared a State of Emergency which closed the International Boundary crossings for approximately four hours. Based on emergency services memorandums of understanding (MOUs), if the border crossings are closed during an emergency situation, emergency service vehicles are allowed to cross the border if they are lighted and sirened. It is also expected that emergency vehicles would be allowed to cross the border to access fuel if necessary considering the one hour time difference. In the past, the Milltown Irving station has stayed open late in order to allow emergency vehicle fueling and access to food for emergency responders.

Each of the dams along the St. Croix River has an up-to-date emergency plan which includes international notification procedure in the case extreme weather event impacts. The Milltown Dam is a run-of-the-river dam and its emergency preparedness plan, although not provided to the facilitators by NB Power the dam owners and operators, does not include any extreme weather events or flow forecasting. The Milltown Dam is classified as a low hazard dam with no chance of flooding in a dam breach scenario by the Maine Emergency Measures Association (personal communication Jeff Babcock, Supervisor of Maintenance, Operations Dept., NB Power, February 2014). During the 2013 flood event, the upriver dam reservoirs were already full which prompted action by Woodland Pulp LLC to open all nine gates at the Grand Falls dam. The local EMO coordinator commented in local news interviews, that having all nine gates opened was an unprecedented event. A number of residents along the St. Croix River in St. Stephen and in areas between Upper Mills and Oak Bay were visited by the RCMP and fire department and were warned to evacuate or shelter-in-place based on the perceived risk of the river flooding into those homes.

Dams along the St. Croix River are controlled by American industry upstream of the Milltown Dam. The Milltown Dam is controlled by NB Power. Woodland Pulp LLC, the owner and operator of the remaining St. Croix River dams, has several measures in place to address extreme weather events and welcomed the opportunity to provide their emergency planning documents. While these measures were not specifically designed with climate change in mind, they were developed to address extreme weather events. One of the original main purposes of the entire storage system (six major dams) was to provide downstream flood control. The original architects of the system considered extreme weather when the dams were built. The Woodland Dam's Emergency Action Plan includes inundation mapping from the Woodland Dam to downtown Calais, Maine as well as an Investigation and Analysis of "Dam break Floods". The owner and operator of the Woodland Dam, Woodland Pulp LLC, has no police or civil power, it is the responsibility of various

governmental agencies and departments to provide emergency services in the wake of an emergency event. It is the responsibility of Woodland Pulp LLC to provide the most up-to-date information possible to these organizations.

The working group indicated that the St. Croix Courier Facebook page was one of the only sources of up to date information during both the 2010 and 2013 flood events, especially regarding road closures. The Government of New Brunswick's Department of Transportation and Infrastructure webpage was also updated to reflect road closures.

3.1.4 MEETING # 4

In Meeting # 4, the working group members were given an overview of the previous three meetings and asked to verify the information collected before Mr. Manzer Young, the Building Inspector and Bylaw Enforcement Officer for St. Stephen, St. Andrews, and Blacks Harbour, provided information on his role within the community. Mr. Young spoke about the in-filled land adjacent to the St. Croix River and answered questions about "unsightly property". He commented that if a property is deemed legally "unsightly", any cost incurred in the determination or legal proceedings is reimbursed to the town by the provincial government. The property is then owned by the province but often the ownership is ultimately reverted back to the municipality. A working group member commented that these types of properties should be considered for storm water retention sites. Mr. Young advised that public awareness is paramount in order to mitigate water runoff from homes and suggested that residents could install rain barrels, proper gutter systems, and buffer gardens. Mr. Young also shared storm water initiatives that are ongoing in other communities including the Halifax Regional Municipality.

Based on discussions with working group members, facilitators organized a meeting, which was open to the working group members, with Lee Johnson, the Acting Chief Administrative Officer, Director of Operations, and the Development Officer for the Town of St. Stephen. This meeting was held to review the status of work underway by Dillon Consulting Ltd, an independent consulting company reviewing some of the recent flooding impacts. The information shared by Mr. Johnson was summarized by the facilitators including:

- Due to the extent of flooding in the Bell subdivision, the Dillon Consulting Ltd. report will complete a focused assessment on the suspected causes of basement flooding that occurred on Bell Avenue, and will locate sources of inflow and infiltration into the sanitary sewer system that results in surcharging during heavy precipitation events
- The Dillon Consulting Ltd. report is also being undertaken to determine any common factors that resulted in sewer backup and/or basement flooding at the 42 reported locations within the community during the 2010 and 2013 flood events
- Currently, locations on Milltown Boulevard and the Tan House Brook are included in a five year plan for culvert upgrades

Other points that were raised during Meeting # 4:

- There is a need for the municipal council to support and create a budget for enforcement of bylaws; currently, enforcement is complaint driven

- In January 2014, the Provincial Government planned to enact the New Brunswick Building Act which would ensure that the qualifications of building officials would be mandated. That date has passed without enactment and further delays are expected. A number of working group members mentioned that they are under the understanding that there are currently no specific staff, at the Provincial level, in place to work through the enactment process
- St. Stephen has a backflow prevention system bylaw for all new construction, however, in existing homes, it is only if the homeowner affects the drain tile during renovations or construction, that a backflow system must be installed
- The National Building Codes for 2015 are currently being written (National Building Codes are updated every 5 years), New Brunswick has not yet adopted the 2010 National Building Codes and is currently using those from 2005. There was concern that by not adopting updated standards, the community may be missing out on mitigation opportunities

3.1.5 MEETING # 5

In Meeting # 5, the St. Stephen working group was presented with information on inland flooding. The inland flooding maps were prepared using the LiDAR information and were analyzed to exhibit the DTW using a specified flow rate initiation of 4ha, representing the end of summer ground saturation. Inland flooding maps (DTW/WAM) were prepared to help the working group understand unseen vulnerabilities related to the depth to water. Figure 29 represents the WAM for the Town of St. Stephen only. Dr. Arp interpreted this map for the facilitators, who then shared this information with the community working group members.

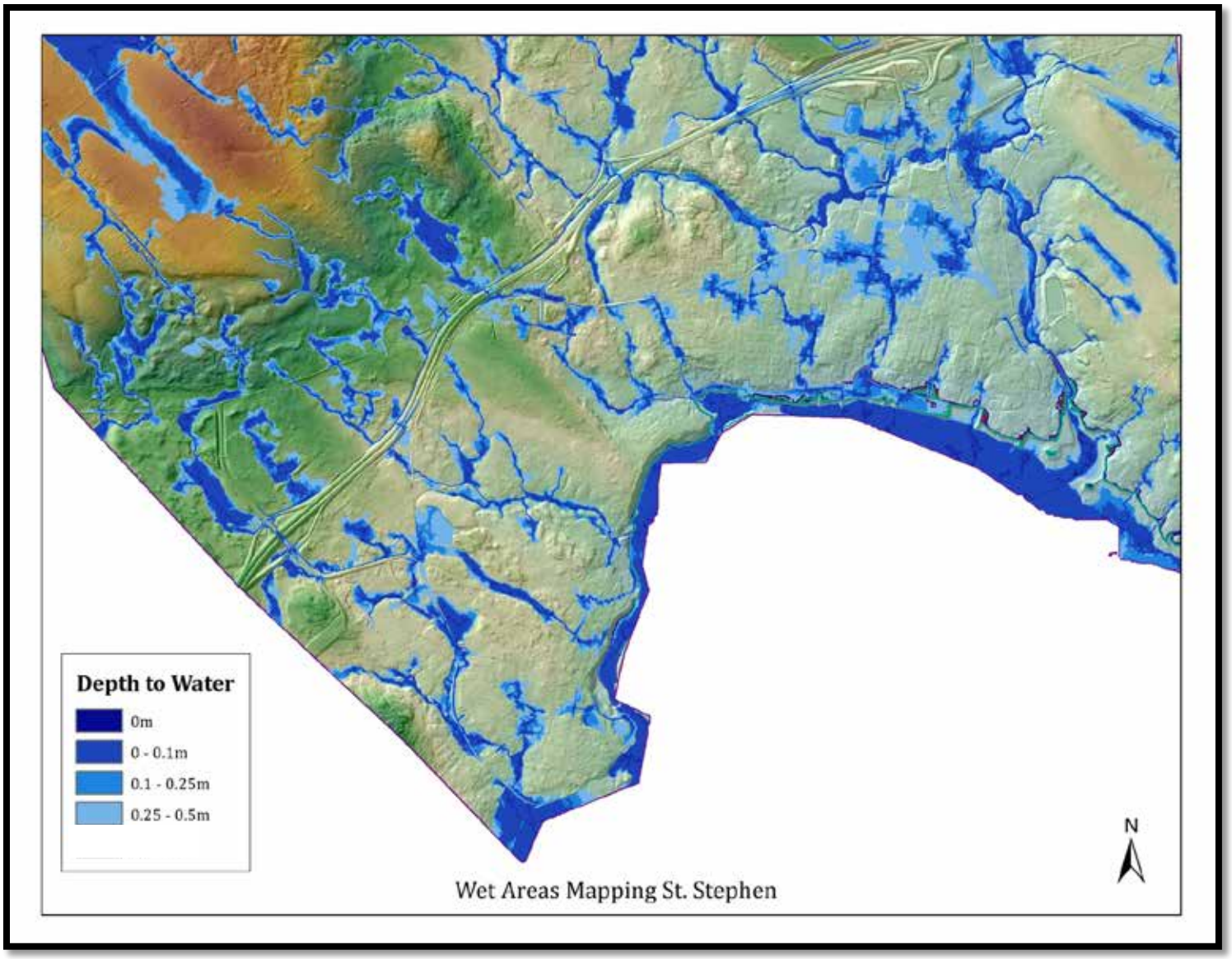


FIGURE 29: WAM 4HA INITIATION, FOR THE TOWN OF ST. STEPHEN (SOURCE: ARP 2013).

The map illustrated in Figure 30 was presented to the working group by overlaying it on the community map that was marked to highlight impacted areas using a projector screen image. This allowed the working group members to identify areas where the DTW could be resulting in more significant flooding. Dr. Arp noted that over 1500ha drains into the Billy Weston Brook culverts behind Downey Ford. The working group commented that the WAM should be available to real estate agents and considered during land use planning. Additionally, they mentioned that as the culverts in the Billy Weston Brook behind Downey Ford drain the largest volume of water in St. Stephen, specific attention is required in this area.

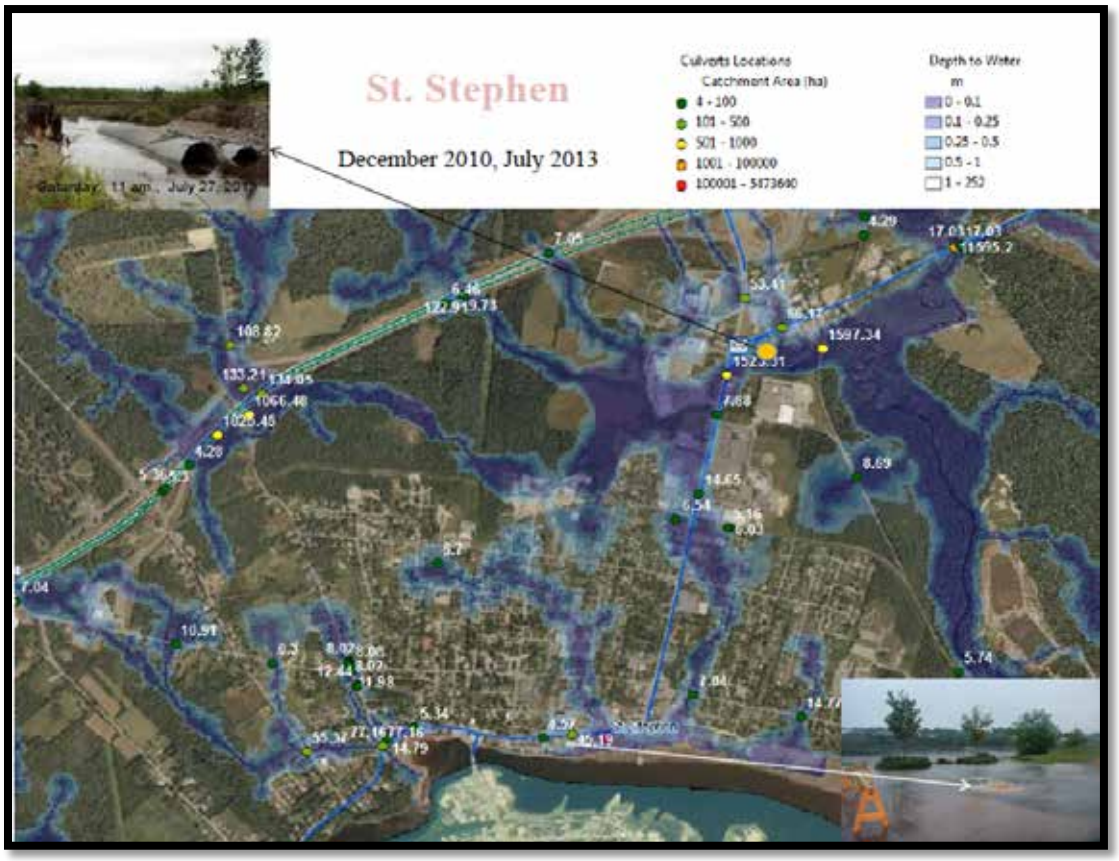


FIGURE 30: DTW OVERLAY ON A ST. STEPHEN AERIAL PHOTOGRAPH, REVEALING AREAS SUBJECT TO FLOODING, WATER POOLING, AND SURFACE WATER FLOW; CATCHMENT AREAS ABOVE ROAD-STREAM CROSSINGS. THE NUMBERS ON THE MAP ARE USEFUL FOR ESTIMATING THE MAXIMUM AMOUNT OF WATER (M^3/DAY) THAT POTENTIALLY FLOWS TO AND THROUGH ANY OF THESE LOCATIONS [=0.1 (TOTAL DAILY RAIN + SNOWMELT IN MM) X CATCHMENT AREA IN HA] (SOURCE: ARP 2013).

Environmental impacts due to the climate hazards were then discussed. *Green sticker dots* were placed on the community map representing past impacts on the environment and those of concern into the future, as well as areas effective as buffers. A list of the numbered dots placed on the community map representing environmental impacts and their description can be found in the Appendix under St. Stephen Meeting # 5 in the green table. Highlights from the environmental mapping included wildlife habitat, various unresolved contaminated lots, and densely vegetated areas within the community. A digitized version of the community map has been created using Google Earth to indicate the location of all of the coloured dots were placed on the community map in St. Stephen as illustrated in Figure 31 below.

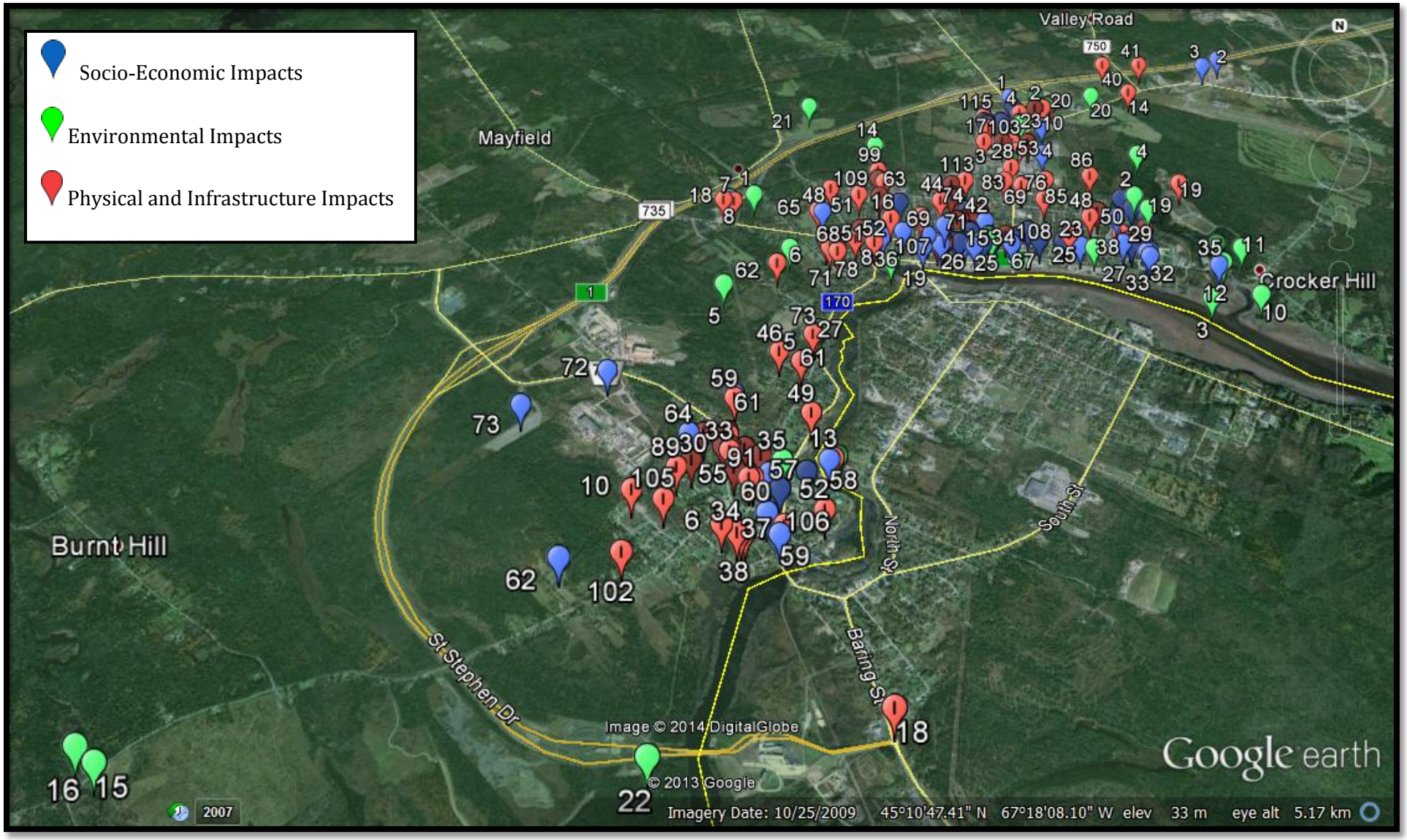


FIGURE 31: RESULTS OF THE COMMUNITY MAPPING EXERCISE FOR ST. STEPHEN (CREDIT: TANYA ANDERSON).

Working group members were then asked to discuss how they could incorporate what they had learned into the development of options for reducing the vulnerability of their community to the impacts of the climate hazards chosen. There was an open discussion which allowed for the determination of issues requiring further study in order to move forward with climate change adaptation planning, as well as initiatives that could potentially be started right away. The working group identified major areas that they felt were the most vulnerable within their community, based on the mapping exercises, previous discussions, presenter information, and their personal knowledge. Figure 32 below is representative of these areas.

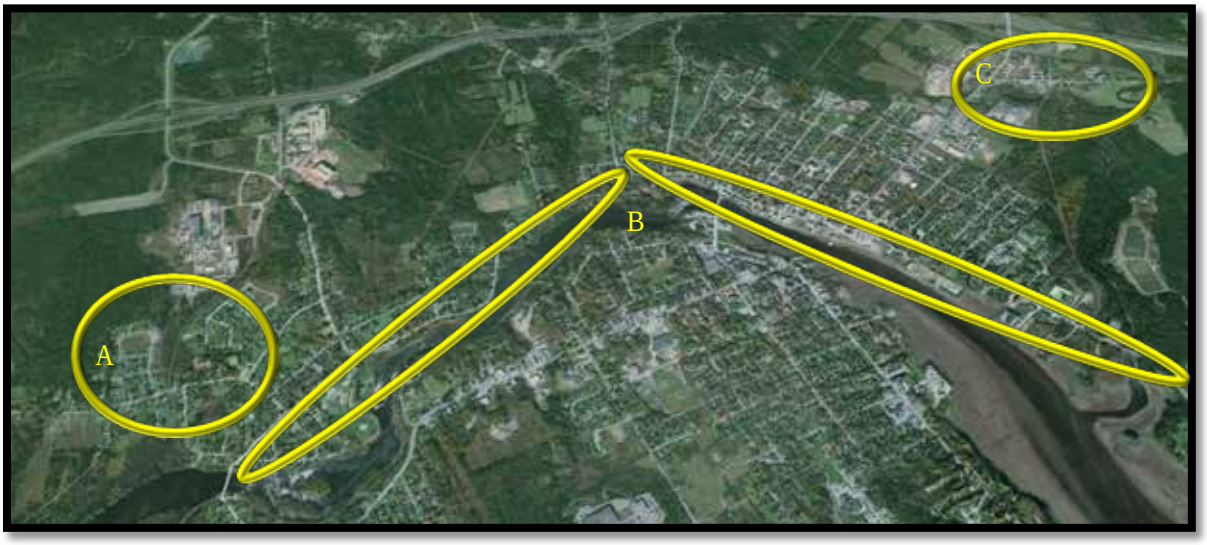


FIGURE 32: MAP OF VULNERABLE AREAS FOR ST. STEPHEN AS DETERMINED BY THE LOCAL WORKING GROUP.

The vulnerable areas chosen, as represented by the yellow circles, are as follows from left to right:

- A> The Bell subdivision, the Tan House Brook, and the Doodle Brook
- B> The areas adjacent to the St. Croix River, extending from the Milltown Dam to the Axe Factory, approximately three blocks inland
- C> The Billy Weston Brook through the residential and commercial areas to the Dennis Stream

Other points that were raised in Meeting # 5:

- The benefit of the MacNicol and other conservation properties along the St. Croix River
- Questions were raised about the existing Sawdust Islands, by the "Narrows" in the St. Croix River remaining from the log-driving days
- The lift stations for sewage have no back-up power
- Downtown has no environmental buffers, the large permeable area existing at Budd Avenue will soon house a hotel and the other large buffer area at the riverside is a brownfields site
- Glass eel (*Anguilla rostrata)* fishery exists in some years in the Dennis Stream and the St. Croix River and is highly regulated due to the status of the American Eel
- The Species at Risk Act (SARA) listed Inner Bay of Fundy (*Salmo salar)* (St. Croix wild return record at Milltown Dam of only two grilse and 2 adult in 2006) and the SARA listed Atlantic

Sturgeon (*Acipenser oxyrinchus oxyrinchus)* have both been recorded in the St. Croix River, into which the Billy Weston eventually discharges

- The Billy Weston Brook, which discharges directly into the New Brunswick defined Ecologically Significant Area (ESA 816) Dennis Stream, was determined to have acceptable dissolved oxygen and temperatures for salmonid. 2005 electro-fishing results determined that the Billy Weston Brook hosted the SARA listed species American Eel (*Anguilla rostrata)* and the salmonid Brook Trout (*Salvelinus fontinalis)* amongst other species
- Need for communication plan, community action group, redundant systems coordinated with provincial system for emergency services/disaster response planning
- Need for the community to monitor emergency response and be involved in debriefings
- Emergency plan, standard operating procedures (SOPs) need to be updated
- Accurately record flood damage, develop a community forum for continual data collection for flood impacts
- General recommendation: water runoff collection education for the community; homeowners guide to better water management on personal property

The working group members were thanked for their participation in the project and discussed a final meeting to verify the results and conclusions of their section of the report.

3.1.6 CONCLUSIONS

In St. Stephen, the working group members were made up of residents from St. Stephen and the surrounding area that had been significantly impacted by the heavy precipitation events of July 2013 and December 2010. The discussions focused more on disaster risk reduction than climate change adaptation planning. However, their contribution to the discussions throughout the meeting process were very helpful in identifying vulnerable areas and what next steps should be taken to increase the resilience of their community to the impacts of climate related hazards. The areas they identified as being most vulnerable to the climate hazards of flooding and sea-level rise, as discussed in Meeting # 5, are:

- The Bell subdivision, the Tan House Brook, and the Doodle Brook
- The areas adjacent to the St. Croix River, extending from the Milltown Dam to the Axe Factory, and inland three blocks
- The Billy Weston Brook through the residential and commercial areas to the Dennis Stream

The working group members were concerned with the scope of the Dillon Consulting Ltd. report. The report will address flood related issues in the Bell subdivision, and determine if there was a connection between residential flooding issues during the 2010 and 2013 flood events based on the 42 calls to the local EMO. However, during the working group meetings, it became evident that many impacted residences were not reported to the local EMO as residents felt that it was their personal responsibility to deal with flood impacts and that the local EMO did not have the capacity to respond. Also, the Dillon Consulting Ltd. report does not seek to address issues related to the Billy Weston Brook however, based on flood related impacts, the working group felt that priority should be given to a study of that waterway.

The working group indicated that the replacement of infrastructure is a long term priority for community members because many residences were impacted by storm water runoff and surcharging of the system including the impact associated with high tides and CSOs. Such localized infrastructure issues as well as vulnerability to flooding as a result of dam management up river involves multiple actors which requires the municipal council to consult with local residents and examine the multi-level and trans boundary governance aspects of their vulnerability. However, updating or replacement of infrastructure comes with large costs, and resources have not yet been identified. The working group felt as though there was a need for better access to information both before, during, and after flood events and that communication, in general, was lacking with respect to flood events.

3.1.7 RECOMMENDATIONS

The recommendations made by the working group were well developed and based on their personal knowledge of the community. With respect to communication, the working group felt that dam control, dam health, and flood response information from dam operators should be explained to the public, including how the water levels/flows from the dams are decided, what happens during a flood event, and what that means for property owners along the river.

There were many recommendations on the replacement of aging infrastructure, or updating infrastructure in need of improvement. The working group discussed that development plans should consider high water marks from previous events regarding inland flooding and consider the installation of culverts that exceed minimum recommendations (greater than the 1 in 100 year storm scenario). The priorities for short term work should focus on areas where infrastructure is causing flooding/environmental problems presently. Concurrently, changes to zoning bylaws should be updated and/or created in response to projected 2100 water levels for both sea-level rise/storm surges. These bylaws should be developed to include a minimum building height above projected 2100 high water levels as well as minimum heights for electrical and mechanical for any new development. Also, a location-specific list of actions needs to be developed regarding how to increase the resilience of existing impact prone locations.

A hydraulic study of the Billy Weston Brook was identified as the most pressing need. The working group unanimously agreed that specific attention to Billy Weston Brook was needed to address the concern for the area. This recommendation was considered such a high priority that steps have been taken to ensure the outcome. In December 2013, the Town of St. Stephen committed $12,000 inclusive of HST to work on the study. Funding has been sought through various avenues including; industrial/commercial partnerships, the RBC Blue Water Fund, the provincial government's Environmental Trust Fund, and Loblaws (Superstore) was approached to support the work through its funding partnership with the World Wildlife Federation. The proposed work would establish a Technical Advisory Group with representatives from each stakeholder group to define the detailed scope of work necessary, the development and promotion of a request for proposal to conduct the work, the acceptance of a consultant, and the completion of the work including final reporting.

Table 4 below outlines the recommendations from the St. Stephen working group including the group responsible, comments, and potential avenues to implement the recommendation.

TABLE 4: RECOMMENDATIONS FROM THE ST. STEPHEN WORKING GROUP FOLLOWING PARTICIPATING IN THE CCCVA.

Recommendation	Responsible Group	Comments/Potential Avenues
Present findings to Council, gain commitment to act	SCEP Inc & current working group	· Gain council commitment to strike a climate change adaptation planning committee within council
Explore strategies to aid existing vulnerable residences, people and natural areas	DOT Municipality Department of Environment and Local Government	**INFRASTRUCTURE - REPLACEMENT AND UPDATING** · Focus on areas where infrastructure is causing flooding/environmental problems presently · Ensure that culvert replacement is completed without restricting water flow or fish passage – bridges – not culverts (new design standards need to be developed and adopted) · Create a flood bylaw, to ensure that storm surge, inland flooding and future sea-level rise scenarios are considered as part of planning functions both for development and for infrastructure upgrades prepared for projected 2100 high water levels · Identification of barriers and solutions to the above listed items**, Priority:** Medium; important, but not urgent
	Municipality, Provincial EMO, NB Power, Woodland Pulp LLC	**SOCIO-ECONOMIC - COMMUNICATION** DAMS - Dam control, dam health and flood response information from dam operators should be explained to the public and/or made publically available · Provide information on how the water levels/flows from the dams are decided · What happens during a flood event, and what that means for property owners along the river · Possible delivery of information through the annual Water Forum (SCIWC) · Identification of barriers and solutions to the above listed items**, Priority:** Low; important, but not urgent
	Municipality, Provincial EMO, St. Stephen Climate Committee	CITIZENS- A flood/storm preparedness guide created and distributed for residents which includes personal, municipal, and provincial responsibilities during a flood/storm event · How to prepare for flooding and power loss events (winter and summer) · Locations of shelters/potential help, What to do in your house before you leave if you are evacuated · Water management on personal property, how to protect personal property, water safety issues · Available incentives for home improvements · Information must be publically accessible · Some items rely on the previous recommendation being completed · Can be adapted from existing guidelines/public documents · Identification of barriers and solutions to the above listed items**, Priority:** High; urgent and important
	St. Stephen Climate Committee, Municipality, Provincial Climate Change Secretariat	CITIZENS- Increase public awareness and personal resiliency to/of climate change and climate hazard impacts · Education campaign, trade show/workshop for the community · **Priority:** High; important and urgent
	Municipality, Regional EMO, Telecommunications and NB Power	MUNICIPALITY - The town's local EMO and regional EMO need to provide hazard information before, during, and after flood/storm events to residents and be able to communicate amongst themselves · Redundancies in the communication system · Mandatory registration in the Sentinel System, Distribute information re permanent emergency locations · Identification of barriers and solutions to the above listed items**, Priority:** High; urgent and important
	RSC, Municipality	INCENTIVES - create programs that are regionally based to reduce personal vulnerability to hazard events · Backwater valves, Rain barrels, Eavestrough, Rain gardens, Emergency kits, Ditch care, Impermeable surfaces · Long term recommendation, **Priority:** Low; important, but not urgent
	Municipality, RSC, Provincial EMO	**GOVERNANCE - EMERGENCY PLANNING** · The local "all hazards" emergency plan standard operating procedures (SOPs) should be updated, the volunteers who execute the plan must understand where emergency shelters are located, be fully trained, as well as to fully understand their legal responsibilities and role within the plan · An "all hazards" emergency plan should be created regionally, a flood-specific plan should be created locally and regionally, and a winter storm-specific plan should be created locally and regionally · The District Emergency Action Committee, as well as the use of the Sentinel system must be mandatory, in any circumstance

	Municipality St. Croix International Waterway Commission, SCEP, ETF, Irving, Crombie-REIT, RBC Blue Water Fund Municipality, Province Municipality, BIA, SCEP, St Croix International Waterway Commission Municipality	when regional EMO is activated · Identification of barriers and solutions to the above listed items **Priority:** High; urgent and important **ENVIRONMENT** HYDRAULIC STUDY OF THE BILLY WESTON BROOK · This work would entail a Technical Advisory Group being set up with representatives from each stakeholder group to define the detailed scope of work necessary; development of a Request for Proposal to conduct the work; the acceptance of consultant, as well as supervision of the completion of the work and reporting · The Town of St. Stephen has committed $12,000 inclusive of HST to work on this study, the RBC Blue Water Fund also committed to supporting this work ($5000) · The Province has also been approached through the Environmental Trust Fund · Primary discussions have been held with J.D. Irving Ltd., SWNB Rail and Crombie-REIT for financial support of this work · **Priority:** High; important and urgent UNSIGHTLY PREMISES - Areas where there are long-vacant and deteriorating buildings, referred to as an *unsightly premises*, should be repurposed · Conversion into green spaces to be used for storm water retention, possible community gardens · Medium term recommendation, **Priority:** Low; not very important, not urgent WATERFRONT - The entire riverfront area is in need of protection · Include in waterfront plan action that minimizes impacts by incorporating buffer zones and green space, adopt sustainable development policies · Long term planning initiative, **Priority:** Low; important, but not urgent WATERFRONT - Create redundancy in the pumping stations · Should have backup power sources/generators · Should all be above high water level including both storm surge scenarios and distance to the water table · **Priority:** High; important and urgent
Explore strategies to mitigate risk to future development	Municipality	**INFRASTRUCTURE - REPLACEMENT AND UPDATING** · Bylaws should be revised to include a minimum height above 2100 projected high water levels for any new development, permanent living space, electrical and mechanical systems · Need to develop/incorporate updated IDF curves against current/future drainage capacity to utilize during development and land use planning decisions · New design standards for private infrastructure projects need to be developed and enforced at the regional level (greater than the 1 in 100 year storm scenario) · Long term development, planning (including generalized land use map within the municipal plan, every five years), or marketing strategies need to include consideration of storm surge, inland flooding scenarios, and future sea-level rise scenarios · Explore and adopt sustainable development policies · Identification of barriers and solutions to the above listed items**, Priority:** Medium; important, not urgent
Seek and support partnerships, networks and funding for climate change adaptation planning and action	Municipality	· Participate in opportunities to increase understanding of climate change impacts to St Stephen, Charlotte County and New Brunswick · Participate in opportunities to discuss and plan for climate change impacts · Work with trans boundary partners to determine common issues and opportunities for resource sharing · Seek funding to support adaptation planning locally · Create and participate in discussion forums within the NB Union of Municipalities focusing on municipal adaptation · **Priority:** High; important and urgent

3.2. St. Andrews

St. Andrews is located adjacent to the estuary, at the mouth of the St. Croix River on the tip of a peninsula that projects into Passamaquoddy Bay and includes Navy Island (Government of NB 2014). St. Andrews was founded by United Empire loyalists in 1783 and is well-preserved with many of the original buildings still standing. In 1998 St. Andrews was designated as a National Historic Site (Town of St. Andrews 2010, St. Andrews by-the-Sea 2014). The town was incorporated in 1903 and served as a seaport, port of entry, and the terminus of the Canadian Pacific Railway (Government of NB 2014). St. Andrews hosts three long-term operations that influence the local socioeconomic system. The St. Andrews Biological Station was permanently established in 1908. The biological station scientists have gained national and international recognition for their pioneering research and industry participation. The Huntsman Marine Science Centre (HMSC) was established by a consortium of 20 universities and several government departments in 1969. The HMSC was developed to become a 'cooperative venture in learning' and still thrives within the community. The Algonquin Hotel, currently with 233 guest rooms, was built in 1889, and has a long-standing history as a top coastal resort. Newer institutions such as a whale watching industry, Ministers Island as a tourist destination, and the Kingsbrae Garden, one of the top 10 horticultural attractions in Canada, are also important to the community. Statistics Canada reported a population of approximately 1,800 residents in 2011.

Figure 33: Municipal boundary of the Town of St. Andrews (Source left: Google Earth, right: GeoNB).

3.2.1 Meeting # 1

At Meeting # 1 in St. Andrews, the working group was first presented with a breakdown of the meetings, an explanation of the major terms, a brief description of climate change, the IPCC, and climate change scenarios. Following this, the working group members were asked to identify the climate hazards that they would like to discuss throughout the course of the meetings. In St. Andrews, the municipality was concurrently undertaking a storm water management strategy.

FIGURE 34: ST. ANDREWS STORM SURGE, FEBRUARY 2008 (SOURCE: FUNDY TIDE RUNNERS).

With this in mind, the working group was asked to consider how storm water management and climate hazard resilience could be mutually addressed in their community. The Town of St. Andrews was also impacted by heavy precipitation events in November 2010, December 2010, and July 2013. Additionally, a storm surge event in February of 2008 was accompanied by approximately 150mm of rain in a four hour time period and caused localized flooding and coastal inundation, see Figure 34. The November 2010 event was accompanied by a large storm surge and had a severe impact on the community. The December 2010 and July 2013 events flooded basements, but roads were not impacted heavily. The working group members decided that the climate hazards they would like to address throughout the course of the community meetings would be *flooding*, *coastal erosion*, and *sea- level rise*. One of the main concerns from the survey was *damage to public infrastructure*.

The working group members were briefed on the storm water management plan by Mr. Tim Henderson, the Chief Administrative Officer (CAO) with the Town of St. Andrews. The company undertaking the storm water management plan, CBCL, will assess the condition of the existing infrastructure. The plan will assess the effect of extreme rainfall events including the 1 in 5 year, 1 in 20 year, and the 1 in 100 year rainfall events on sanitary and combined sewer overflows (CSOs), considering existing and future development within the town. The results will be used to establish extreme values for overflow volume and peak flows. The flows will be generated based on historical rainfall records and will be modified to reflect increasing rainfall intensities.

FIGURE 35: MEETING # 1 IN ST. ANDREWS (SOURCE: KRISTIE SIGNER).

The working group was asked to identify areas that were physically impacted by recent storm events or those of concern into the future. They marked areas of physical and infrastructure impact with red sticker dots on the community map including information on the type and degree of impact. The table outlining the red dot number and description of the impact is located in Table

A2.1 of the Appendix under St. Andrews in the red table. The areas marked on the community map were primarily impacts that occurred in the past. The mapping exercise revealed that impacts were mainly to the basement level of homes. Travel was dangerous but, within town events did not heavily impact road infrastructure. Major coastal erosion in 2010 was confined to the area of Indian Point in front of the Irish Cross memorial. Lesser erosion impacts were seen around the entire peninsula. Armour stone already in place was reinforced after the November 2010 event, and the market square seawall was impacted. The working group noted that many roads were undermined or topped with high ridges of sediment in the adjacent LSDs.

FIGURE 36: MEETING # 1 IN ST. ANDREWS (SOURCE: KRISTIE SIGNER).

Other points that were raised by the working group in Meeting # 1:

- The February 2008 heavy precipitation event, 150mm in 4 hours, flooded basements and was a combination of sewage and storm water in some homes
- A rare and extreme flooding event of the Market Square was noted. This event took place on a completely calm day. The extreme levels were attributed to a nearby storm. Two working group members had witnessed the event but the date remains unconfirmed. It is thought that the event happened in the spring of 1998, but newspapers reported no such event at this time, or in the spring of 1999. It is possible this event was not reported.

3.2.2 MEETING # 2

In Meeting # 2, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercise from Meeting # 1. Dr. MacLellan, a Senior Research Scientist and Project Leader for the New Brunswick Climate Change Research Collaborative, presented how climate change adaptation is defined in simple systems. Using examples from a climate change adaptation project he was involved with in Lake Simcoe, Ontario, Dr. MacLellan provided information on climate hazard impacts to infrastructure and socioeconomic considerations. He also provided statistical data from the

FIGURE 37: ST. ANDREWS RESIDENT, FRANK HAUGHN, SHOWS COUNCILOR LEE SOCHASKY AND MAYOR STAN CHOPTIANY HISTORICAL PHOTOGRAPHS OF ST. ANDREWS (SOURCE: KRISTIE SIGNER).

2011 Statistics Canada National Household Survey for New Brunswick and St. Andrews to guide discussion. Dr. MacLellan explained that community profiles, based on the census data, provided a snapshot of who lives in the community, their age, income, profession, and sector they work in and can help in deriving a broad idea of what climate hazard impacts may be important to the community. Based on the statistics and his analysis, Dr. MacLellan suggested that St. Andrews is a long established community with a high percentage of residents established for three generations or more. St. Andrews is a relatively stable community in terms of mobility. Based on the information presented, Dr. MacLellan commented that there is a mixed industry focus within the community, but that it is service dominated.

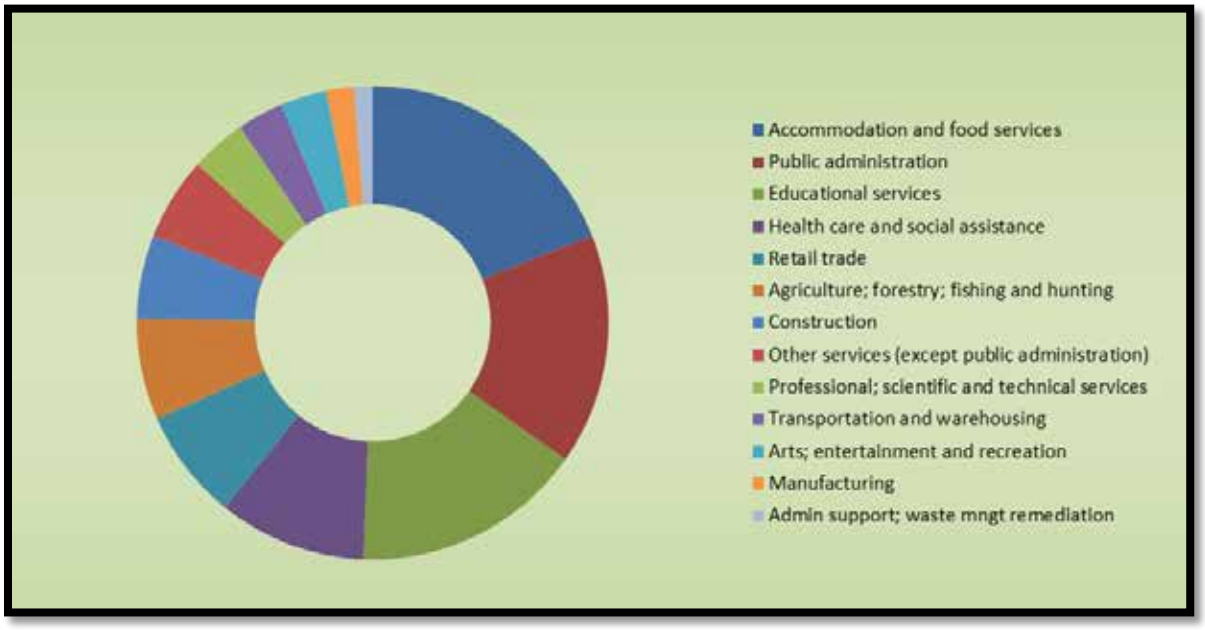


FIGURE 38: OCCUPATIONS BY SECTOR FOR ST. ANDREWS (SOURCE: DR. JAMES MACLELLAN).

There is an older population within the community with the highest home value in Charlotte County. St. Andrews had the oldest population for primary household maintainers with over 24% being 75 years of age or older, followed by 19.5% being 55 to 64 years of age, as seen in Figure 42 below. Additional information provided by Dr. MacLellan can be found in Figures A2.1 to A2.4 of the Appendix under St. Andrews.

Home Maint (age Group)	CANADA	ATLANTIC CAN	NEW BRUNSWICK	CHARLOTTE County	St Andrews T	St Stephen T
Under 25 years	3.4	3.5	3.6	2.9	9.4	4.4
25 to 34 years	14.4	12.4	12.7	9.9	4.7	10.9
35 to 44 years	17.9	16.6	16.7	16.8	11.8	17.4
45 to 54 years	22.7	22.0	21.8	21.4	18.8	20.5
55 to 64 years	19.2	21.0	20.9	21.5	19.4	20.0
65 to 74 years	12.2	13.7	13.4	13.6	12.4	9.1
75 years and over	10.2	10.9	11.0	13.8	24.1	17.9
Median value of dwellings ($)	280552	159687.5	139537	120010	190226	125051
Average value of dwellings ($)	345182	179376.5	153484	142713	209749	126580

FIGURE 42: COMPARATIVE TOTAL NUMBER OF PRIVATE HOUSEHOLDS BY AGE GROUP OF PRIMARY HOUSEHOLD MAINTAINERS AND DWELLING VALUE, BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

Dr. MacLellan suggested the working group should try to think broadly about interconnections between values when examining social and economic impacts. He made the following points to help guide the mapping of socioeconomic impacts:

- Think about who is vulnerable and how might they be vulnerable
- Think about the history of socioeconomic impacts and the potential impacts into the future
- Local knowledge is a valid source of knowledge
- Analysis that describes economic damages are critical, but also include non-market factors

The community was then presented with two examples of community members, an elderly woman who lives on her own in a historical home and a young, single mother who lives in an apartment. These fictional community members were used as examples of residents that should be considered when discussing social and economic impacts during climate hazard events. The working group members were then asked to use blue sticker dots to identify areas on the community map where social and economic impacts have been felt or were of concern for the future. The table outlining the number and description of the impact is located in the Appendix under St. Andrews Meeting # 2 in the blue table.

Working group discussions indicated that many residences had basement flooding impacts and also that flood insurance is not available in New Brunswick. Sewer back-up insurance is sometimes an option on homeowner and business policies. However, within the population that does carry this coverage, it has been interpreted by them (and confirmed by a local insurance company) that claiming damage may lead to restrictions or recommendations by insurance policy-holders (need to install back-flow preventer, etc.), increases in premiums or cancellation of that coverage. It was pointed out that residents of the Quinn House, a nine unit low cost housing for senior citizens and residents of the Wabanaki apartments, which house students, are vulnerable populations. It was also observed that the only access roads for the Town are both impacted by gathering water and large areas of ice in winter, making travel dangerous. If these areas experience undermining, this will become a more critical issue, impacting movement of not only citizens in and out of the area, but emergency resources as well.

FIGURE 39: WORKING GROUP MEETING IN ST. ANDREWS (SOURCE: KIM REEDER).

The area's large elderly population was acknowledged and it was indicated that there is a large amount of community support for them in both normal and extreme circumstances. Despite the impact events in St. Andrews, it appeared, based on working group discussions, that the community was able to function as normal during the heavy precipitation and storm surge events and that the social and economic impacts were not as severe as elsewhere in Charlotte County. There was concern for the reputation of the town as a resort destination, if it were to be largely impacted by climate hazard events. Any irregularities in water quality would have a large impact on residents as well as impacting tourism as the town supplies water for many tourist accommodations including the Algonquin, a specific destination for many visitors. The town currently has a plan for importing water if circumstances require. Cyanobacteria in the water supply of Chamcook Lake first appeared in 2010. If changes in cyanobacteria ecology are linked to climate change, it may cause future issues in the town's water supply.

Other points that were raised by the working group in Meeting # 2:

- The time of the hazard events have not coincided with the tourist season and, as such, the impacts to the economic sector have been limited as many businesses close for the winter months. However, increased precipitation has impacted the use of the golf course, especially the driving range, and recreational field use has been impacted for the same reason

- The community has an elderly population and some live on a fixed income, however, the working group specified that a fixed income is not necessarily indicative of poverty
- Various areas that are being considered for development include Indian Point, the area of the Bar Road above Rose Lane, the recently approved seniors facility, and future options for Marine Science Drive and the golf course fairways

3.2.3 MEETING # 3

In Meeting # 3, the working group was asked to recall the climate hazards chosen and revisit the mapping exercises from the previous meetings. They were then presented with sea-level rise information by Réal Daigle, a New Brunswick based meteorologist and climate change consultant with R. J. Daigle Enviro. Mr. Daigle began by informing the working group about the most recent IPCC AR5 and the development and use of RCPs. He presented the LiDAR-based DEM for the St. Andrews area, as shown in Figure 40.

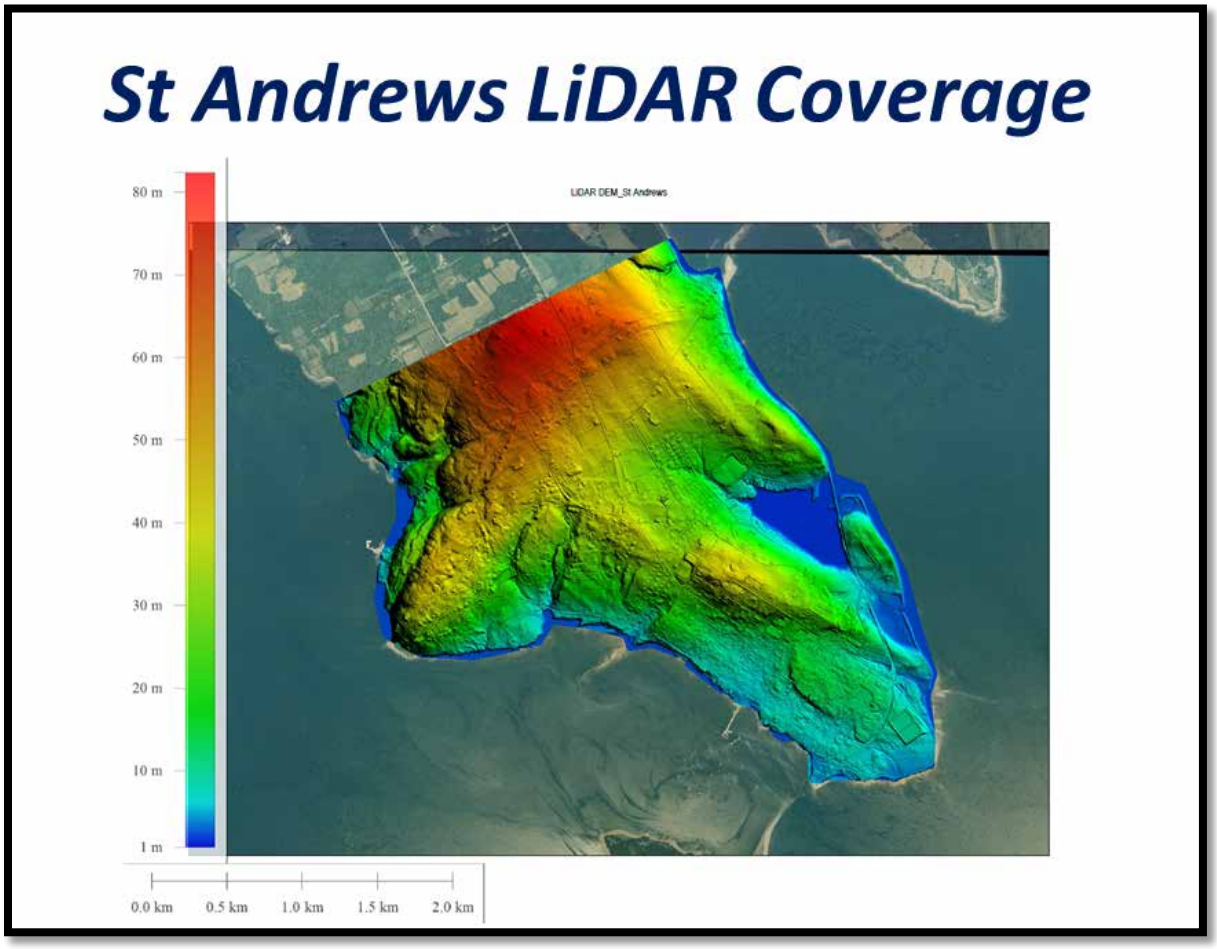


FIGURE 40: DEM FOR ST. ANDREWS (SOURCE: DAIGLE 2014).

Mr. Daigle used the DEM to make projections of sea-level rise into the future incorporating information from the IPCC, the extreme high tide value (HHWLT), crustal subsidence, and varying storm surge return periods. The HHWLT is determined using the average of each of the annual

maximum predicted tide values over a 19 year tidal cycle as shown in Figure 41. A further explanation of how Mr. Daigle made his calculations can be found in the Methodology section.

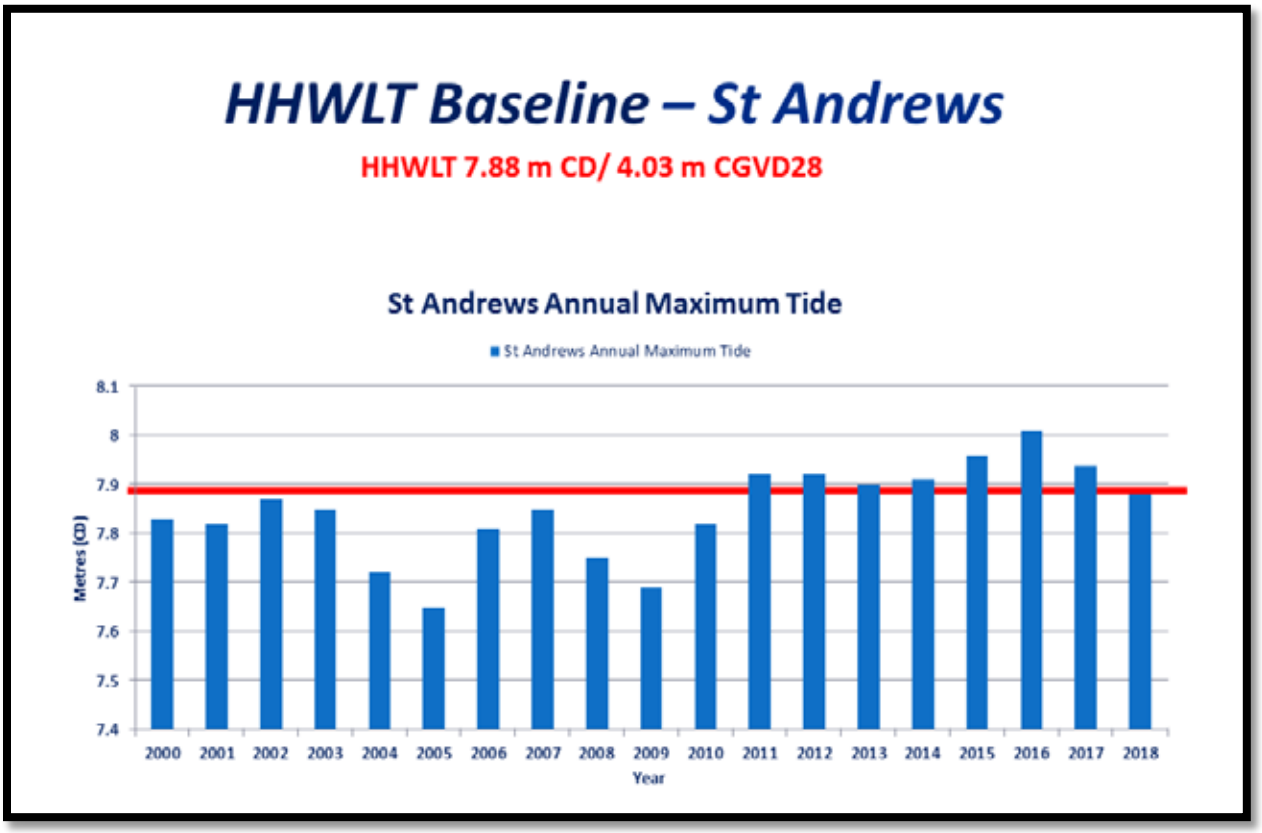


FIGURE 41: 19 YEAR TIDE CYCLE FOR ST. ANDREWS, THE RED LINE ILLUSTRATES THE AVERAGE VALUE OF THE HHWLT: 7.88M CD/ 4.03M CGVD28 (SOURCE: DAIGLE 2014).

Mr. Daigle developed extreme total sea-level flooding scenarios for St. Andrews. The value is given for the vertical height in meters from the CGVD28 baseline along with a margin of error for the estimates as shown in Table 4 below. Estimates of the anticipated changes in total sea-levels for the time frames of 2010, 2025, 2055, 2085, and 2100 are represented in Table 4 and are meant to represent the worst case flooding scenario resulting from the simultaneous occurrence of a significant storm surge event for the respective RPs and a high astronomical tide (HHWLT) at a given location. It should be noted from Table 4 that with an estimated increase in sea-level of 0.88m by 2100, the present day 1 in 100 year flooding scenario (4.94m) becomes an annual event between 2055 and 2085.

TABLE 5: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR ST. ANDREWS (SOURCE: DAIGLE 2014).

St Andrews HHWLT 4.0 m (CGVD28)						
Return Period	**Surge Residual**	**Level 2010**	**Level 2025**	**Level 2055**	**Level 2085**	**Level 2100**
1-Year	0.47 ± 0.20	4.47 ± 0.20	4.60 ± 0.23	4.82 ± 0.31	5.15 ± 0.41	5.35 ± 0.49
2-Year	0.54 ± 0.20	4.54 ± 0.20	4.67 ± 0.23	4.89 ± 0.31	5.22 ± 0.41	5.42 ± 0.49
5-Year	0.64 ± 0.20	4.64 ± 0.20	4.77 ± 0.23	4.99 ± 0.31	5.32 ± 0.41	5.52 ± 0.49
10-Year	0.71 ± 0.20	4.71 ± 0.20	4.84 ± 0.23	5.08 ± 0.31	5.41 ± 0.41	5.61 ± 0.49
25-Year	0.80 ± 0.20	4.80 ± 0.20	4.93 ± 0.23	5.15 ± 0.31	5.48 ± 0.41	5.68 ± 0.49
50-Year	0.87 ± 0.20	4.87 ± 0.20	5.00 ± 0.23	5.22 ± 0.31	5.55 ± 0.41	5.75 ± 0.49
100-Year	0.94 ± 0.20	4.94 ± 0.20	5.07 ± 0.23	5.29 ± 0.31	5.62 ± 0.41	5.82 ± 0.49

The colour-coded lines on the map represented in Figure 46 are indicative of the extreme total sea-level flooding scenarios for a 1 in 100 year storm surge RP for the years 2010, 2025, 2055, 2085 and 2100 along the St. Andrews waterfront. There is an additional line representing the year 2100 flooding scenario with the uncertainty factor.

For the additional extreme total sea-level flooding scenario maps for St. Andrews (1 in 1 year, 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, and 1 in 50 year) produced by Mr. Daigle, please refer to the included DVD.

FIGURE 42: ST. ANDREWS EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR STORM SURGE RETURN PERIOD (SOURCE: DAIGLE 2014).

After the presentation, the working group discussed the information as well as various governance and policy issues related to climate change adaptation. The discussion included how the LiDAR and resultant sea-level rise contours can help the CBCL consultants decide where to make changes to storm water infrastructure. The working group also indicated that the information presented could help the municipal council strengthen and change bylaws, or create new bylaws. The CBCL consultants and the town's new development officer will also be examining various bylaws. It was also mentioned that with respect to provincial governance, there are no bylaws in LSDs which have impacts on nearby municipalities. Although not specified, it was also discussed that there are gaps in provincial legislation which have allowed for development that was unsupported by the town. The community was aware of upcoming reforms to the Municipalities Act and Community Planning Act.

Discussion also focused on the 19 year tide cycle prediction and the new awareness that from the period of 2014-2017 annual maximum tide values will exceed the average value of the HHWLT over the 19 year cycle (which it has since 2011). By 2016 the annual maximum tide is predicted to reach an approximate 10 cm additional to the 2013 annual maximum tide value. This will be a concern for certain physical structures and infrastructure and may be of significant concern if the maximum annual tide coincides with a heavy precipitation or storm event. Due to this new understanding, suggestions were made regarding tracking weather specifically at the times of predicted maximum tides for the years 2014 – 2017. As well, it was pointed out that weather systems should be tracked when they coincide with high tide cycles in any year, because we must consider that in comparison with a 1+ metre surge, the additional 10 cm may not be the most critical factor.

This was the first meeting where recommendations for future action started to take form. Discussion focused on municipal strategies to reduce their vulnerability to climate hazard impacts, such as whether to focus on bylaws (regulation) or communication (awareness). It was identified that there may be areas within the municipality that have no short term adaptation solutions, such as low-lying areas that are prone to flooding which are already developed. The working group also discussed the issue of land considered "buildable" in a legal sense, but not "protectable" in an economic sense, and areas where temporary uses may be the only option, such as the Kiwanis Oceanfront Campground. A discussion of a time frame for planning climate change adaptation was mentioned, but no decisive recommendations were made.

Other points that were raised by the working group in Meeting # 3:

- In a 15 minute period one metre of land was lost near the Irish Cross during the storm surge event of November 5, 2010
- Communities that have a plan, and who have experienced climate-related impacts may be at the top of the list to receive funding support when it becomes available
- There is a heritage image to be maintained within the town and adaptation planning must consider this
- It may be worthwhile to review building codes for piers as there are currently no bylaws

3.2.4 MEETING # 4

In Meeting # 4, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises and discussions from previous meetings. This was done to verify the important points made in the discussions and for facilitators to gain context on some of the points previously raised. Recommendations for future climate change adaptation planning were further discussed and expanded to include a communications strategy; personal responsibilities and adaptations, such as the use of eavestrough, water barrels, rain gardens and tree planting; how to budget for long term adaptation to sea-level rise; and if, or to what level, municipalities will be held accountable (liable) for releasing information on the scenarios of climate change impacts in relation to land values or the designation/zoning of vulnerable areas.

Other points that were raised by the working group in Meeting # 4:

- Many bylaws are written without a penalty for non-compliance
- Community television channel is a means for disseminating information
- Future development should be limited in vulnerable areas

3.2.5 MEETING # 5

In Meeting # 5, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises and discussions from previous meetings. In Meeting # 5 the working group members were presented information on inland flooding. The inland flooding maps were prepared using the LiDAR data and were analyzed to exhibit the DTW using a specified flow rate initiation of 4ha, which represents the end of summer ground saturation. The WAM was prepared to help the working group understand unseen vulnerabilities related to water depth. The WAM is illustrated in Figure 43 below. Using a projector and screen, the WAM was overlaid on the community map previously used to identify climate hazard impacts. This allowed the working group members to identify where the DTW could be responsible for more significant flooding in some areas. In consideration of the DTW map, the working group commented that the two roads in and out of the peninsula were very close to the water table. The WAM also brought to light possible options for new drainage flows.

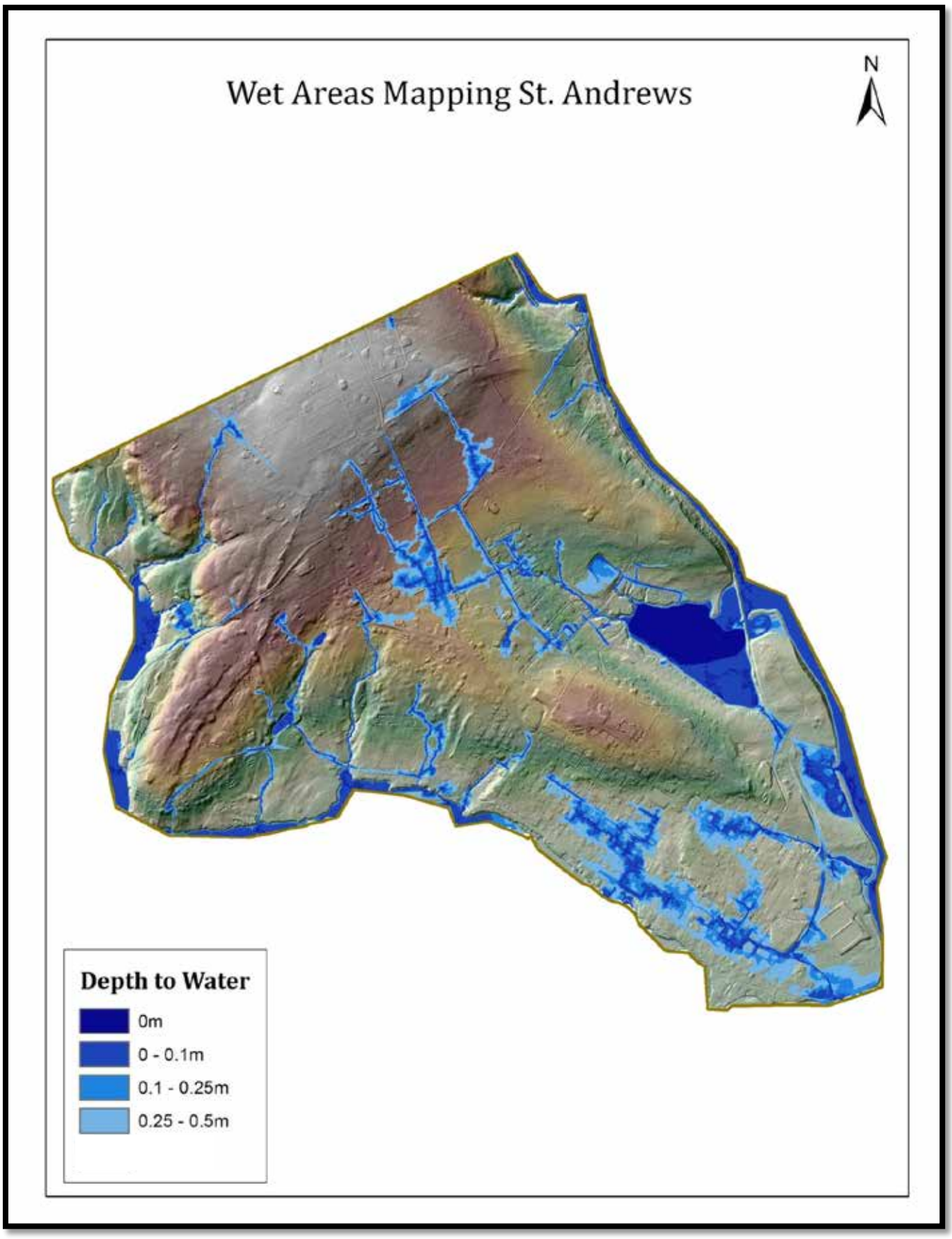


FIGURE 43: WAM FOR THE TOWN OF ST. ANDREWS (SOURCE: ARP 2013).

The environmental impacts of the climate hazards were then discussed. Green sticker dots were placed on the community map representing past environmental impacts and those of concern in the future. A list of the numbered dots placed on the community map representing environmental impacts and their description can be found in Table A2.3 of the Appendix under St. Andrews in the green table. While mapping environmental impacts, the working group commented specifically on shoreline protection and public versus personal responsibility regarding seawall upkeep. Indian Point was a topic of major concern for the working group, as it acts as a natural buffer during storm events and is closely tied to the recreational identity of the community. The working group identified areas of possible ground contamination, such as old dump sites and gas stations. There were no specific impacts to wildlife defined however the working group was aware of two ongoing wildlife monitoring projects, the Greenlaw Mountain Hawk Watch and the Huntsman Marine Science Centre's Bird Banding Station. A digitized version of the community map has been created using Google Earth to indicate where all of the coloured dots were placed on the community map in St. Andrews as illustrated in Figure 44 below.

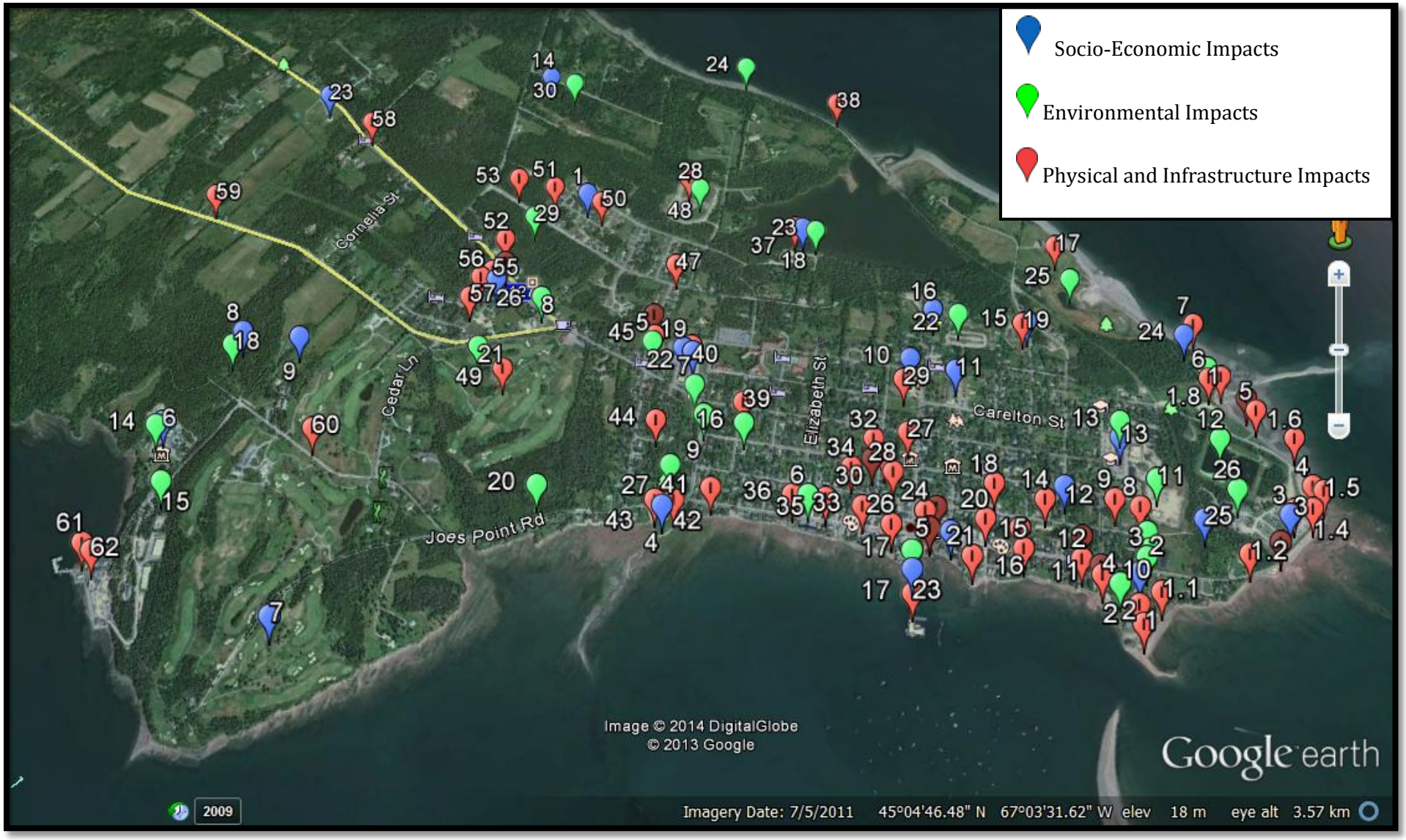


FIGURE 44: DIGITIZED MAP OF THE COMMUNITY MAPPING EXERCISE FOR ST. ANDREWS (CREDIT: TANYA ANDERSON).

Working group members were then asked to discuss how they could incorporate newly gained information into the development of sound options for reducing the vulnerability of their community to the impacts of climate hazards. Options for further study to move forward with climate change adaptation planning were discussed in addition to options to address specific vulnerabilities. Based on the mapping exercises, group discussions, presenter information, and their personal knowledge, the working group identified four major areas that were the most vulnerable within their community, as seen in Figure 45.

FIGURE 45: VULNERABLE AREAS OF ST. ANDREWS, NB AS DETERMINED BY THE LOCAL WORKING GROUP.

From left to right, the four vulnerable areas chosen, as represented by the yellow circles, are:

A. The access roads in and out of the town

B. The area of new development including the area prone to saturation as illustrated by the WAM

C. The downtown area along the shoreline

D. Indian Point

The working group members were thanked for their participation in the project and discussed a final meeting to verify the results and conclusions of their section of the report.

3.2.6 CONCLUSIONS

The working group in St. Andrews was made up of extremely knowledgeable participants, including an employee of the both the local biological research station and the Huntsman Marine Science Centre, long-time residents, new residents, and representatives of local government. In St. Andrews, the impacts of recent events were discussed and concerns related to the climate hazards of flooding, sea-level rise, and coastal erosion were communicated effectively. The working group was very focused on developing options for the long term, as sea-level rise and coastal erosion concerns will have a major impact on the community and its economic core which is located along the shoreline. The working group members agreed unanimously that what they have learned during the CCCVA should be communicated effectively to the rest of the community. The areas they identified as being most vulnerable to the climate hazards of flooding, sea-level rise, and coastal erosion, as discussed in Meeting # 5, are:

- The access roads in and out of the town
- The downtown area along the shoreline
- Indian Point
- The new development area including the area prone to saturation as illustrated by the WAM

In general, the entire coastal zone around the peninsula was of concern. The community has already experienced coastal erosion impacts, having to repeatedly replace armour stone throughout the town. They also recognized that there were a few low-lying areas, such as Queen Street and Augustus Street, that are flood prone, and that there may not be a solution to this issue in the short term. The working group also discussed limiting new development in areas that have the potential to be affected by long term sea-level rise, coastal erosion, and flooding. The working group expressed concern for the projected impacts of sea-level rise on the business core and historical buildings within the downtown area. They recognized the need for further information from citizens and business owners as well as further discussion to specifically address adaptation options.

3.2.7 RECOMMENDATIONS

The working group strongly recommended further climate change adaptation planning in their community, focusing on the development of long term options to reduce the town's vulnerability to climate hazards. Of particular importance, the development of a communication strategy that would share what had been learned throughout the meeting process in order to increase citizen awareness on the projected impacts of climate change on the community as well as to gain feedback.

The working group recognized the value of community-based recommendations for initiatives to reduce vulnerability, which would ensure that citizen support is evident to municipal decision makers. The working group also suggested the possibility of temporary land uses, and identified areas where impacts are expected into the future, but that could be used in the short term. An example of this is Indian Point, where the majority of assets are mobile. The working group recommended that bylaws, especially zoning bylaws, will need to be examined in respect to climate

change and the projected impacts in St. Andrews. Bylaw development and upgrading must reflect the present and expected impacts to low-lying areas, areas prone to erosion, and areas that will be impacted by projected sea-level rise. Table 6 below outlines the recommendations from the St. Andrews working group including the comments and avenues to pursue the recommendation.

TABLE 6: RECOMMENDATIONS FROM THE ST. ANDREWS WORKING GROUP FOLLOWING PARTICIPATING IN THE CCCVA.

Recommendation		Comments/Potential Avenues
Create a new committee to evaluate and pursue the recommendations	*First priority*	· Instituted by council · Aim to include members of the current working group
Explore strategies to aid existing vulnerable residences, people and natural areas	*Develop communications strategy*	· Communicate information learned throughout the meeting process to the greater community. Seek out further recommendations and feedback from the larger community · Communications strategy must consider the development of support for those receiving the information · Develop and deliver communications in a multitude of formats - Workshop, Community TV, written information · Involve youth citizenry · Physically stake out the limits of sea-level rise in a local area, as drafted by Mr. Daigle, - this option must be given much thought to ensure sensitivity · Create a publically available calendar to draw attention to extreme high tides of the year - weather forecasts could be monitored prior to these times so that if extreme weather events effecting storm surge is expected, then maintenance (sump pumps and catch basins) and a community warning could be issued. Specific attention to 2016, when the 19 year tide cycle is at its peak · Create a visual communication tool at the wharf to indicate various tide and surge levels - current and expected · Investigate current and deemed best practices for buyout, relocation and flood proofing buildings, personal adaptations, investigate incentive program development · Investigate current and deemed best practices for allowing for water to travel through basements, encourage leaving basements undeveloped · Investigate current and deemed best practices for soft engineering solutions for coastal protection · Identification of barriers and solutions to the above listed items
Explore strategies to mitigate risk to future development	*Specific attention to bylaws – updates and enforcement*	· Ensure that storm surge, inland flooding scenarios, and future sea-level rise scenarios are considered as part of planning functions both for development and for infrastructure upgrades · Pay specific attention to depressed areas, areas defined on the WAM as saturated, areas that are erosion prone and areas that are projected to be impacted by sea-level rise into the future · Bylaws could be revised to include minimum heights above 2100 projected high water levels for permanent living space, electrical and mechanical systems · Consider development/incorporation of updated IDF curves against current/future drainage capacity to utilize during development and land use planning decisions · New design standards for private infrastructure projects need to be developed and enforced at the regional level (greater than the 1 in 100 year storm scenario) · Long term development, planning (including generalized land use map within the municipal plan, every five years), or marketing strategies need to include consideration of storm surge, inland flooding scenarios, and future sea-level rise scenarios · Identify if there are sites which would enable temporary use of land - an example of this is at the Point where the majority of assets are mobile · Identification of barriers and solutions to the above listed items
Seek partnerships, networks and funding for climate change adaptation		· Participate in opportunities to increase understanding of climate change impacts to St Andrews, Charlotte County and New Brunswick · Participate in opportunities to discuss and plan for climate change impacts · Seek funding to support adaptation planning locally · Participate in discussion forums within the NB Union of Municipalities focusing on municipal adaptation

3.3 St. George

The Town of St. George is located in the centre of Charlotte County, as shown in Figure 46 below. The Magaguadavic River and Valley runs north to south through the core of the parish and, following a series of rapids and waterfalls, reaches sea level at the Town of St. George (SGAHAM 2009). The town was established in 1784, incorporated in 1904, and served as a port of entry for the Shore Line Railway (Government of NB 2014). The town was also made famous by the red-granite quarries which operated from 1872 to 1953 (Town of St. George 2012). Today, the Town of St. George is the commercial, business and service centre of the eastern Charlotte Coastal Region, and processing of a large portion of the aquaculture salmon grown in the Bay of Fundy occurs in St. George (Charlotte Coastal Region 2008). Statistics Canada reported a population of approximately 1,500 residents in 2011.

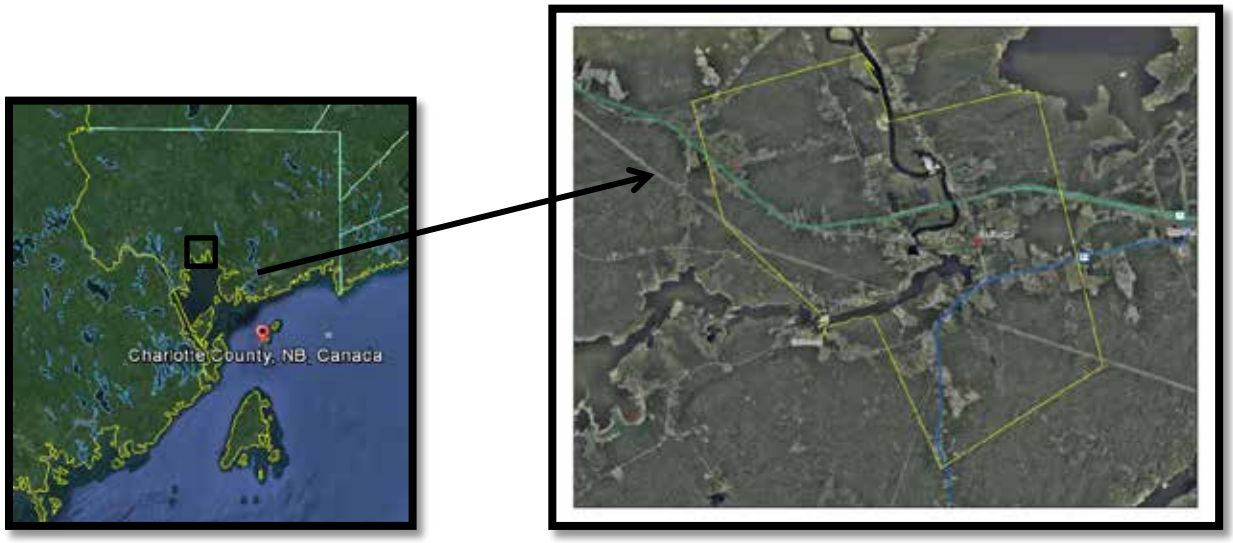


Figure 46: Municipal boundary of the Town of St. George (Source left: Google Earth, right: GeoNB).

3.3.1 Meeting # 1

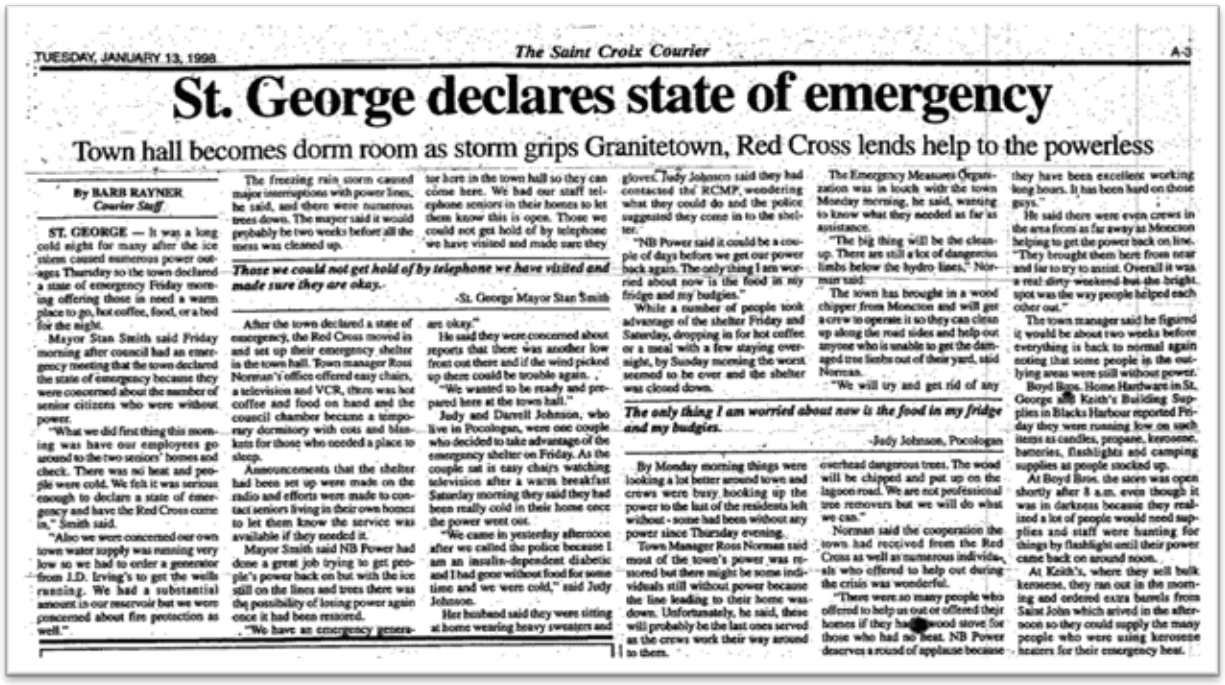
At Meeting # 1, the working group was presented with a breakdown of the project process, an explanation of the major terms used throughout the meeting process, and a brief description of climate change, the IPCC, and climate change scenarios. Following this, the working group members were asked to identify the climate hazards that they would like to discuss throughout the course of the meetings. St. George was significantly impacted by the December 2010 heavy precipitation event and by the 1998 ice storm. In 2010, the Magaguadavic River, which runs through the town, swelled from the heavy precipitation, flooding roads and washing away debris. The St. George working group chose *flooding* and *increased frequency of storm events* as the most appropriate climate hazards to discuss in their community.

FIGURE 47: ST. GEORGE POWER DAM DECEMBER 15, 2010 ON LEFT (SOURCE: ST. CROIX COURIER) ST. GEORGE POWER DAM (SOURCE: S. KING).

The working group members were asked to identify areas that were physically impacted by the recent storm events. They marked areas of physical and infrastructure impact with red sticker dots on the community map, also providing information on the type and degree of impact. The table outlining the number and description of the impact is located in Table A4.1 of the Appendix under St. George in the red table. The areas marked on the map were primarily impacts that took place during the December 2010 event, with a few additional markings that reflected concern for future impacts. During this event, the Town of St. George declared a "state of emergency", as shown in Figure 48 below. The mapping exercise revealed that impacts were mainly to homes, roads, and businesses along the river, as well as the location of telephone, electrical, and utility junction boxes and cables.

3.3.2 MEETING # 2

In Meeting # 2, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercise from Meeting # 1. The working group was then presented with information on social and economic impacts which was prepared by Ms. Abby Pond, the Executive Director of the St. Croix International Waterway Commission, and presented by the facilitators. Information on the social and economic aspects of the Town of St. George that had been prepared by Dr. Jim MacLellan, a Senior Research Scientist, and Project Leader for the New Brunswick Climate Change Research Collaborative was also presented to help the working group members in understanding potential impacts to socioeconomic systems in their community from the chosen climate hazards. The community profile, based on the census data, provided a snapshot of who lives in the community, their age, income, profession, and employment sector they work in. It can help in deriving a broad idea of what socioeconomic climate hazard impacts may be important to the community.



TUESDAY, JANUARY 13, 1998 — The Saint Croix Courier — A-3

St. George declares state of emergency

Town hall becomes dorm room as storm grips Granitetown, Red Cross lends help to the powerless

By BARB RAYNER
Courier Staff

ST. GEORGE — It was a long cold night for many after the ice storm caused numerous power outages Thursday so the town declared a state of emergency Friday morning offering those in need a warm place to go, hot coffee, food, or a bed for the night.

Mayor Stan Smith said Friday morning after council had an emergency meeting that the town declared the state of emergency because they were concerned about the number of senior citizens who were without power.

"What we did first thing this morning was have our employees go around to the two seniors' homes and check. There was no heat and people were cold. We felt it was serious enough to declare a state of emergency and have the Red Cross come in," Smith said.

"Also we were concerned our own town water supply was running very low so we had to order a generator from J.D. Irving's to get the wells running. We had a substantial amount in our reservoir but we were concerned about fire protection as well."

The freezing rain storm caused major interruptions with power lines, he said, and there were numerous trees down. The mayor said it would probably be two weeks before all the mess was cleaned up.

Those we could not get hold of by telephone we have visited and made sure they are okay.

-St. George Mayor Stan Smith

After the town declared a state of emergency, the Red Cross moved in and set up their emergency shelter in the town hall. Town manager Ross Norman's office offered easy chairs, a television and VCR, there was hot coffee and food on hand and the council chamber became a temporary dormitory with cots and blankets for those who needed a place to sleep.

Announcements that the shelter had been set up were made on the radio and efforts were made to contact seniors living in their own homes to let them know the service was available if they needed it.

Mayor Smith said NB Power had done a great job trying to get people's power back on but with the ice still on the lines and trees there was the possibility of losing power again once it had been restored.

"We have an emergency generator here in the town hall so they can come here. We had our staff telephone seniors in their homes to let them know this is open. Those we could not get hold of by telephone we have visited and made sure they are okay."

He said they were concerned about reports that there was another low front out there and if the wind picked up there could be trouble again.

"We wanted to be ready and prepared here at the town hall."

Judy and Darrell Johnson, who live in Pocologan, were one couple who decided to take advantage of the emergency shelter on Friday. As the couple sat in easy chairs watching television after a warm breakfast Saturday morning they said they had been really cold in their home once the power went out.

"We came in yesterday afternoon after we called the police because I am an insulin-dependent diabetic and I had gone without food for some time and we were cold," said Judy Johnson.

Her husband said they were sitting at home wearing heavy sweaters and gloves. Judy Johnson said they had contacted the RCMP, wondering what they could do and the police suggested they come in to the shelter.

"NB Power said it could be a couple of days before we get our power back again. The only thing I am worried about now is the food in my fridge and my budgies."

While a number of people took advantage of the shelter Friday and Saturday, dropping in for hot coffee or a meal with a few staying overnight, by Sunday morning the worst seemed to be over and the shelter was closed down.

The only thing I am worried about now is the food in my fridge and my budgies.

-Judy Johnson, Pocologan

By Monday morning things were looking a lot better around town and crews were busy hooking up the power to the last of the residents left without - some had been without any power since Thursday evening.

Town Manager Ross Norman said most of the town's power was restored but there might be some individuals still without power because the line leading to their home was down. Unfortunately, he said, these will probably be the last ones served as the crews work their way around to them.

The Emergency Measures Organization was in touch with the town Monday morning, he said, wanting to know what they needed as far as assistance.

"The big thing will be the clean-up. There are still a lot of dangerous limbs below the hydro lines," Norman said.

The town has brought in a wood chipper from Moncton and will get a crew to operate it so they can clean up along the road sides and help out anyone who is unable to get the damaged tree limbs out of their yard, said Norman.

"We will try and get rid of any overhead dangerous trees. The wood will be chipped and put up on the lagoon road. We are not professional tree removers but we will do what we can."

Norman said the cooperation the town had received from the Red Cross as well as numerous individuals who offered to help out during the crisis was wonderful.

"There were so many people who offered to help us out or offered their homes if they had a wood stove for those who had no heat. NB Power deserves a round of applause because they have been excellent working long hours. It has been hard on those guys."

He said there were even crews in the area from as far away as Moncton helping to get the power back on line. "They brought them here from near and far to try to assist. Overall it was a real dirty weekend but the bright spot was the way people helped each other out."

The town manager said he figured it would be about two weeks before everything is back to normal again noting that some people in the outlying areas were still without power.

Boyd Bros. Home Hardware in St. George and Keith's Building Supplies in Blacks Harbour reported Friday they were running low on such items as candles, propane, kerosene, batteries, flashlights and camping supplies as people stocked up.

At Boyd Bros. the store was open shortly after 8 a.m. even though it was in darkness because they realized a lot of people would need supplies and staff were hunting for things by flashlight until their power came back on around noon.

At Keith's, where they sell bulk kerosene, they ran out in the morning and ordered extra barrels from Saint John which arrived in the afternoon so they could supply the many people who were using kerosene heaters for their emergency heat.

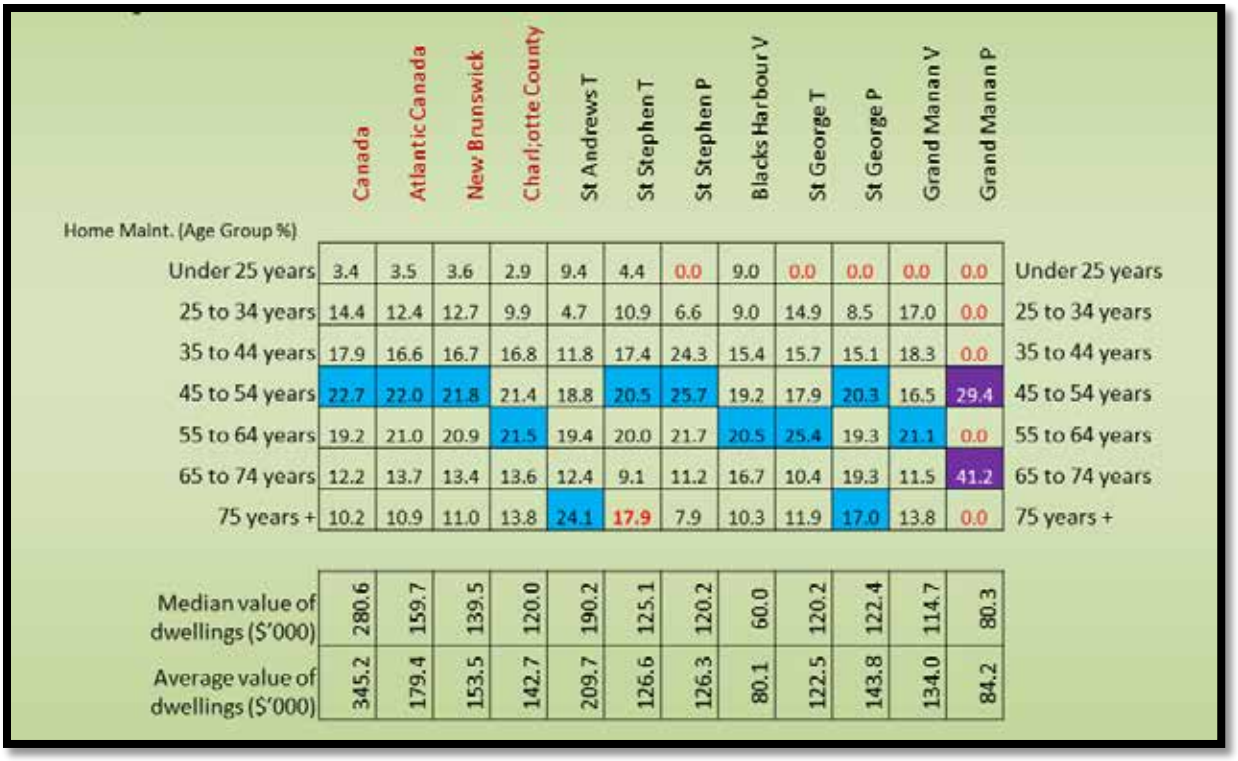
FIGURE 48: NEWSPAPER ARTICLE, JANUARY 13, 1998 (SOURCE: THE ST. CROIX COURIER).

Based on the statistics and analysis from Dr. MacLellan, it was determined that, similar to the other municipalities in Charlotte County, the Town of St. George is a long established community with a high percentage of residents being of third generation or more. St. George is a relatively stable community in terms of mobility. The community has a diverse range of employment sectors including manufacturing, public administration, construction, and natural resources. It was indicated by the working group that the percentage of those working in the construction sector was skewed because at the time of the census, a major construction project on a nearby highway was underway, and that there were fewer residents currently employed in the construction sector. The working group also mentioned that the aquaculture industry, particularly Cooke Aquaculture, employs many people in St. George, accounting for the number residents employed in both the manufacturing and natural resource sectors.

	CANADA	ATLANTIC CAN	NEW BRUNSWICK	CHARLOTTE County	St George T	St George P
Retail trade	11.6	12.4	11.9	9.7	11.6	5.3
Health care and social assistance	11.1	12.8	12.8	11.3	5.2	5.3
Manufacturing	9.2	7.6	8.6	16.3	14.5	22.8
Educational services	7.4	7.6	7.0	4.4	2.3	4.8
Public administration	7.2	10.3	10.2	7.0	12.1	3.9
Professional; scientific and technical services	7.1	4.5	4.2	2.3	2.3	2.6
Construction	6.9	7.5	7.5	9.4	9.8	11.8
Accommodation and food services	6.4	6.4	6.1	5.2	1.7	5.3
Transportation and warehousing	4.7	4.5	4.9	4.9	4.6	2.2
Other services (except public administration)	4.6	4.5	4.6	4.9	9.8	5.3
Finance and insurance	4.4	3.0	3.4	1.0	2.3	0.0
Wholesale trade	4.2	3.0	3.1	1.0	0.0	0.0
Admin. support; waste mngt $ remediation ser.	4.1	4.6	4.9	3.5	1.7	2.2
Agriculture; forestry; fishing and hunting	2.5	4.2	4.0	13.6	15.0	23.2
Information and cultural industries	2.4	1.9	1.9	0.6	0.0	0.0
Arts; entertainment and recreation	2.1	1.7	1.6	1.3	0.0	0.0
Real estate and rental and leasing	1.8	1.3	1.1	1.0	0.0	0.0
Mining; quarrying; and oil and gas extraction	1.5	1.5	1.2	0.3	0.0	0.0
Utilities	0.9	0.8	1.0	2.5	3.5	2.2
Management of companies and enterprises	0.1	0.1	0.1	0.0	0.0	0.0

FIGURE 49: OCCUPATION BY SECTOR EXPRESSED AS A PERCENTAGE FOR THE TOWN OF ST. GEORGE, BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

Income distribution patterns in St. George are consistent with the Atlantic region, with a high proportion of individuals earning between $20,000 and $50,000. The area's household maintainers skew towards an older demographic, as seen in Figure 50 below. Additional information provided by Dr. MacLellan can be found in Figures A4.1 to A4.4 of the Appendix under St. George.



Home Maint. (Age Group %)	Canada	Atlantic Canada	New Brunswick	Charlotte County	St Andrews T	St Stephen T	St Stephen P	Blacks Harbour V	St George T	St George P	Grand Manan V	Grand Manan P	
Under 25 years	3.4	3.5	3.6	2.9	9.4	4.4	0.0	9.0	0.0	0.0	0.0	0.0	Under 25 years
25 to 34 years	14.4	12.4	12.7	9.9	4.7	10.9	6.6	9.0	14.9	8.5	17.0	0.0	25 to 34 years
35 to 44 years	17.9	16.6	16.7	16.8	11.8	17.4	24.3	15.4	15.7	15.1	18.3	0.0	35 to 44 years
45 to 54 years	22.7	22.0	21.8	21.4	18.8	20.5	25.7	19.2	17.9	20.3	16.5	29.4	45 to 54 years
55 to 64 years	19.2	21.0	20.9	21.5	19.4	20.0	21.7	20.5	25.4	19.3	21.1	0.0	55 to 64 years
65 to 74 years	12.2	13.7	13.4	13.6	12.4	9.1	11.2	16.7	10.4	19.3	11.5	41.2	65 to 74 years
75 years +	10.2	10.9	11.0	13.8	24.1	17.9	7.9	10.3	11.9	17.0	13.8	0.0	75 years +
Median value of dwellings ($'000)	280.6	159.7	139.5	120.0	190.2	125.1	120.2	60.0	120.2	122.4	114.7	80.3	
Average value of dwellings ($'000)	345.2	179.4	153.5	142.7	209.7	126.6	126.3	80.1	122.5	143.8	134.0	84.2	

FIGURE 50: TOTAL NUMBER OF PRIVATE HOUSEHOLDS BY AGE GROUP OF PRIMARY HOUSEHOLD MAINTAINERS AND DWELLING VALUE BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

The working group members were then asked to identify areas on the community map, using blue sticker dots, where social and economic impacts were of concern into the future with respect to the chosen climate hazards. The social and economic areas identified were aquaculture hatchery sites, age care facilities and nearby blueberry and cranberry operations. The table outlining the number and description of the socioeconomic impacts is located in Table A4.2 of the Appendix under St. George in the blue table.

3.3.3 MEETING # 3

In Meeting # 3, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises from Meeting # 1 and 2. During Meeting # 3 the working group members were presented with information on the December 2010 flood event based on the LiDAR data and corresponding digital elevation maps (DEM). The information was presented by Réal Daigle, a New Brunswick based meteorologist and climate change consultant with R. J. Daigle Enviro. Mr. Daigle began by informing the working group about the most recent IPCC AR5, the development and use of RCPs and the ACASA Futures maps. Mr. Daigle then presented the LiDAR-based digital elevation map for the St. George area as shown in Figure 51 below.

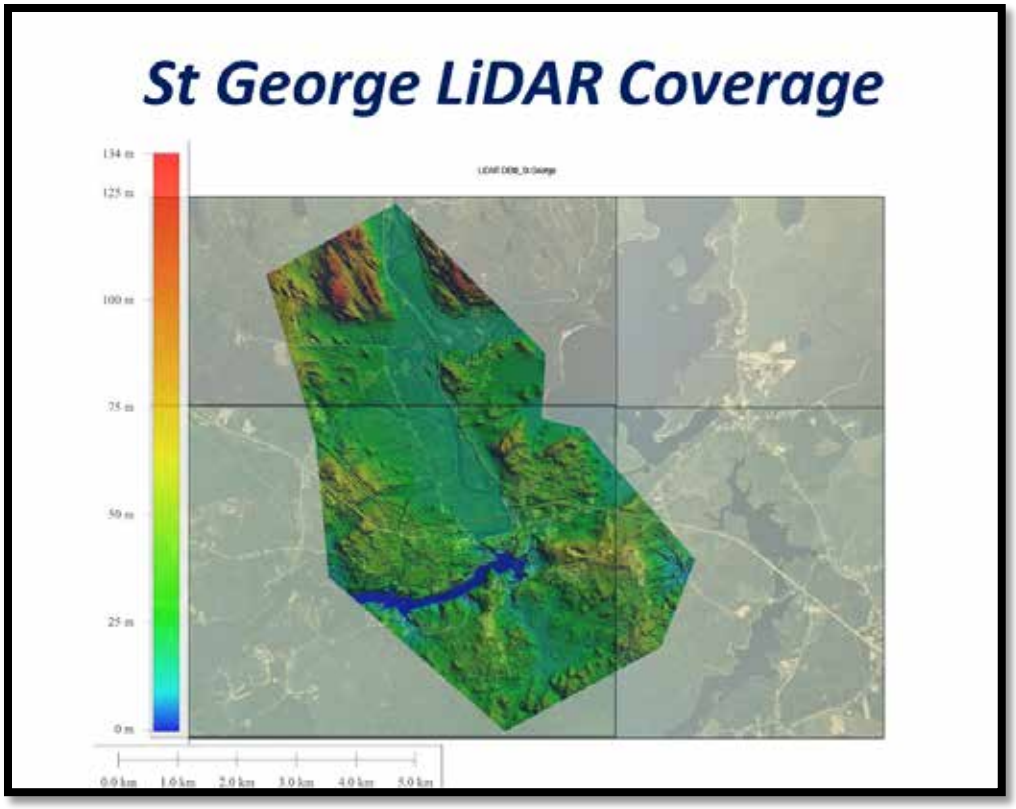


FIGURE 51: DEM OF THE ST. GEORGE AREA (SOURCE: DAIGLE 2014).

Using the LiDAR information and water depth markers at various points within the community, Mr. Daigle mapped the extent of the flooding in St. George during the December 2010 event; see Figures 53 and 54 below. Community members pointed out that there were some inconsistencies between the LiDAR modelling and the highway construction at the time of the December 2010 flood event. The working group determined that more LiDAR coverage is needed as the area flown did not encompass the total area that was impacted during the December 2010 event.

FIGURE 52: BRUNSWICK STREET BRIDGE, ST. GEORGE DECEMBER 13, 2010 (SOURCE: ALEX CHENEY).

During the December 2010 flood event in St. George, the water height was estimated at approximately 21.4m within most of the community, with the exception of the downtown area which was estimated at approximately 20.8m. This information was confirmed by the working group and the local EMO coordinator. As the river level rose, holes were cut into the sides of the Canal Covered Bridge to allow water to pass through. This is an example of a climate hazard adaptation as the bridge was inevitably saved by the holes that allowed the rising water to pass through.

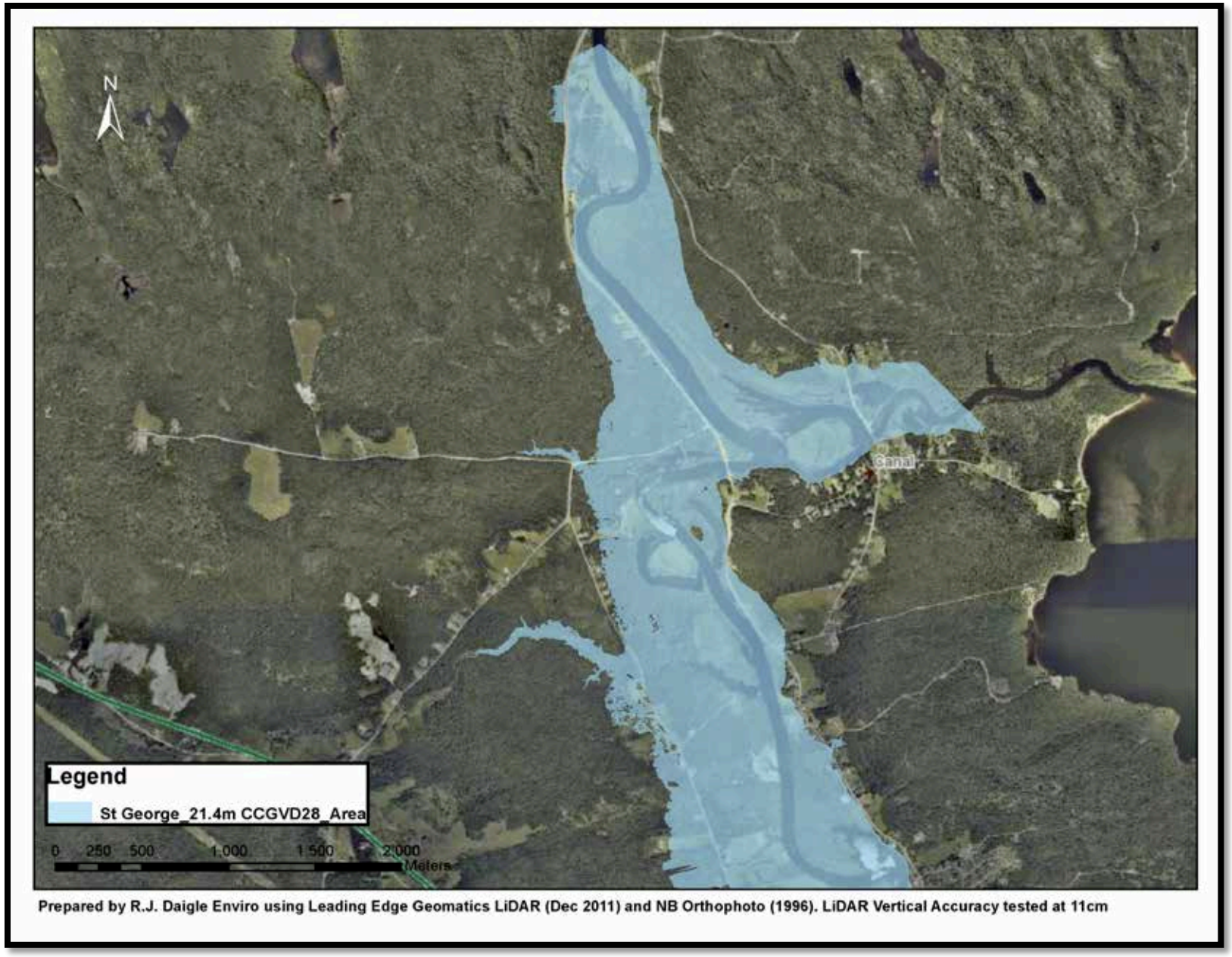


FIGURE 53:EXTENT OF THE DECEMBER 2010 FLOODING IN ST. GEORGE WITHIN LIDAR COVERAGE, CALCULATED BASED ON A WATER DEPTH OF 21.4M (SOURCE: DAIGLE 2014).

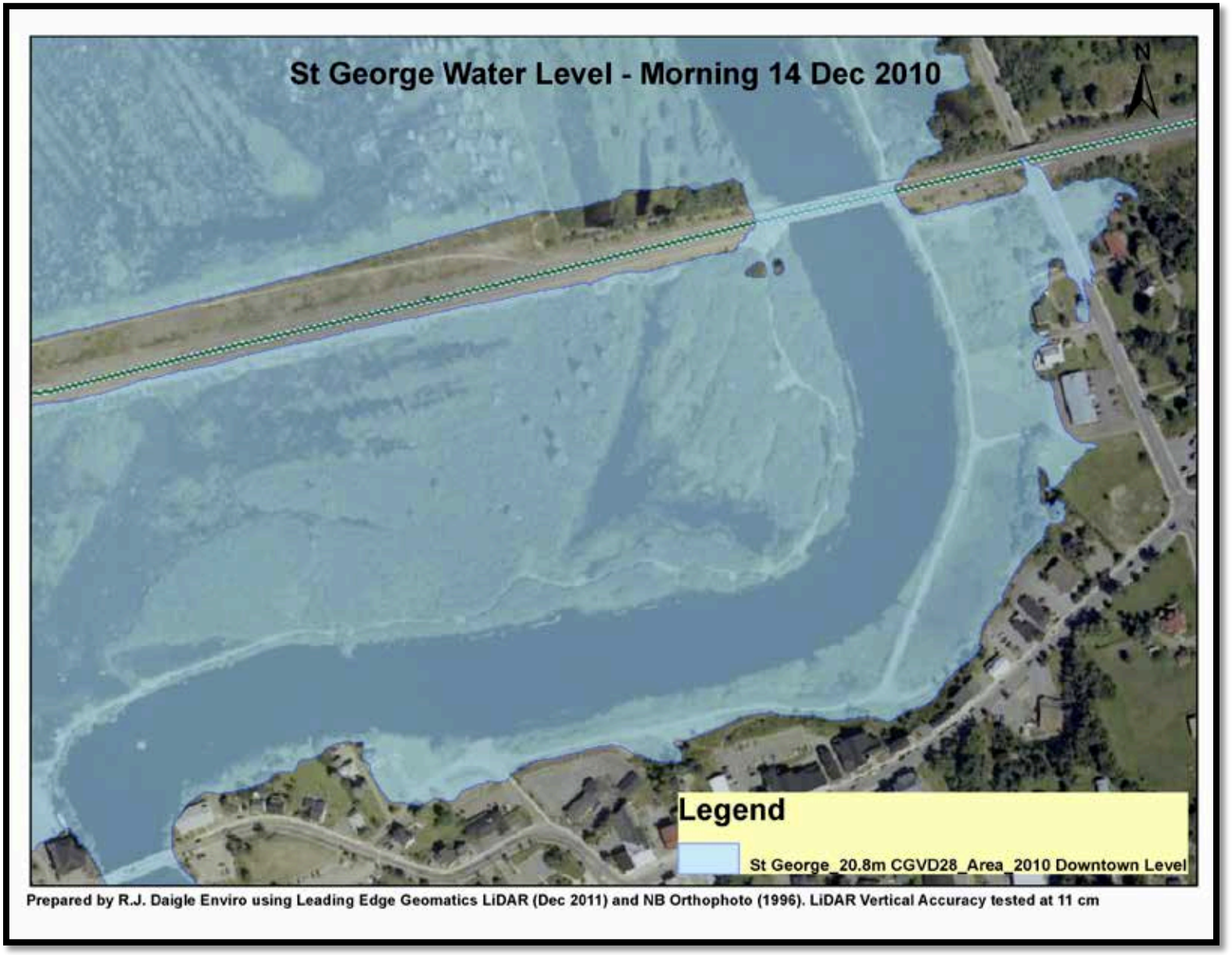


FIGURE 54:EXTENT OF FLOODING IN DOWNTOWN ST. GEORGE ON THE MORNING OF DECEMBER 14, 2010, CALCULATED BASED ON A WATER DEPTH OF 20.4 (SOURCE: DAIGLE 2014).

After the presentation by Mr. Daigle, the working group discussed the information presented to them as well as various governance and policy issues. The working group was very focused on making recommendations, specifically regarding how flood warnings could be better communicated to the local area. Some of the major points of that discussion included comments regarding the St. George hydroelectric dam, which is controlled by J. D. Irving. It was mentioned that there is little to no communication between the town and Irving with respect to opening the dam and that there is tension between residents and the company. It was expressed by the working group that there is a need for increased communication with respect to opening the dam, which would best be facilitated by provincial EMO officials. The only place to currently access information on the dam is on the St. George Power website (stgeorgepower.ca). The working group suggested that New Brunswick should have a comprehensive dam regulation, governing the operation of all the province's dam structures. The working group commented that there were issues during the December 2010 flood event with respect to NB Power not cutting off the power to submerged or unsafe power supplies to residences. Other recommendation included:

- Enforcement for replanting of clear-cut areas
- Larger set-backs from rivers and lakes
- Updated topographical maps
- There is a need for a hydrologic and hydraulic study of the lower Magaguadavic Watershed by a third party

Environmental impacts due to the climate hazards were then discussed. Green sticker dots were placed on the community map representing past impacts on the environment and those of concern into the future. During environmental mapping, the working groups specifically identified wetland areas and fish spawning habitat. A list of the numbered dots placed on the community map representing environmental impacts and their description can be found in Table A4.3 of the Appendix under St. George in the green table. A digitized version of the community map has been created using Google Earth to indicate where all of the coloured dots were placed on the community map in St. George as illustrated in Figure 55 below.

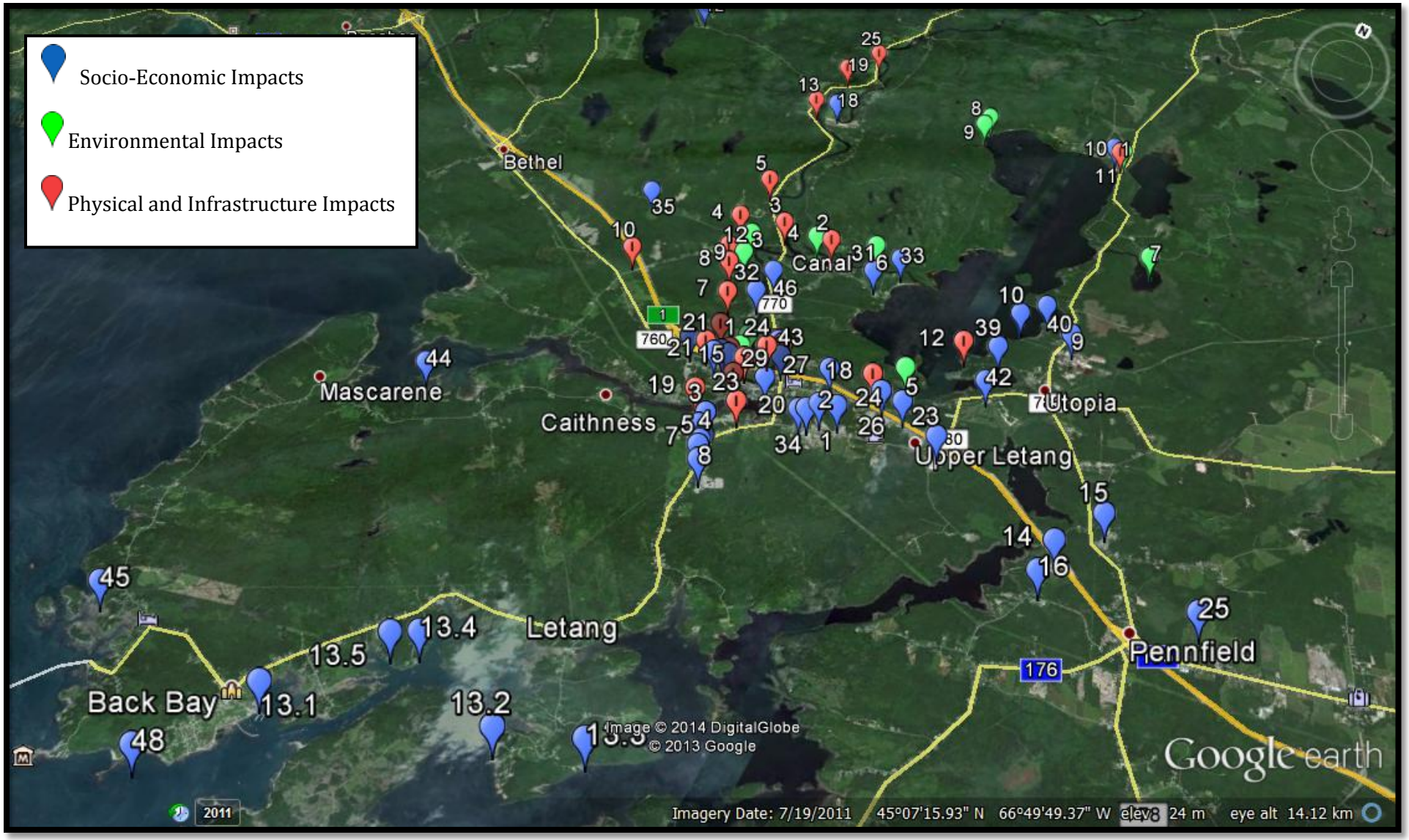


FIGURE 55: DIGITIZED MAP OF THE COMMUNITY MAPPING EXERCISE FOR ST. GEORGE (CREDIT: TANYA ANDERSON).

3.3.4 MEETING # 4

In Meeting # 4, the working group members were asked to recall the climate hazards chosen, the previous mapping exercises, and the policy and governance issues discussed in Meeting # 3. As environmental impacts were discussed and mapped in the previous meeting, Meeting # 4 was the last in St. George. In Meeting # 4, the working group members were first presented with information on inland flooding. The inland flooding maps were prepared using the LiDAR information and were analyzed to exhibit the depth to the water using a specified flow rate initiation of 4ha, which represents the end of summer ground saturation. Inland flooding maps, referred to as depth to water maps, were prepared to help the community in understanding unseen vulnerabilities. The depth to water map is illustrated in Figure 57 below.

FIGURE 56: MEETING # 4 IN ST. GEORGE, NB (SOURCE: KRISTIE SIGNER).

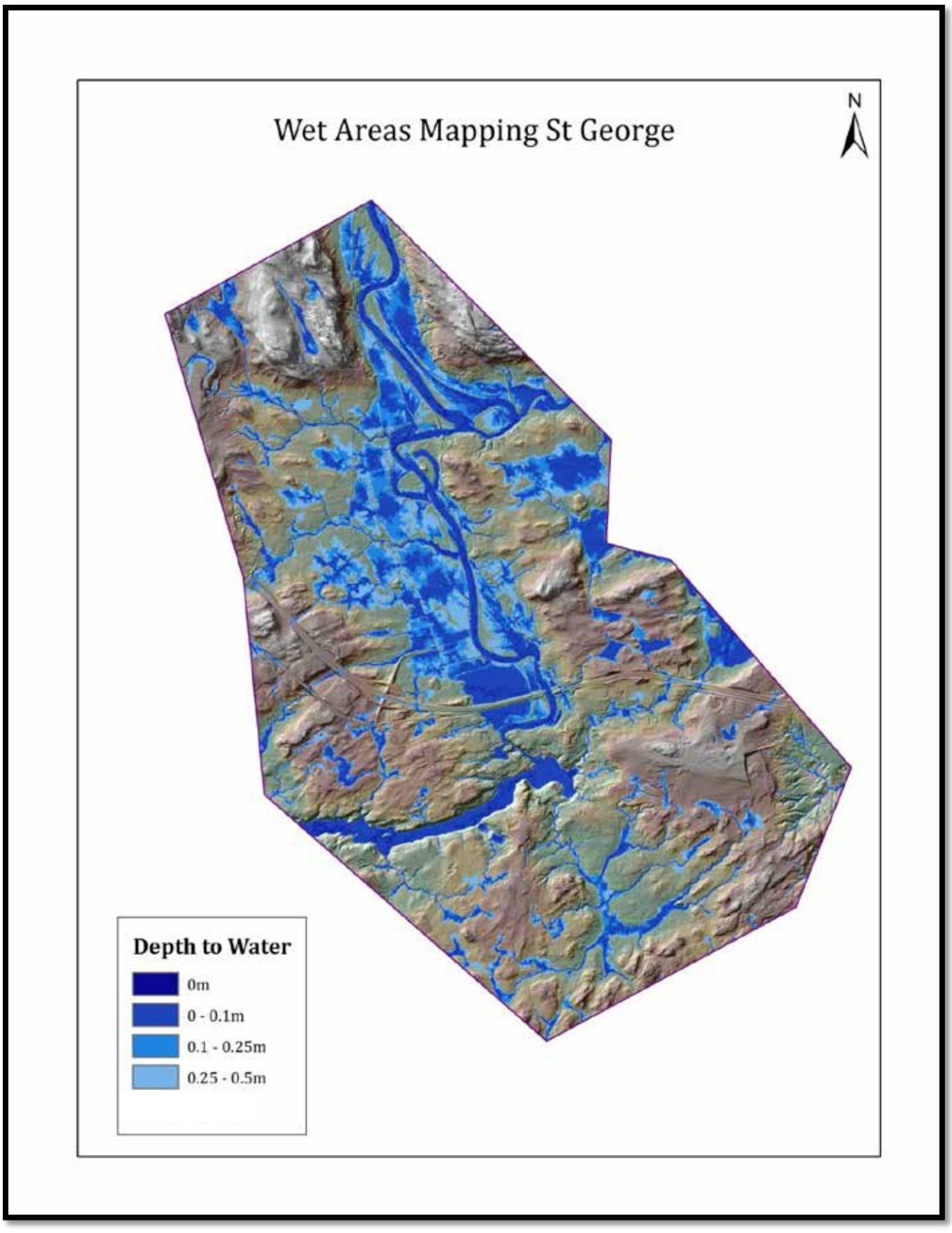


FIGURE 57: WAM MAP FOR THE TOWN OF ST. GEORGE, 4 HA INITIATION (SOURCE: ARP 2013).

Working group members were then asked to discuss how they felt they could incorporate what they have learned into the development of options for reducing the vulnerability of their community to the impacts of the climate hazards chosen. There was a discussion of options for further study to move forward with climate change adaptation planning and the working group analyzed how the community's specific issues could be addressed to reduce vulnerability. The working group revisited the recommendations made at the previous meeting and worked to clarify and expand on some of the points discussed. The working group identified major areas throughout the lower Magaguadavic Watershed that they felt were the most vulnerable within their community, based on the mapping exercises, previous discussions, presenter information, and their personal knowledge, Figure 58 below is representative of these areas. Areas indicated on the map include the choke points in the Magaguadavic River and areas that were severely impacted during the December 2010 flood event.

Other points that were raised by the working group in Meeting # 4:

- There were approximately 136 insurance claims that applied for DFA assistance through the EMO, within the town limits there were approximately 36
- Some LSDs are in the process of developing emergency plans
    - RSCs and municipalities will be incorporated into Regional Plans
- Large social impact in St. George
- EMO has "All Hazard Planning" which covers everything
    - Then a hazard risk analysis is undertaken by the municipality
        - § Plans for reactions

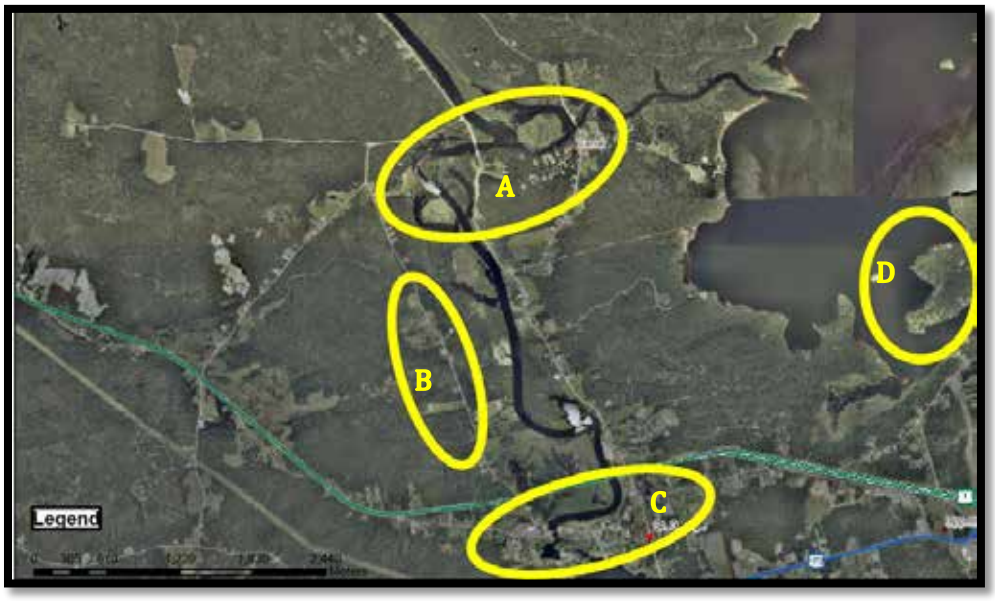


FIGURE 58: VULNERABLE AREAS OF ST. GEORGE AS DETERMINED BY THE LOCAL WORKING GROUP.

FIGURE 59: CLOSE UP OF THE VULNERABLE AREAS OF ST. GEORGE AS DETERMINED BY THE LOCAL WORKING GROUP (MAP SOURCE: DAIGLE 2014).

FIGURE 60: CLOSE UP OF THE VULNERABLE AREAS OF ST. GEORGE AS DETERMINED BY THE LOCAL WORKING GROUP (MAP SOURCE: DAIGLE 2014).

3.3.5 CONCLUSIONS

The working group members in St. George had an excellent knowledge and understanding of their community and the impacts of the December 2010 flood event. They were focused on addressing issues related to their chosen climate hazards: flooding and the increase of storm events. As an increase in storm events was likely to increase the chances of reoccurring flooding within the community, the working group members focused their discussions on the December 2010 flood event. Their identification of the vulnerable areas of their community was inclusive of:

A. The Canal
B. Manor Road
C. Riverview Avenue
D. Woodbury's Cove

Second Falls (wanted to include, but it was off of the map area)

The working group mentioned that there was a general lack of communication preceding and during hazard events and that there is a need for the development of a sound regional emergency plan which should be created in consultation with the participating communities. The working group also felt that communication of emergency information should be broadcast on St. Stephen and Saint John radio stations and that there is a need for better communication of road closures during hazard events and that the enforcement of these closures must be effective, such as the use of barriers. The working group was very concerned about the St. George Power hydroelectric dam in St. George. They felt that flooding issues could be directly attributed to dam procedures and a lack of communication. The working group indicated that the St. George hydroelectric dam could become more proactive in advance of storm events if the northeastern American weather models were incorporated into local models. The National Oceanic and Atmospheric Administration (NOAA) is the first to identify weather warnings in the region with Environment Canada following their lead. The working group believed that, by depending only on Environment Canada for weather information, the dam operators were not utilizing all the tools at their disposal to mitigate flooding. The working group also indicated that in July of 2011, St. George Power LP, owned by J. D. Irving, released the results of a study undertaken by Kleinschmidt Associates regarding the flood event of December, 2010. Kleinschmidt Associates had been hired directly following the flood event to "review the role of the dam at St. George in the flood event. The study focused on pre-storm conditions, the magnitude of the storm, and five key scenarios to address questions in the community about the impact that operations at St. George Power LP would have had during the course of the event" (J. D. Irving no date). The working group expressed concern over the validity of the conclusions made by the study and felt it was not conducted by an independent party.

3.3.6 RECOMMENDATIONS

The working group members in St. George were very focused on making recommendations for reducing their vulnerability to the climate hazards chosen. As the major concern amongst the community members was a repeat of the December 2010 flooding event, recommendations focused on disaster risk reduction techniques rather than long term climate change adaptation planning.

The working group insisted that a revised emergency measures plan for the RSC was required, and should include all parties participating in the December 2010 flood relief effort, as well as the DOTI, the Canadian Army, and the Department of Fisheries and Oceans (DFO) which were not involved during the previous flood event.

The working group was adamant that the new Emergency Measures Plan must take into account rainfall, ground saturation, and lake levels when determining a flood threat. The working group also recommended that the entire valley area should be included in the St. George Emergency Measure Plan as issues related to jurisdiction have prevented the local EMO from undertaking rescue efforts farther upstream.

Many issues relating to the dam were discussed throughout the meeting process and included the fact that there is no governing body in the province that regulates dams for standard operating procedures and monitoring. The working group members expressed that such a regulatory body would have to be operated at the provincial level. It was also recommended that the ideal response time for opening the dam gates during potential flood events is between 12 and 24 hours prior to the arrival of precipitation and should also take into account ground saturation and the water level of Lake Utopia. The working group recommended that the EMO should have the authority to override industry on the opening of the dam once an emergency has been declared, as the industry members responsible for opening the dam gates are located in Saint John and would not have on-the-ground knowledge of what was happening at the dam.

3.4 BLACKS HARBOUR

Blacks Harbour is located on the shores of the Bay of Fundy, as shown in Figure 61 below, and boasts a strong fishing industry based, almost exclusively, on herring in addition to multiple aquaculture sites for the production of Atlantic salmon (Village of Blacks Harbour ND). Two companies play a major role in the community, Connors Bros. and Cooke Aquaculture. Each has a longstanding relationship in the village. Blacks Harbour is a small, rural community of about 982 residents based on the Statistics Canada 2011 report, and serves as the only ferry point to the island of Grand Manan. Blacks Harbour was incorporated in 1972 (Government of NB 2014).

FIGURE 61: MUNICIPAL BOUNDARY OF THE VILLAGE OF BLACKS HARBOUR (SOURCE LEFT: GOOGLE EARTH, RIGHT: GEO NB).

3.4.1 MEETING # 1

The Blacks Harbour working group was represented by residents from the communities of Blacks Harbour, Beaver Harbour and Pennfield. As such, concerns for Beaver Harbour and Pennfield were also discussed at the Blacks Harbour working group meetings. At Meeting # 1, the working group was presented with a breakdown of the project process, an explanation of the major terms used throughout the meeting process, a brief description of climate change, the IPCC, and climate change scenarios. The working group members were asked to identify the climate hazards that they would like to discuss throughout the course of the vulnerability assessment. Blacks Harbour, and area, experienced very little impact from the 1998 ice storm and the heavy precipitation events of December 2010 and July 2013 compared to other Charlotte County communities. The working group members decided in Meeting #1 that the climate hazards they would like to discuss throughout the course of the meetings would be *access to safe drinking water* and *ocean acidification and warming.* They also mentioned that they would like to discuss, to a lesser degree, *sea-level rise, invasive species,* and *loss of species.*

FIGURE 62: MEETING # 1 IN BLACKS HARBOUR, DONALD KILLORN FACILITATING THE MAPPING EXERCISE (SOURCE: KRISTIE SIGNER).

The chosen climate hazards had not significantly impacted the community to date, so the working group marked the community map with the locations of critical infrastructure using red sticker dots as shown in Figure 70. They also discussed the potential physical and infrastructure impacts of the climate hazards. The table outlining the number and corresponding description of physical and infrastructure impacts is located in Table A3.1 of the Appendix under Blacks Harbour in the red table. The working group discussed that there was little protection for the local aquifer which is quite large and is located in Pennfield, supplying water to Blacks Harbour, Beaver Harbour, and Pennfield. The working group members commented that older residences throughout the area

FIGURE 63: MEETING # 1 IN BLACKS HARBOUR (SOURCE: KRISTIE SIGNER).

have connected water and sewer lines. The working group marked blue lines on the map, indicating where the village stops supplying water to rural residents, and where the water travels from the aquifer to the pumping station. Issues of flooding in the area were discussed but there had not been significant impacts.

3.4.2 MEETING # 2

In Meeting # 2, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercise from Meeting # 1. The facilitators presented information on the climate hazards chosen by the community, *ocean acidification and warming* and *access to safe drinking water.* The information presented on ocean acidification was provided by Gregor Reid, a St. Andrews working group member and Senior Research Scientist at the St. Andrews Biological Station. The facilitators then presented the working group with a general overview of social and economic impacts which was prepared by Ms. Abby Pond, the Executive Director of the St. Croix International Waterway Commission, and information on the social and economic aspects of the Village of Blacks Harbour, which was prepared by Dr. Jim MacLellan, a Senior Research Scientist and Project Leader for the New Brunswick Climate Change Research Collaborative. This community profile, based on the census data, provided a snapshot of who lives in the community, their age, income, profession, and sector they work in and can help in deriving a broad idea of what climate hazard impacts may be important to the community. This information helped the working group understand the potential impacts to socioeconomic systems in their community.

A safe harbor

Village survives with little damage

By BARB RAYNER
Courier Staff

BLACKS HARBOUR — While all around them there were major power outages the village escaped the wrath of the ice storm relatively unscathed.

Village Manager Deanna Hunter said Monday that they were prepared for the worst and she was amazed that they were not harder hit by the storm than they were.

There were power outages at the mobile home court behind the Pentecostal Church and at Wallace Cove from the Catholic Church down, she said. The power was not restored to the mobile homes until Monday afternoon but was back on at the church Sunday afternoon.

"We met Friday to discuss what action we would take if we had to declare an emergency. Myself and David Watson, our emergency measures co-ordinator, approached people (without power) to see if there was any way we could help them," she said.

"We were very fortunate here in Blacks Harbour. I still cannot believe nothing really happened down here when I see what happened everywhere else. There were tree limbs broken but nothing like what I expected to see. I don't know why we were so lucky."

FIGURE 64: NEWSPAPER ARTICLE FROM JANUARY 13, 1998 (SOURCE: ST. CROIX COURIER).

Based on the statistics and corresponding analysis from Dr. MacLellan, it was determined that Blacks Harbour is a long established community with a high percentage of residents being of a third generation or greater. Blacks Harbour is a relatively stable community in terms of mobility and more than 45% of the community is employed by the manufacturing sector and 20% in the natural resource sector. This is significantly more than national and provincial standards, as seen in Figure 69 below. The working group identified these sectors as the fish processing facility and the fishing of herring and lobster, as well as the salmon aquaculture industry. Income distribution within the community is strongly weighted towards the $15, 000 to $40,000 range. There is a large population of teenagers, aged 15 – 19, in Blacks Harbour with very few residents aged 25 – 29, it was

determined that this age gap reflects that portion of the population that relocates from the area in search of employment. The price of homes in Blacks Harbour is the lowest in Charlotte County and the age of home maintainers was generally between 35 and 64 as seen in Figure 66 below. Additional information provided by Dr. MacLellan can be found in Figures A3.1 to A3.4 of the Appendix under Blacks Harbour.

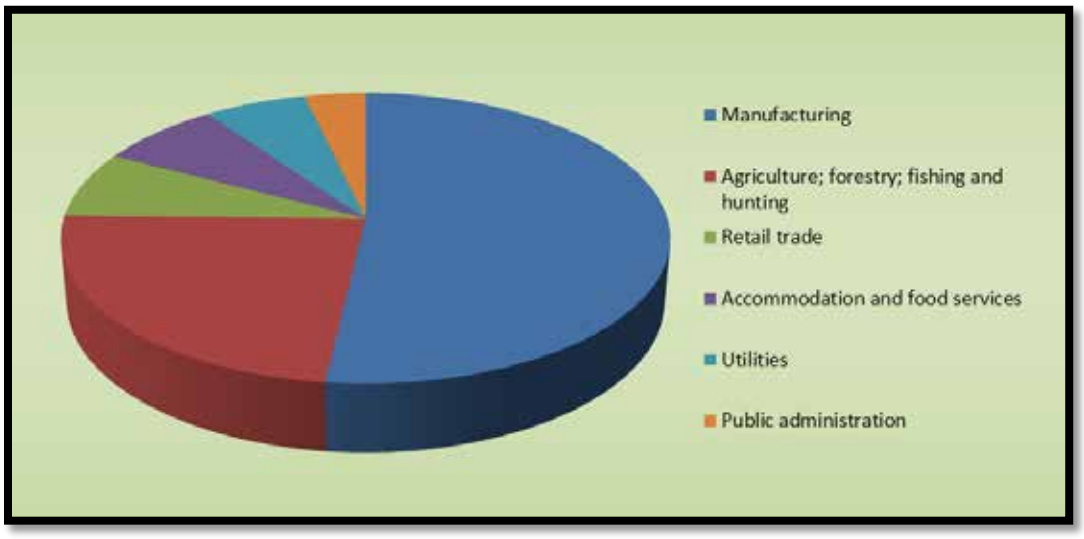


FIGURE 65: OCCUPATION BY SECTOR FOR THE VILLAGE OF BLACKS HARBOUR BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

Home Maint. (Age Group %)	Canada	Atlantic Canada	New Brunswick	Charlotte County	St Andrews T	St Stephen T	St Stephen P	Blacks Harbour V	St George T	St George P	Grand Manan V	Grand Manan P	
Under 25 years	3.4	3.5	3.6	2.9	9.4	4.4	0.0	9.0	0.0	0.0	0.0	0.0	Under 25 years
25 to 34 years	14.4	12.4	12.7	9.9	4.7	10.9	6.6	9.0	14.9	8.5	17.0	0.0	25 to 34 years
35 to 44 years	17.9	16.6	16.7	16.8	11.8	17.4	24.3	15.4	15.7	15.1	18.3	0.0	35 to 44 years
45 to 54 years	22.7	22.0	21.8	21.4	18.8	20.5	25.7	19.2	17.9	20.3	16.5	29.4	45 to 54 years
55 to 64 years	19.2	21.0	20.9	21.5	19.4	20.0	21.7	20.5	25.4	19.3	21.1	0.0	55 to 64 years
65 to 74 years	12.2	13.7	13.4	13.6	12.4	9.1	11.2	16.7	10.4	19.3	11.5	41.2	65 to 74 years
75 years +	10.2	10.9	11.0	13.8	24.1	17.9	7.9	10.3	11.9	17.0	13.8	0.0	75 years +
Median value of dwellings ($'000)	280.6	159.7	139.5	120.0	190.2	125.1	120.2	60.0	120.2	122.4	114.7	80.3	
Average value of dwellings ($'000)	345.2	179.4	153.5	142.7	209.7	126.6	126.3	80.1	122.5	143.8	134.0	84.2	

FIGURE 66: NUMBER OF PRIVATE HOUSEHOLDS BY AGE GROUP OF PRIMARY HOUSEHOLD MAINTAINERS AND DWELLING VALUE BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

The working group members were then asked to identify areas on the community map, using blue sticker dots, where social and economic impacts were of concern with respect to the chosen climate hazards. Because the climate hazards had not yet had a significant impact on the area, the working group members identified the major areas of social and economic activity within the community.

During Meeting # 2 in Blacks Harbour, it was revealed that Connors Bros. owns and operates the water lines and water treatment facilities. As access to safe drinking water was one of the chosen climate hazards for Blacks Harbour, the working group discussed how issues related to water quality are communicated to the affected communities through the use of the village Sentinel Alert system. It was mentioned that in one instance, boil water advisories had to be communicated personally in a door-to-door manner. It was discussed during this meeting that there are limited access points in and out of the village and if water quality were to be compromised at such a time that the roads were impassable, the only place to purchase water within Blacks Harbour is at the Freshmart grocery store. The working group commented that the two main employers and economic drivers of the village, Connors Bros. and Cooke Aquaculture, are also connected to the town drinking water supply. Ocean acidification and warming was a general economic concern because the economic base of the community lies in ocean resources. Further study is required to better understand the effect of changing ocean conditions on the Blacks Harbour economy.

3.4.3 MEETING # 3

In Meeting # 3, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises from the previous meetings. The working group was then presented with sea-level rise information derived using LiDAR data and corresponding digital elevation maps for Blacks Harbour by Mr. Réal Daigle, a New Brunswick based meteorologist and climate change consultant with R. J. Daigle Enviro. Mr. Daigle began by informing the working group about the most recent IPCC AR5, the development and use of RCPs, and the ACASA Futures Maps. Mr. Daigle then presented the LiDAR-based digital elevation map for the Blacks Harbour area as shown in Figure 67 below.

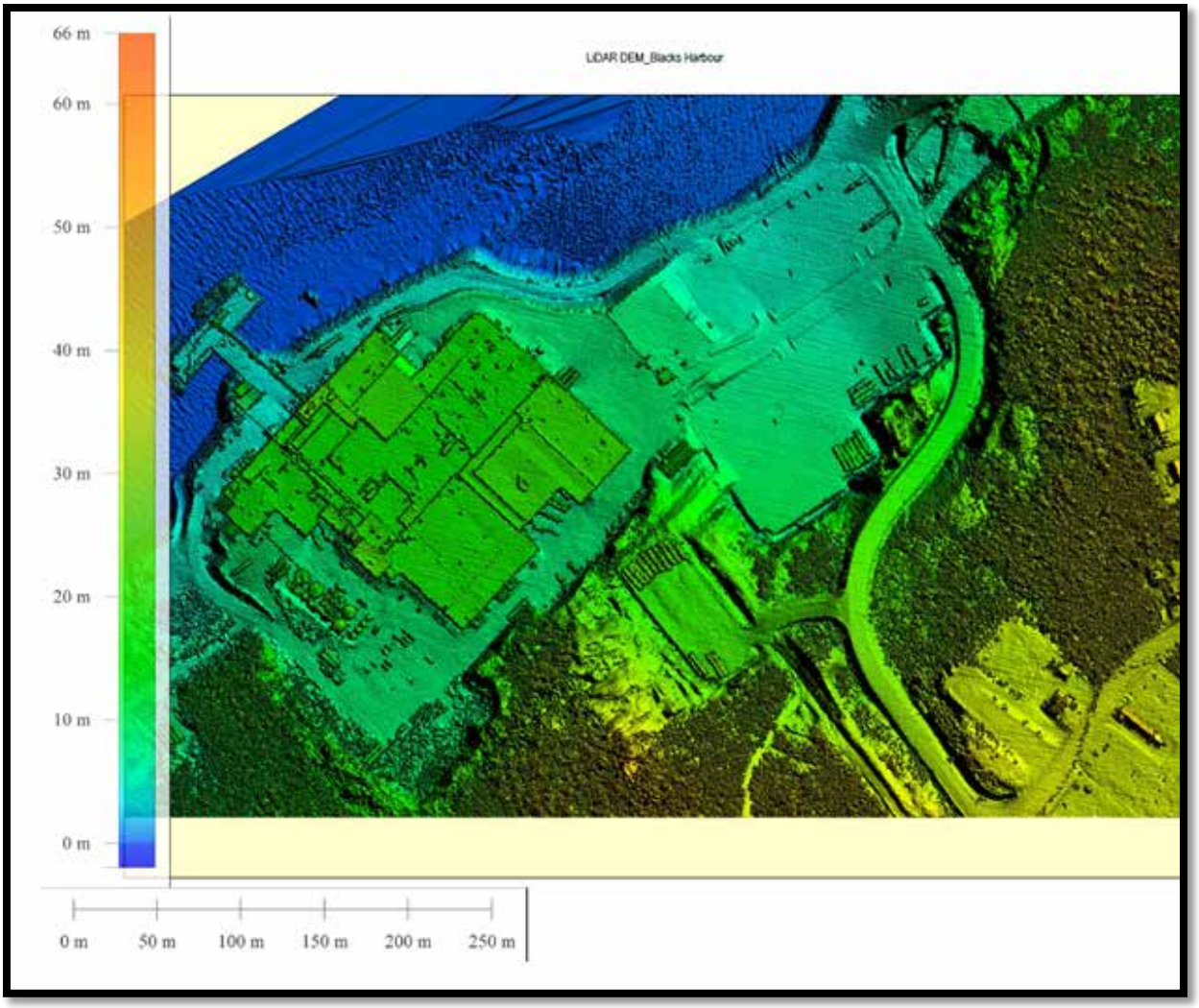


FIGURE 67: DEM OF THE CONNORS BROS. PROCESSING PLANT IN BLACKS HARBOUR (SOURCE: DAIGLE 2014).

Mr. Daigle used the DEM to make projections of sea-level rise into the future incorporating information from the IPCC, the extreme high tide value (HHWLT), crustal subsidence, and varying storm surge return periods. The HHWLT is determined using the average of each of the annual maximum predicted tide values over a 19 year tidal cycle as shown in Figure 68. A further explanation of how Mr. Daigle made his calculations can be found in the Methodology section.

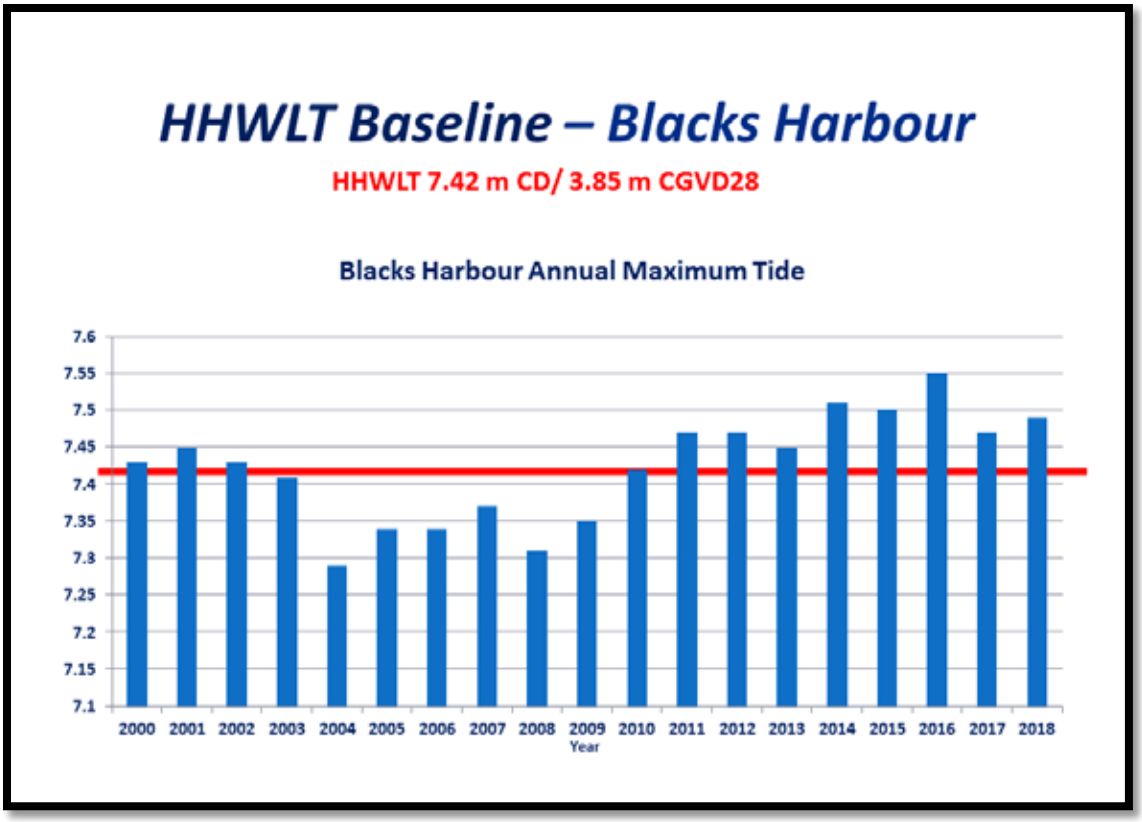


FIGURE 68: 19 YEAR TIDE CYCLE OF BLACKS HARBOUR, THE RED LINE ILLUSTRATES THE AVERAGE VALUE OF THE HHWLT: 7.42MCD/ 3.85M CGVD28 (SOURCE: DAIGLE 2014).

Mr. Daigle developed extreme total sea-level flooding scenarios for Blacks Harbour. The value is given for the vertical height in meters from the CGVD28 baseline along with a margin of error for the estimates as shown in Table 7 below. Estimates of the anticipated changes in total sea-levels (HHWLT + sea-level rise + storm surge flooding) for the time frames of 2010, 2025, 2055, 2085 and 2100, represented in Table 7 are meant to represent the worst case flooding scenario resulting from the simultaneous occurrence of a significant storm surge event for the respective return-periods and a high astronomical tide (HHWLT) at a given location. It should be noted from Table 7 that with an estimated sea-level increase of 0.88m by 2100, the present day 1 in 100 year flooding scenario (4.79m) becomes an annual event between 2055 and 2085.

TABLE 7: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR BLACKS HARBOUR (SOURCE: DAIGLE 2014).

Zone 11: Blacks Harbour HHWLT 3.85 m (CGVD28)						
Return Period	**Surge Residual**	**Level 2010**	**Level 2025**	**Level 2055**	**Level 2085**	**Level 2100**
1-Year	0.47 ± 0.20	4.32 ± 0.20	4.46 ± 0.23	4.68 ± 0.31	5.01 ± 0.41	5.21 ± 0.49
2-Year	0.54 ± 0.20	4.44 ± 0.20	4.53 ± 0.23	4.75 ± 0.31	5.08 ± 0.41	5.28 ± 0.49
5-Year	0.64 ± 0.20	4.49 ± 0.20	4.63 ± 0.23	4.85 ± 0.31	5.18 ± 0.41	5.38 ± 0.49
10-Year	0.71 ± 0.20	4.56 ± 0.20	4.70 ± 0.23	4.92 ± 0.31	5.25 ± 0.41	5.45 ± 0.49
25-Year	0.80 ± 0.20	4.65 ± 0.20	4.79 ± 0.23	5.01 ± 0.31	5.34 ± 0.41	5.54 ± 0.49
50-Year	0.87 ± 0.20	4.72 ± 0.20	4.86 ± 0.23	5.08 ± 0.31	5.41 ± 0.41	5.61 ± 0.49
100-Year	0.94 ± 0.20	4.79 ± 0.20	4.93 ± 0.23	5.15 ± 0.31	5.48 ± 0.41	5.68 ± 0.49

The colour-coded lines on Figure 69 indicate the extreme total sea-level flooding scenarios for a 1 in 100 year (1% chance of occurrence in any given year) storm surge return period for the years 2010, 2025, 2055, 2085 and 2100 along the Blacks Harbour waterfront. There is an additional line representing the year 2100 flooding scenario with the uncertainty factor.

For the additional extreme total sea-level flooding scenario maps for Blacks Harbour (1 in 1 year, 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, and 1 in 50 year) produced by Mr. Daigle, please refer to the included memory stick.

As sea-level rise was not included as a climate hazard for Blacks Harbour, sea-level rise and any associated impacts were not discussed outside of the presentation by Mr. Daigle. However, sea-level will not have a dramatic impact to the village of Blacks Harbour.

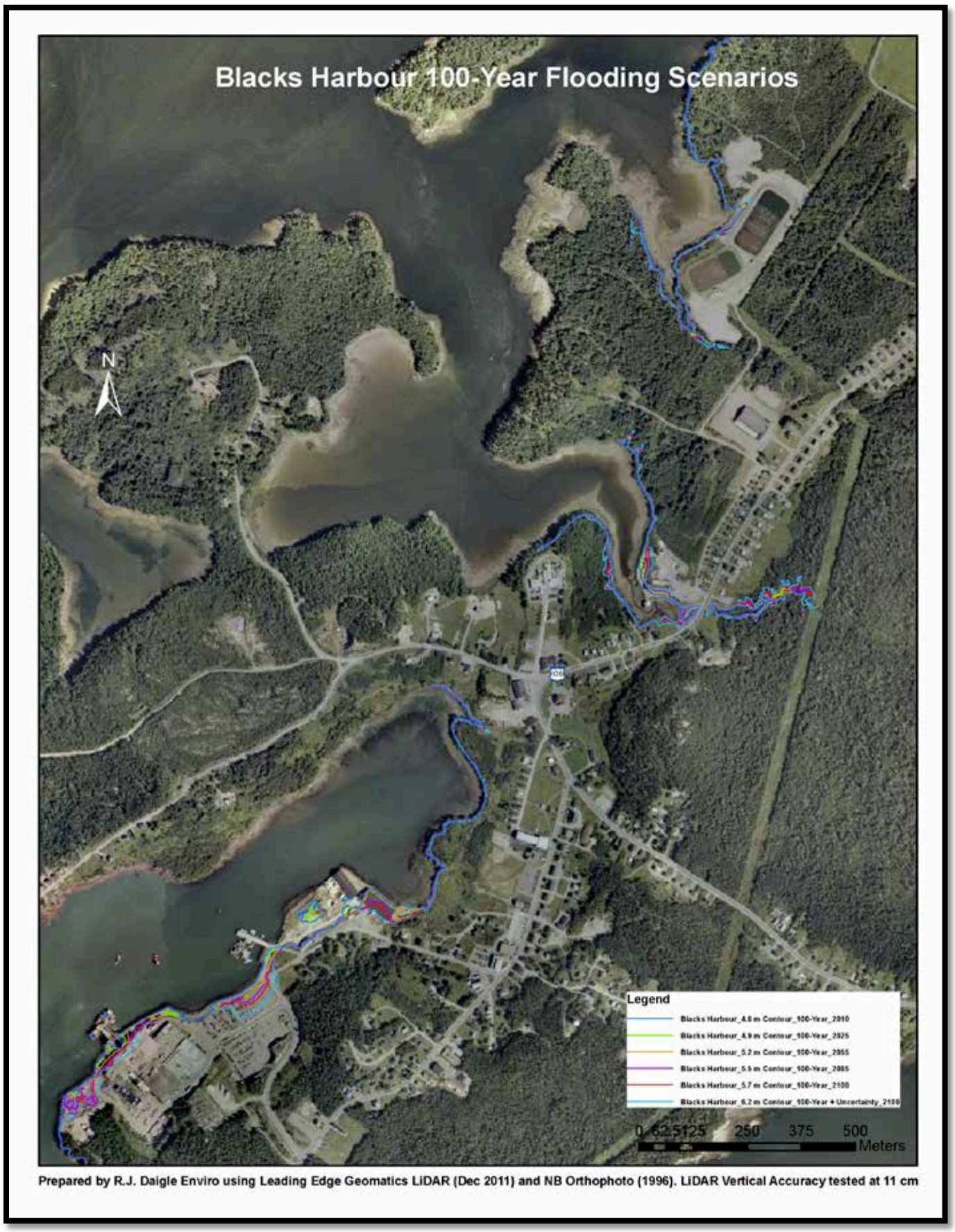


FIGURE 69: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR EVENT FOR BLACKS HARBOUR (SOURCE: DAIGLE 2014).

After the presentation, the working group discussed the information presented to them as well as various governance and policy issues within their community related to climate hazard events. The working group was very knowledgeable of the governance and policy issues in their community as representatives of industry, with a longstanding relationship with the municipal council, participated in working group meetings. The discussed issues included a lack of information on the aquifer that supplies water to the area. It was mentioned that some people within the village limits are on independent water well systems and are not connected to the municipal lines. There was also a comment about issues with the jurisdiction of main water line and how impacts to the water line are handled, specifically the line heading from the arena to Beaver Harbour which is inclusive of approximately 42 homes. The working group stated that Connors Bros. owns the water lines and treats the water. It was discussed that if there is an issue with the water, the village contacts Connors Bros. immediately, and it was noted that there is a high level of communication between the municipal government and Connors Bros.

Environmental impacts due to the climate hazards were then discussed. Green sticker dots were placed on the community map representing past impacts on the environment and those of concern into the future. A list of the numbered dots placed on the community map representing environmental impacts and their description can be found in Table A3.3 of the Appendix under Blacks Harbour in the green table. During the environmental mapping exercise, the working groups commented specifically on waste disposal sites throughout the community and whether or not they were currently in use. A digitized version of the community map has been created using Google Earth to indicate where all of the coloured dots were placed on the community map in Blacks Harbour as illustrated in Figure 70 below.

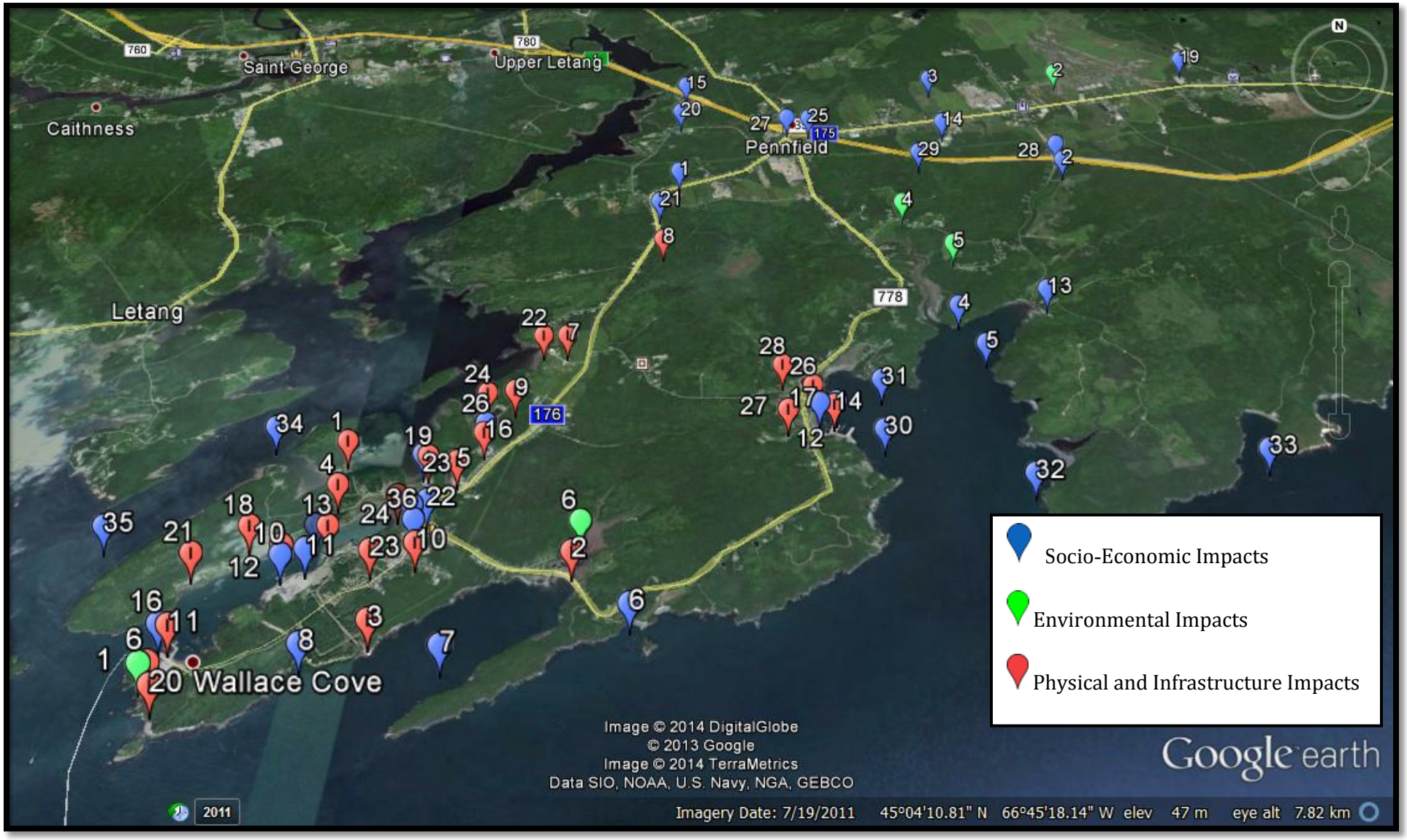


FIGURE 70: DIGITIZED MAP OF THE COMMUNITY MAPPING EXERCISE FOR BLACKS HARBOUR (CREDIT: TANYA ANDERSON).

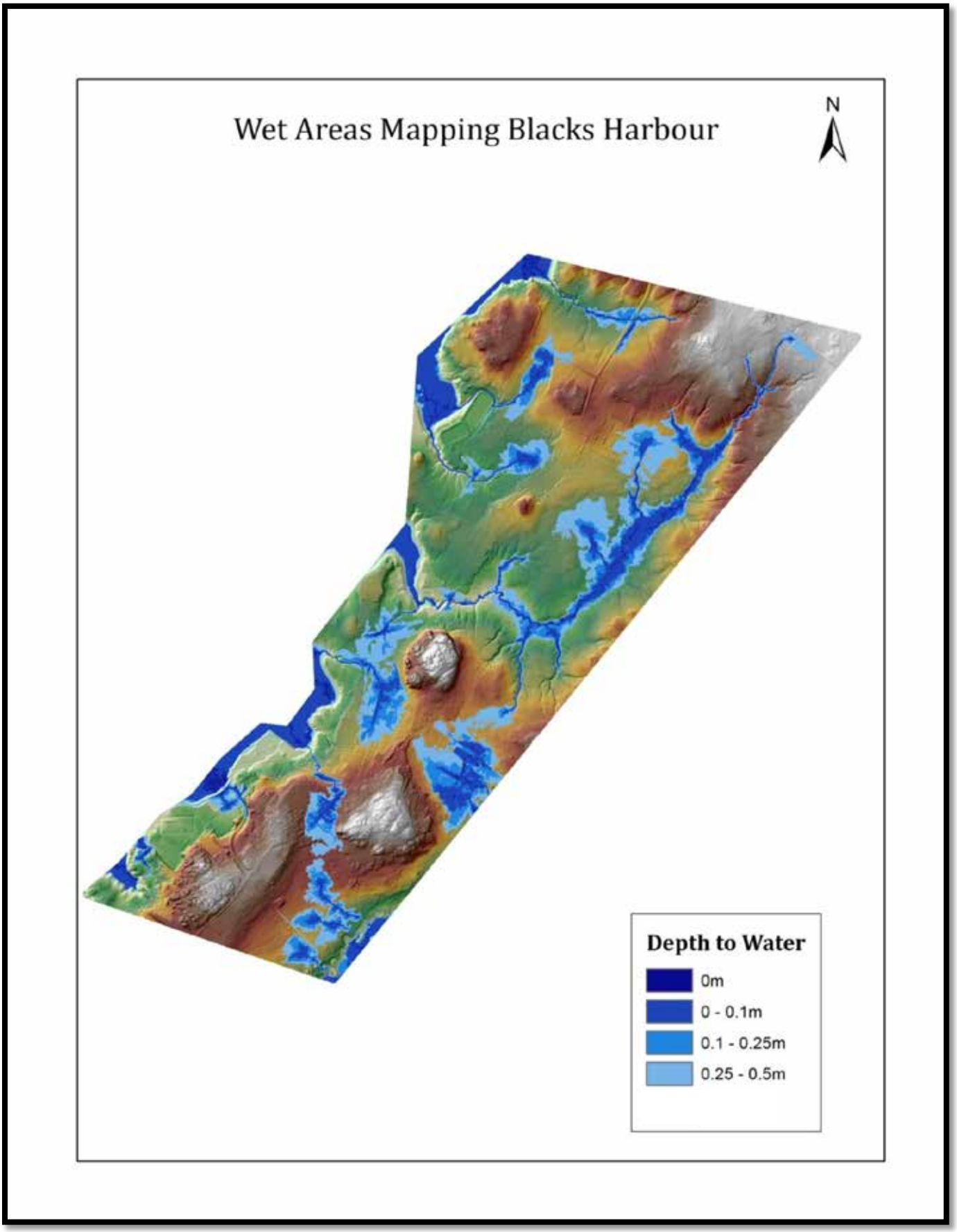


FIGURE 71: WAM MAP FOR THE VILLAGE OF BLACKS HARBOUR, 4HA INITIATION (SOURCE: ARP 2013).

3.4.4 CONCLUSIONS

The working group members were well dispersed throughout the Blacks Harbour area and had a wide-ranging knowledge and understanding of their community. The impacts of ocean acidification and warming, and access to safe drinking water had not been an issue of major concern for the community to date, discussions were focused on future impacts and what policy and governance issues exist. The mapping exercises provided the opportunity to highlight areas where important infrastructure is located, and where social and economic systems function. It was noted by the working group that there is a need to gain a better understanding of the aquifer which provides drinking water to the communities of Pennfield, Beaver Harbour and Blacks Harbour and that further information is needed to determine if the aquifer is at risk due to climate change and the associated impacts. Control of the aquifer, the water lines, and water treatment by Connors Bros. and matters related to that relationship were also discussed. It was established within the meetings that there is deferential communication between the village and Connors Bros. with respect to drinking water related issues.

The economic base of the community is founded, almost entirely, on the fishing industry, and, as such, ocean acidification and warming was of great concern to the working group members into the future. Issues related to shell formation and migration of harvested species due to warming ocean temperatures were discussed and how the greater fisheries might be impacted if any one species is threatened. As the harvesting and manufacturing/processing of marine species has been long established as the main source of economic income for the community, economic diversification for the community was discussed because of the potential impact of a changing ocean environment. Additionally, the vulnerability of the agriculture industry in the local area, namely blueberries and cranberries, was discussed and how it might be affected by climate change into the future.

Although impacts from the recent storm events had greatly affected other communities throughout Charlotte County, impacts in Blacks Harbour had been relatively minor in comparison. Even so, emergency measures were discussed by the working group members and there was a level of uncertainty regarding specific measures and shelter locations. In the December 2013, an ice storm had a significant impact on the community and comments have since been made publicly by residents and local government about the lack of preparedness and emergency response.

3.4.5 RECOMMENDATIONS

There were few recommendations brought forward by the working group, however, it was suggested that there is a need to learn more about the local aquifer and that this information should be communicated to those communities which access it. Additionally, based on meeting discussions, it was evident that there may be a need to explore economic diversification within the Blacks Harbour area in order to safeguard the community's economic wellbeing against the changing ocean conditions and resultant economic impacts to the local fisheries. The working group also indicated that emergency measures planning needed to be improved, as there is no designated emergency plan or shelter for the area. It was discussed that the community school is an option for an emergency shelter in Blacks Harbour if a generator could be purchased. The school's use as an

emergency shelter would then have to be outlined in emergency plans and communicated to the village and surrounding communities.

3.5 Grand Manan

The island of Grand Manan is the largest of the islands in the Bay of Fundy, located 32 kilometers south of Blacks Harbour, see Figure 72 (Government of NB 2014). The main industry of the village has always been fisheries, and more recently, the lobster industry has flourished. The tourism industry also continues to grow on Grand Manan as whale watching, sea kayaking, and bird watching have made this area favourable to domestic and international tourists alike. Additionally, Seal Cove has been designated as a National Historic Site of Canada, as it remains comparatively unchanged since the 19th century. In 1995, the village was incorporated when five small settlements on the island were amalgamated into what is now known as the Village of Grand Manan, a single municipality (Village of Grand Manan 2004). Statistics Canada reported that the population of Grand Manan was just over 2,300 in 2011 based on the National Household Survey.

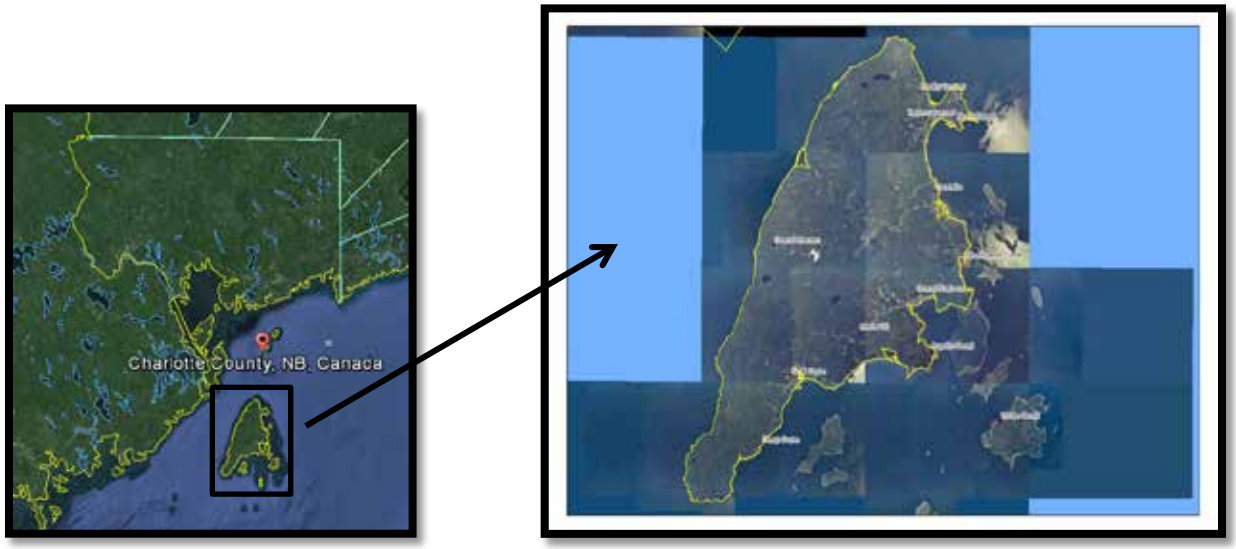


Figure 72: Municipal boundary of Village of Grand Manan (Source left: Google Earth, right: GeoNB).

3.5.1 Meeting # 1

At Meeting # 1, the working group was presented with a breakdown of the project process, an explanation of the major terms used throughout the meeting process, a brief description of climate change, the IPCC, and climate change scenarios. The working group was asked to identify the climate hazards that they would like to discuss throughout the vulnerability assessment. In comparison to the other municipalities of Charlotte County, the island of Grand Manan was not affected by any of the recent storm events. The working group chose *increase in ocean temperatures, invasive species* and *loss of species* as the climate hazards they would like to discuss.

As the climate hazards chosen had not had a significant impact throughout the island to date, the working group members marked the locations where critical infrastructure exists, such as wharves and emergency service structures, with red sticker dots on the community map provided. They

identified infrastructure and physical structures in need of repair or replacement and discussed potential physical and infrastructure impacts in the future. The table outlining the number and corresponding description is located in Table A5.1 of the Appendix under Grand Manan in the red table. The working group members noted that the entire population of the island is on independent water and sewer systems.

Other points that were raised by the working group in Meeting # 1:

- Herring is a keystone species for Grand Manan
- The municipal CAO, Rob MacPherson, is also the EMO coordinator
- There has been a new species of tree beetle identified as Larch Beetle, a spruce beetle has also been recognized to a lesser extent
- The power cable was installed in 1978
    - Lifespan is estimated at approximately 15 years
    - Has never been replaced
- In November 2010, there was a storm surge during a high tide, water flooded into the harbour and over the wharf

3.5.2 MEETING # 2

In Meeting # 2, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercise from Meeting # 1. The working group was then offered information on the impact of ocean warming with respect to invasive species, and the loss of marine species that the local industry is dependent on. The working group was presented with information on social and economic impacts which was prepared by Ms. Abby Pond, the Executive Director of the St. Croix International Waterway Commission, and information on the social and economic aspects of Grand Manan which was prepared by Dr. Jim MacLellan, a Senior Research Scientist, and Project Leader for the New Brunswick Climate Change Research Collaborative. The community profile, based on census data, provided a snapshot of who lives in the community, their age, income, profession, and sector they work in and can help in deriving a broad idea of what climate hazard impacts may be important to the community. This information assisted the working group when identifying potential impacts to socioeconomic systems in their community as a result of the chosen climate hazards.

Grand Manan is a long established community with a high percentage of residents being of a third generation or more. It is a more mobile community compared to others in the county. Based on the information presented and verified by the working group, Grand Manan is dominated by the natural resources sector, with a minimal complement of service sectors, as seen in Figure 73 below. Income distribution patterns on Grand Manan are consistent with the Atlantic region, however, house prices in general are below the national, Atlantic, and provincial averages with little variability. Householder maintainers skew towards the older proportion of the population as seen in Figure 74 below. Additional information provided by Dr. MacLellan can be found Figures A5.1 to A5.4 of the Appendix under Grand Manan.

	CANADA	ATLANTIC CAN	NEW BRUNSWICK	CHARLOTTE County	Grand Manan V	Grand Manan P
Retail trade	11.6	12.4	11.9	9.7	9.0	0.0
Health care and social assistance	11.1	12.8	12.8	11.3	13.3	0.0
Manufacturing	9.2	7.6	8.6	16.3	5.5	0.0
Educational services	7.4	7.6	7.0	4.4	1.6	0.0
Public administration	7.2	10.3	10.2	7.0	4.3	0.0
Professional; scientific and technical services	7.1	4.5	4.2	2.3	1.6	0.0
Construction	6.9	7.5	7.5	9.4	4.3	0.0
Accommodation and food services	6.4	6.4	6.1	5.2	5.1	0.0
Transportation and warehousing	4.7	4.5	4.9	4.9	6.3	0.0
Other services (except public administration)	4.6	4.5	4.6	4.9	3.5	0.0
Finance and insurance	4.4	3.0	3.4	1.0	0.0	0.0
Wholesale trade	4.2	3.0	3.1	1.0	1.6	0.0
Admin. support; waste mngt $ remediation ser.	4.1	4.6	4.9	3.5	3.9	0.0
Agriculture; forestry; fishing and hunting	2.5	4.2	4.0	13.6	34.8	50.0
Information and cultural industries	2.4	1.9	1.9	0.6	0.0	0.0
Arts; entertainment and recreation	2.1	1.7	1.6	1.3	0.0	0.0
Real estate and rental and leasing	1.8	1.3	1.1	1.0	2.0	0.0
Mining; quarrying; and oil and gas extraction	1.5	1.5	1.2	0.3	0.0	0.0
Utilities	0.9	0.8	1.0	2.5	0.0	0.0
Management of companies and enterprises	0.1	0.1	0.1	0.0	0.0	0.0

FIGURE 73: OCCUPATION BY SECTOR EXPRESSED AS A PERCENTAGE FOR GRAND MANAN, BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

Home Maint. (Age Group %)	Canada	Atlantic Canada	New Brunswick	Charlotte County	St Andrews T	St Stephen T	St Stephen P	Blacks Harbour V	St George T	St George P	Grand Manan V	Grand Manan P	
Under 25 years	3.4	3.5	3.6	2.9	9.4	4.4	0.0	9.0	0.0	0.0	0.0	0.0	Under 25 years
25 to 34 years	14.4	12.4	12.7	9.9	4.7	10.9	6.6	9.0	14.9	8.5	17.0	0.0	25 to 34 years
35 to 44 years	17.9	16.6	16.7	16.8	11.8	17.4	24.3	15.4	15.7	15.1	18.3	0.0	35 to 44 years
45 to 54 years	22.7	22.0	21.8	21.4	18.8	20.5	25.7	19.2	17.9	20.3	16.5	29.4	45 to 54 years
55 to 64 years	19.2	21.0	20.9	21.5	19.4	20.0	21.7	20.5	25.4	19.3	21.1	0.0	55 to 64 years
65 to 74 years	12.2	13.7	13.4	13.6	12.4	9.1	11.2	16.7	10.4	19.3	11.5	41.2	65 to 74 years
75 years +	10.2	10.9	11.0	13.8	24.1	17.9	7.9	10.3	11.9	17.0	13.8	0.0	75 years +
Median value of dwellings ($'000)	280.6	159.7	139.5	120.0	190.2	125.1	120.2	60.0	120.2	122.4	114.7	80.3	
Average value of dwellings ($'000)	345.2	179.4	153.5	142.7	209.7	126.6	126.3	80.1	122.5	143.8	134.0	84.2	

FIGURE 74: NUMBER OF PRIVATE HOUSEHOLDS BY AGE GROUP OF PRIMARY HOUSEHOLD MAINTAINERS AND DWELLING VALUE BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

The working group then used blue sticker dots to identify areas on the community map where the social and economic impacts of climate change have been felt or were of concern in the future. Because the climate hazards were less quantifiable compared to other municipalities in the county, the working group members identified the major areas of social and economic activity on the island. The table outlining the number and description of the impact is located in Table A5.2 of the Appendix under Grand Manan in the blue table. The working group indicated that the fishing industry, which employs the majority of residents on the island, is focused on lobster, herring, scallops, dulse, and salmon farming. One working group member also commented that the major industries on the island are referred to as the "big three" and include lobster, aquaculture, and tourism. It was also revealed that there are fewer lenders of mortgages because of the foreclosure rate on the island and that a large percentage of real estate buyers are "off island" or non-permanent residents.

3.5.3 MEETING # 3

In Meeting # 3 the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises from the previous meetings. The working group was then offered sea-level rise information based on LiDAR data and associated digital elevation maps (DEMs) for the island. These were presented by Mr. Réal Daigle, a New Brunswick based meteorologist and climate change consultant with R. J. Daigle Enviro. Mr. Daigle began by informing the working group about the most recent IPCC AR5, the development and use of RCPs, and the ACASA Futures maps. Mr. Daigle then presented the LiDAR-based DEM for the selected area of Grand Manan as shown in Figure 75 below. The working group indicated that more LiDAR coverage was needed to encompass the total residential area of the island. This highlights a major issue when working with LiDAR, the time it takes between ordering and receiving analyzed data.

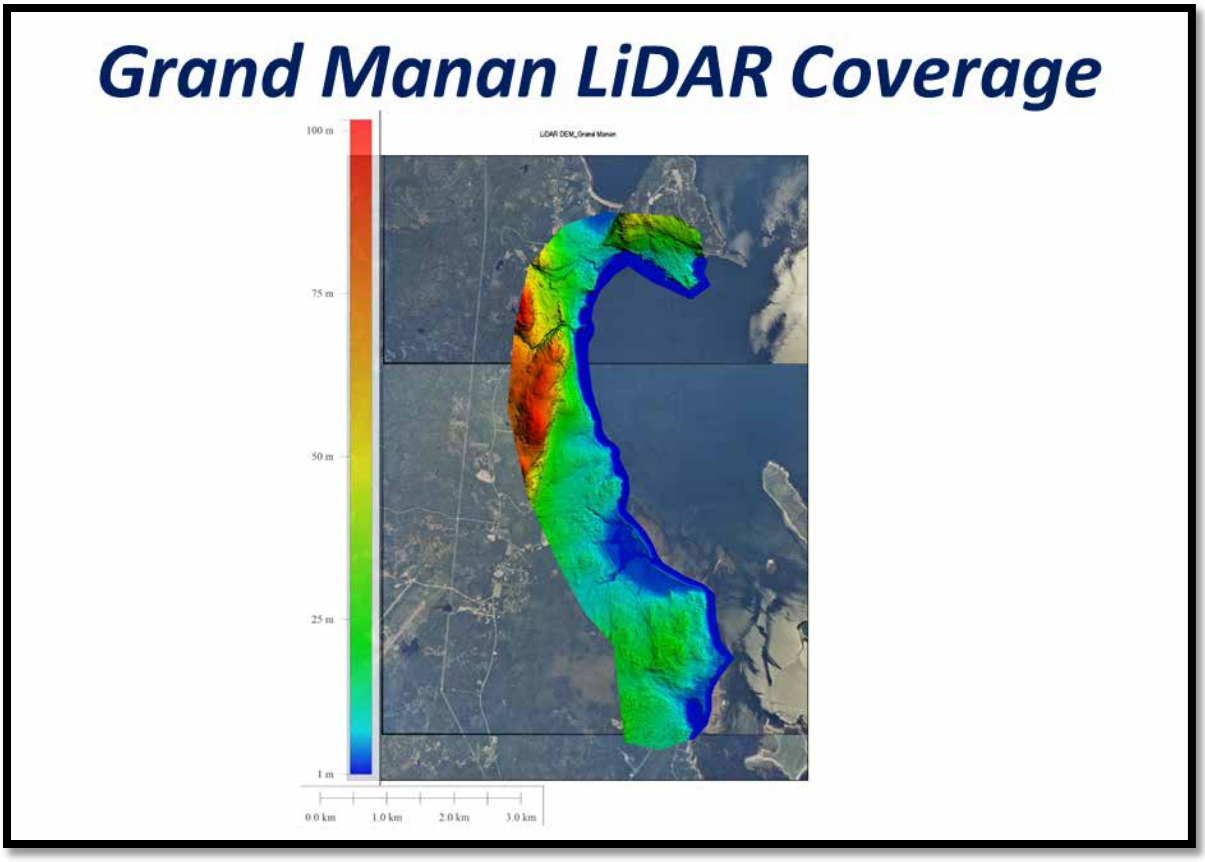


FIGURE 75: DEM OF GRAND MANAN (SOURCE: DAIGLE 2014).

Mr. Daigle used the DEM to make projections of sea-level rise into the future incorporating information from the IPCC, the extreme high tide value (HHWLT), crustal subsidence, and varying storm surge return periods. The HHWLT is determined using the average of each of the annual maximum predicted tide values over a 19 year tidal cycle as shown in Figure 76. A further explanation of how Mr. Daigle made his calculations can be found in the Methodology section.

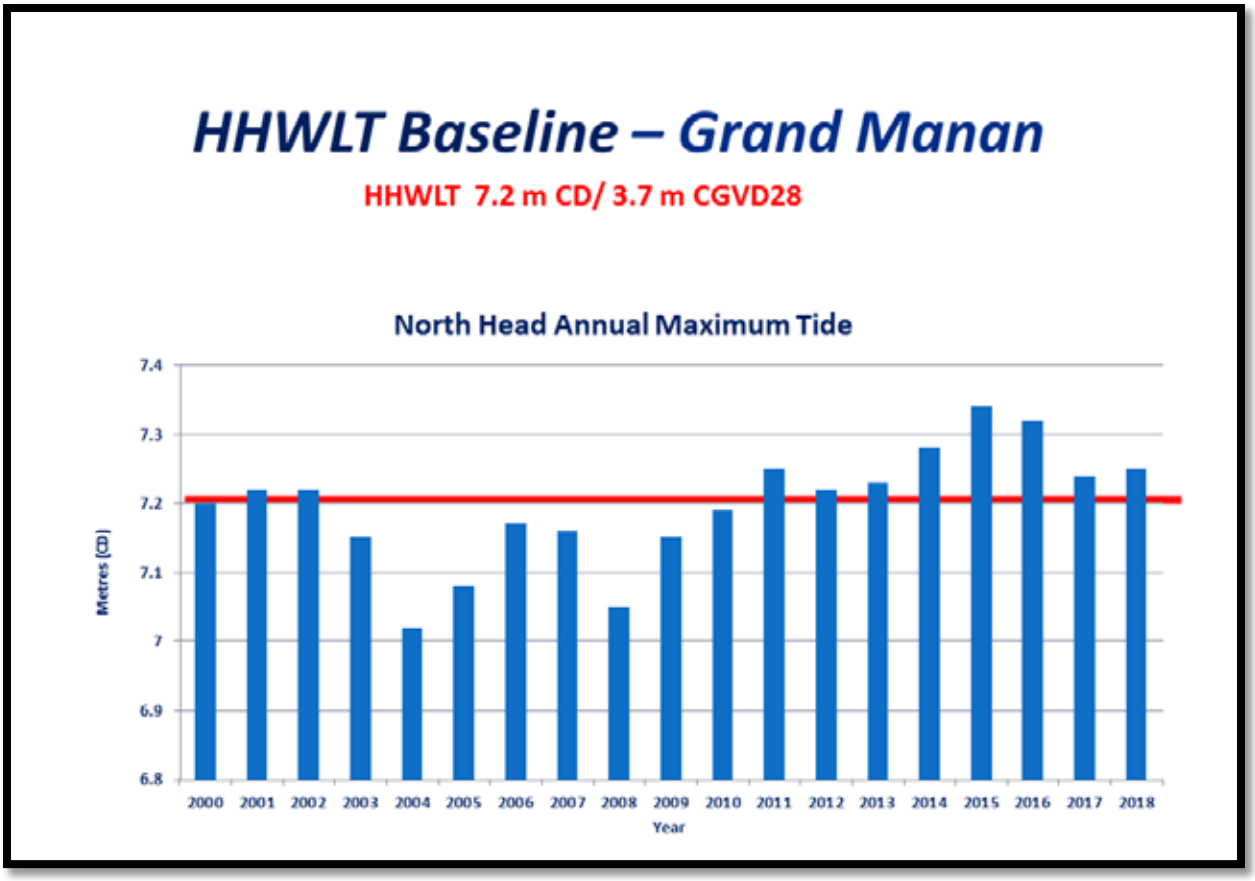


FIGURE 76: 19 YEAR TIDE CYCLE FOR GRAND MANAN, THE RED LINE ILLUSTRATES THE AVERAGE VALUE OF THE HHWLT: 7.2MCD/ 3.7M CGVD28 (SOURCE: DAIGLE 2014).

Mr. Daigle developed extreme total sea-level flooding scenarios for Grand Manan; the value is given for the vertical height in meters from the CGVD28 baseline along with a margin of error for the estimates as shown in Table 8 below. Estimates of the anticipated changes in total sea-levels (HHWLT + sea-level rise + storm surge flooding) for the time frames of 2010, 2025, 2055, 2085 and 2100, represented in Table 8 are meant to represent the worst case flooding scenario resulting from the simultaneous occurrence of a significant storm surge event for the respective return-periods and a high astronomical tide (HHWLT) at a given location. It should be noted from Table 8 that with an estimated sea-level increase of 0.88m by 2100, the present day 1 in 100 year flooding scenario (4.64m) becomes an annual event between 2055 and 2085.

TABLE 8: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR GRAND MANAN (SOURCE: DAIGLE 2014).

Grand Manan (North Head) HHWLT 3.7 m (CGVD28)						
Return Period	**Surge Residual**	**Level 2010**	**Level 2025**	**Level 2055**	**Level 2085**	**Level 2100**
1-Year	0.47 ± 0.20	4.17 ± 0.20	4.32 ± 0.23	4.54 ± 0.31	4.88 ± 0.41	5.08 ± 0.49
2-Year	0.54 ± 0.20	4.24 ± 0.20	4.39 ± 0.23	5.61 ± 0.31	4.95 ± 0.41	5.15 ± 0.49
5-Year	0.64 ± 0.20	4.34 ± 0.20	4.49 ± 0.23	4.71 ± 0.31	5.05 ± 0.41	5.25 ± 0.49
10-Year	0.71 ± 0.20	4.41 ± 0.20	4.56 ± 0.23	4.80 ± 0.31	5.14 ± 0.41	5.34 ± 0.49
25-Year	0.80 ± 0.20	4.50 ± 0.20	4.65 ± 0.23	4.87 ± 0.31	5.21 ± 0.41	5.41 ± 0.49
50-Year	0.87 ± 0.20	4.57 ± 0.20	4.72 ± 0.23	4.94 ± 0.31	5.28 ± 0.41	5.48 ± 0.49
100-Year	0.94 ± 0.20	4.64 ± 0.20	4.79 ± 0.23	5.01 ± 0.31	5.35 ± 0.41	5.55 ± 0.49

The colour-coded lines on Figures 77–80 indicate the extreme total sea-level flooding scenarios for a 1 in 100 year (1% chance of occurrence in any given year) storm surge return period for the years 2010, 2025, 2055, 2085 and 2100 along the North Head Central, North Head East, Woodwards Cove and Castalia Marsh waterfronts. There is an additional line representing the year 2100 flooding scenario with the uncertainty factor added.

For the additional extreme total sea-level flooding scenario maps for Grand Manan (1 in 1 year, 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, and 1 in 50 year) produced by Mr. Daigle, please refer to the included DVD.

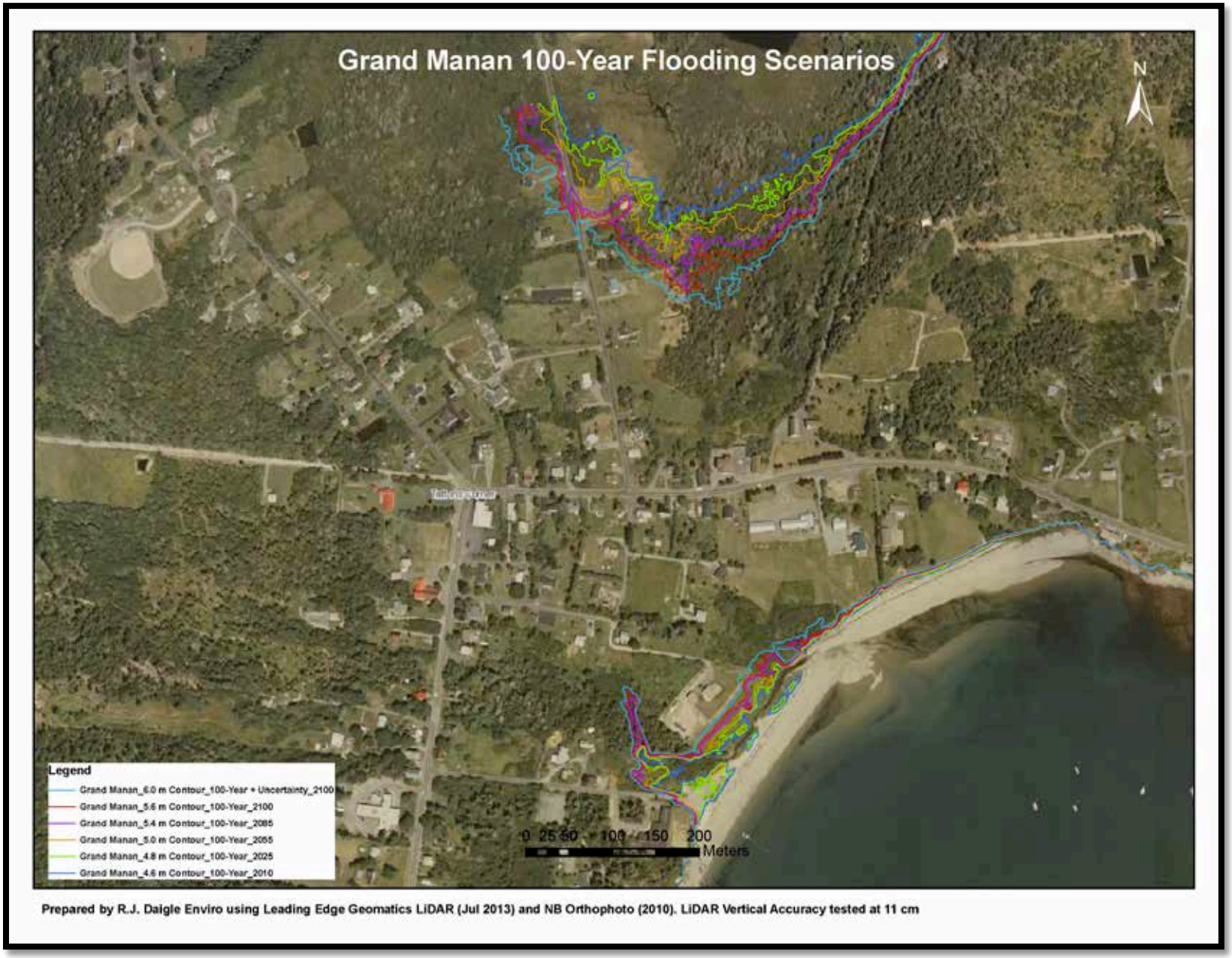


FIGURE 77: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A1 IN 100 YEAR STORM EVENT FOR NORTH HEAD CENTRAL (SOURCE: DAIGLE 2014).

FIGURE 78: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR EVENT FOR NORTH HEAD EAST (SOURCE: DAIGLE 2014).

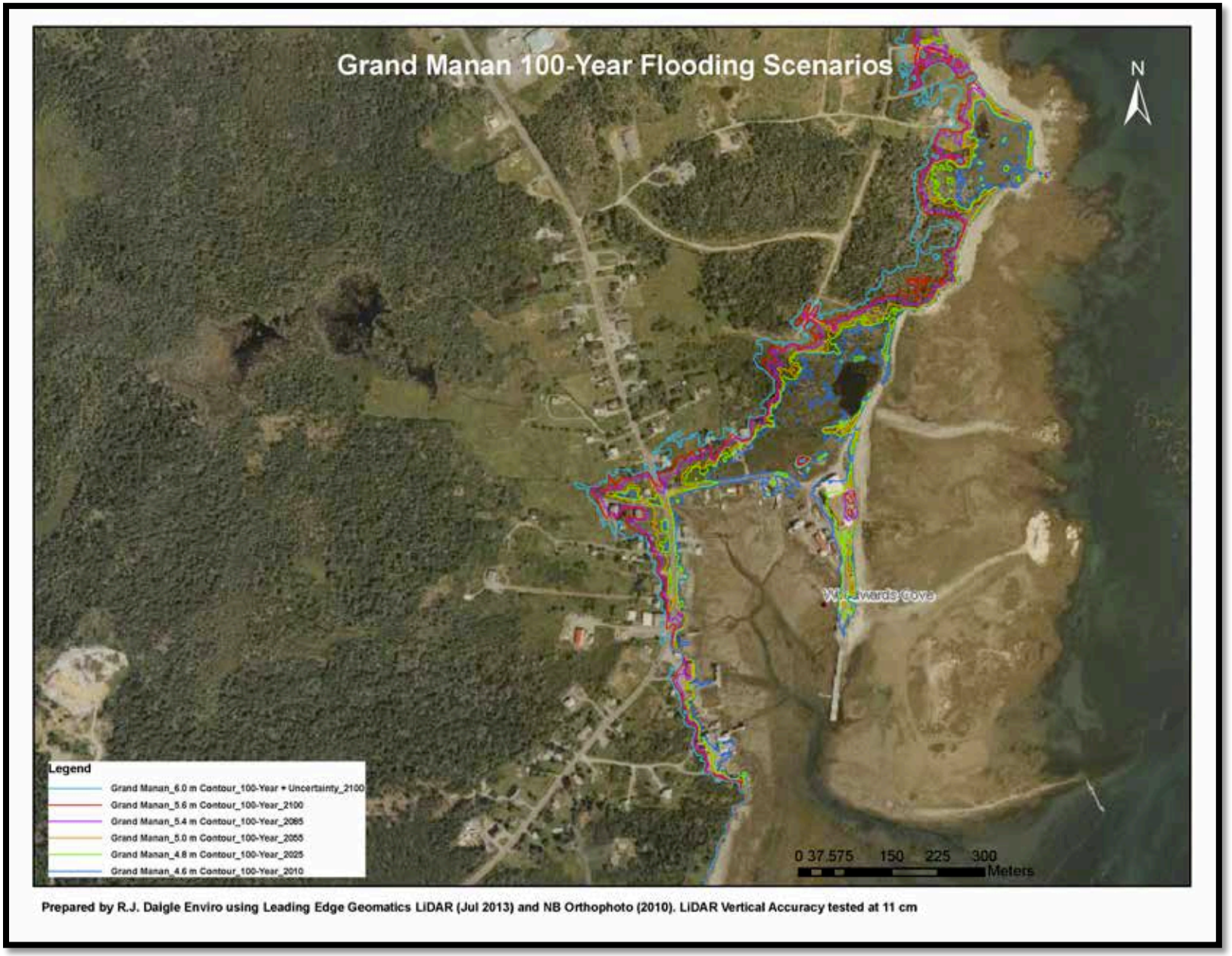


FIGURE 79: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR EVENT FOR WOODWARDS COVE (SOURCE: DAIGLE 2014).

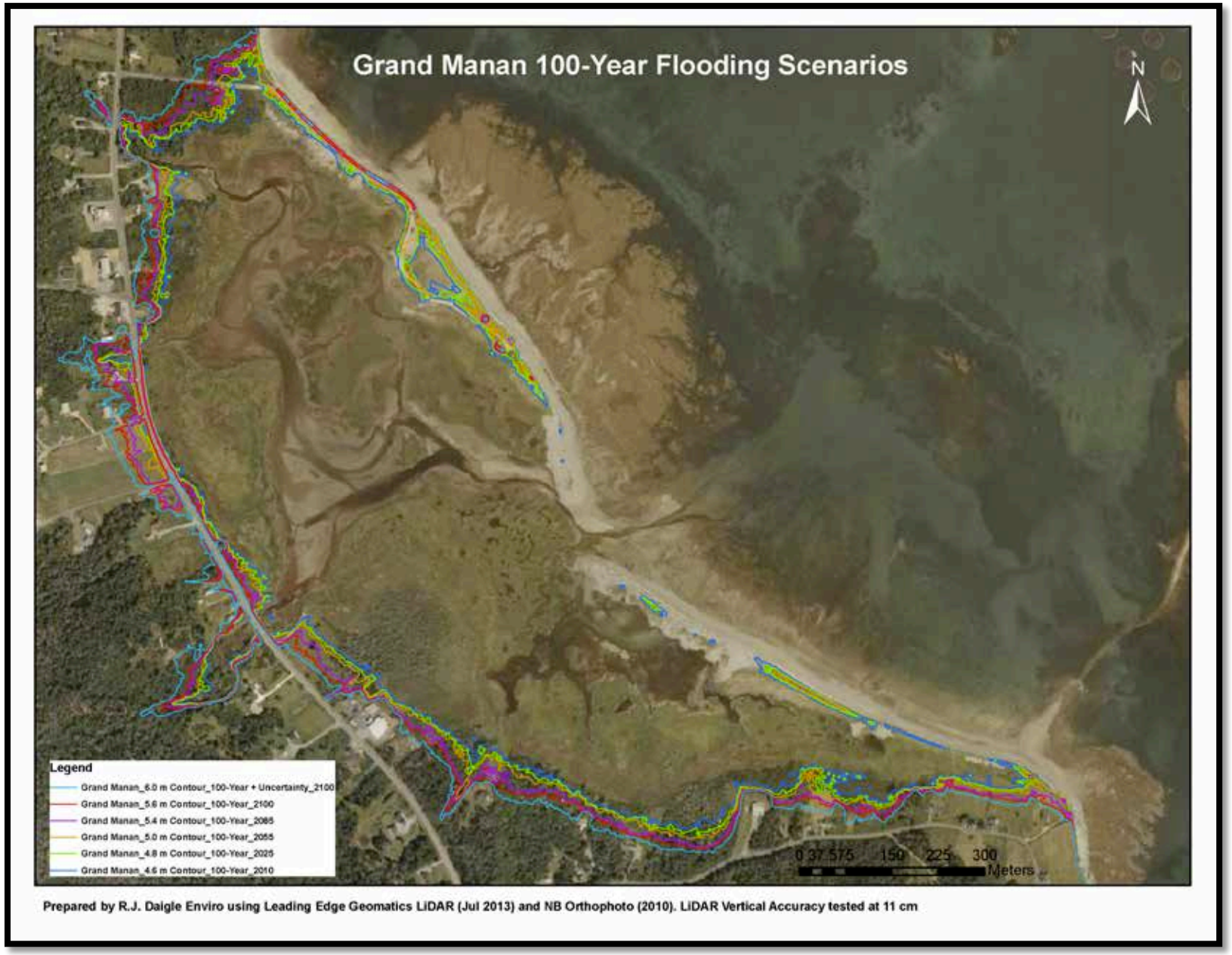


FIGURE 80: EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR EVENT FOR CASTALIA MARSH (DAIGLE 2014).

Following Mr. Daigle's presentation, the working group identified Whale Cove and the nearby Nature Trust Conservation Area to have the most severe impacts with respect to sea-level rise. It appeared that at Woodwards Cove there would be some impacts to homes and roads under the worst case scenario, and the working group indicated that the wharf in the area had been condemned. The working group commented that Route 776, the main road on Grand Manan, had faced issues with erosion because of storm surges.

Issues of governance and policy were then discussed, based on the information presented to the working group and their personal knowledge of the island. The working group indicated that the Grand Manan economy was largely dependent on the lobster fishery, with a net worth of approximately $20 million per year. It was noted that the price for lobster was about $4.00 – $4.50 per pound (November 2013), and that catches were exceptionally high. The working group commented that the Fisherman's Association manages the Harbour Authority Program which is responsible for the upkeep and maintenance of the wharves. The Harbour Authority secured funding for harbour dredging and continues to lobby the federal government for large scale expansion to local harbours. The cost of raising and updating the wharves was estimated at $100 million. This action, however, will soon be necessary as most of the wharves are 50 to 60 years old. Additionally, under the projected impacts of sea-level rise, all of the wharves will be vulnerable and many have already been under water. Other comments included the absence of hurricane preparedness for fishing vessels. Additionally, the working group detailed the role of DFO, which regulates local fisheries policy. It was clear that the Fisherman's Association lobbies them for action on issues important to the island fishers.

The forestry industry was also considered. The island is pulped every 40 to 50 years. It was mentioned that one third of the island is owned by H. J. Crabbe & Sons Ltd., a lumber company, and that this large expanse of land was purchased within the last 20 years. There was also a comment that there have been approximately four different plans to install wind farms on the H. J. Crabbe & Sons Ltd. owned land. The group stated that there is currently no forest management on Grand Manan and that residents are responsible for the management of their own tree lots. As such, there is no beetle control program in place which could explain, in part, why the population numbers of larch and spruce beetles has increased so dramatically. It was mentioned that the increase in tree beetles is an education issue and should be communicated effectively to both permanent and seasonal residents. There has also been a large increase in the number of ticks on the island which has resulted in an increase in cases of Lyme disease. It was revealed that warblers are carriers of Lyme disease that the Grand Manan is on the migratory route. However difficult it would be to limit migratory carriers of Lyme disease, there was a comment made about removing other vectors from the island.

Environmental impacts due to the climate hazards were then discussed. Green sticker dots were placed on the community map representing past impacts on the environment and those of concern into the future. A list of the numbered dots placed on the community map representing environmental impacts and their description can be found in Table A5.3 of the Appendix under Grand Manan in the green table. During the environmental mapping exercise, the working groups commented specifically on protected areas, areas of oil storage and locations where there has been

either a loss of species or a noticeable increase in invasive species. It was also commented that the phytoplankton in 2012 was the lowest ever recorded from the mid-Atlantic to Nova Scotia and that 2012 was one of the highest for ocean temperatures globally. A digitized version of the community map has been created using Google Earth to indicate where all of the coloured dots were placed on the community map in Grand Manan as illustrated in Figure 81 below.

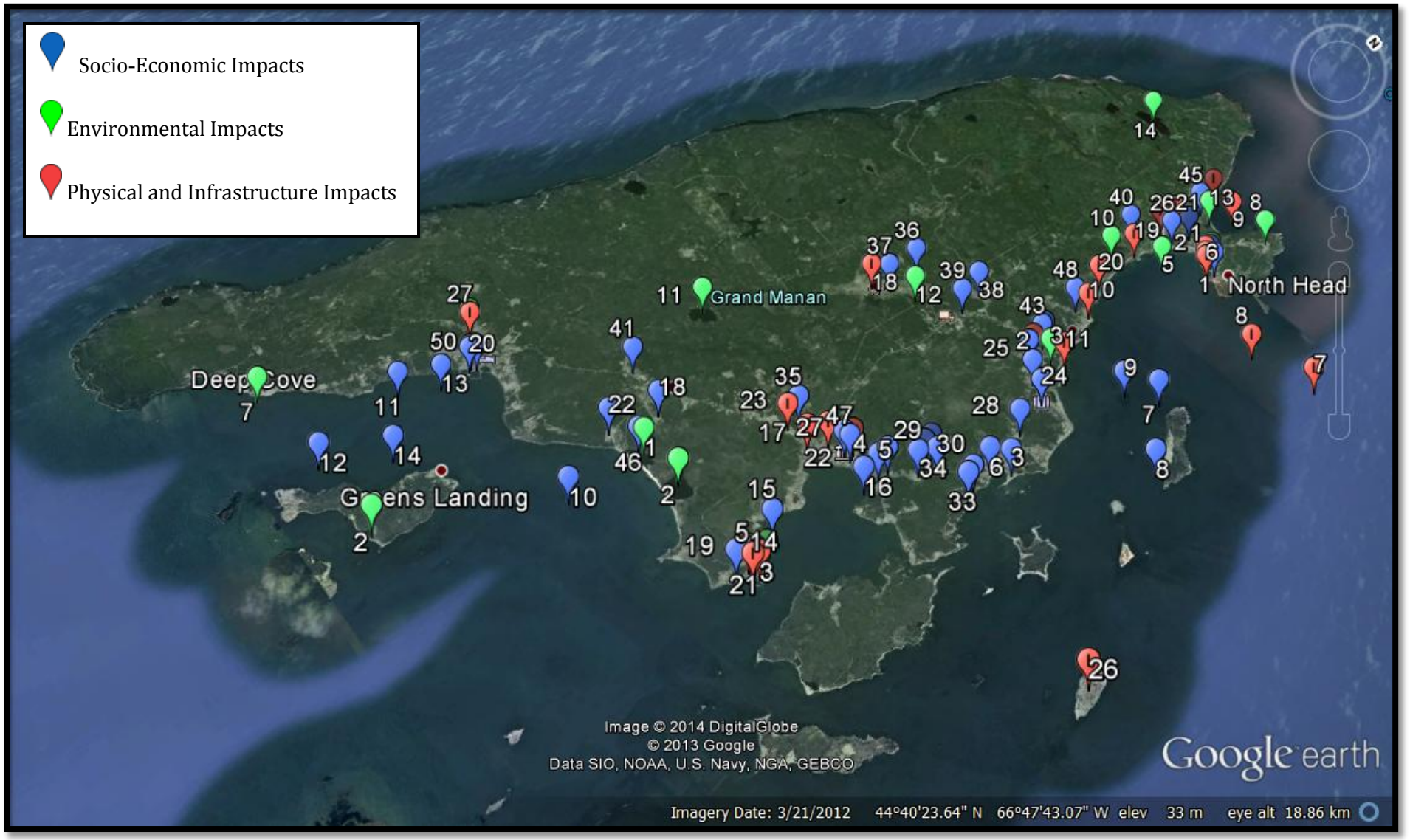


FIGURE 81: DIGITIZED MAP OF THE COMMUNITY MAPPING EXERCISE FOR GRAND MANAN, NB (CREDIT: TANYA ANDERSON).

3.5.4 MEETING # 4

In Meeting # 4, the working group members were asked to recall the climate hazards chosen, revisit the previous mapping exercises, and the policy and governance issues discussed in Meeting # 4. As environmental impacts were discussed and mapped in the previous meeting, Meeting # 4 was the last on Grand Manan. The working group members were then presented information on inland flooding. The inland flooding maps were prepared using the LiDAR information and were analyzed to exhibit the depth to the water using a specified flow rate initiation of 4ha which represents the end of summer ground saturation. Inland flooding maps, referred to as depth to water maps, were prepared to help the community in understanding unseen vulnerabilities. The depth to water map is illustrated in Figure 82 below.

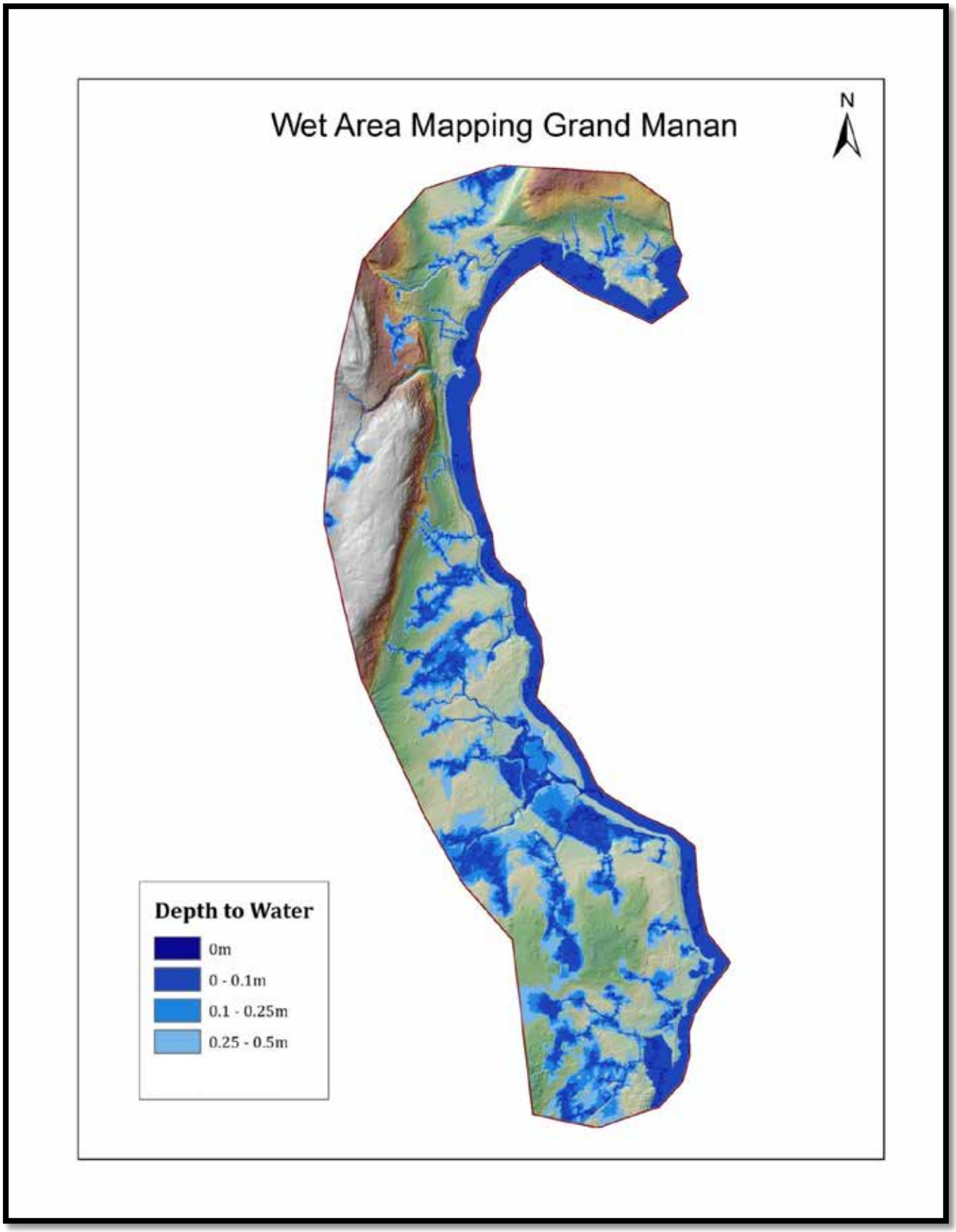


FIGURE 82: WAM MAP FOR GRAND MANAN, 4 HA INITIATION SOURCE: ARP 2013).

Working group members were then asked to discuss how they felt they could incorporate what they have learned into the development of options for reducing the vulnerability of their island community to the impacts of the climate hazards chosen. The group benefitted from an open discussion of options to move forward with climate change adaptation planning and analyzed how their specific issues could be addressed to reduce vulnerability. The working group identified the major areas throughout the island that they felt were the most vulnerable which was based on the mapping exercises, previous discussions, presenter information, and their personal knowledge. Figures 83 and 84, below are representative of these areas. The areas marked on the maps include locations where there are projected impacts from sea-level rise into the future and the wharves that may be compromised.

FIGURE 83: MAP OF VULNERABLE AREAS FOR WHALE COVE AND NORTH HEAD, GRAND MANAN AS DETERMINED BY THE LOCAL WORKING GROUP.

FIGURE 84: MAP OF VULNERABLE AREAS OF WOODWARDS COVE, GRAND MANAN AS DETERMINED BY THE LOCAL WORKING GROUP.

3.5.5 CONCLUSIONS

Even though the working group on Grand Manan was smaller than the other working groups in the county, it was made up of very knowledgeable community residents including the Program Coordinator for the Grand Manan Fisherman's Association who is also a councilor for the Village of Grand Manan, the executive director of the Grand Manan Whale & Seabird Research Station, as well as another municipal councilor who is also a tourism accommodation owner. The working group was very focused on the social and economic systems of the island and how they have the potential to be impacted by the climate hazards chosen: warming ocean temperatures, the loss of species and the arrival of invasive species. Based on the information presented, in addition to their personal knowledge of the island, the working group members identified that the most vulnerable areas of island include:

- Woodwards Cove
- Whale Cove
- All of the wharves, particularly at North Head East

Comments were made on the decline of the right whale population, which can be attributed, in part, to a decrease in plankton, that the herring population has significantly decreased and that ground fish species are also in decline, with almost no halibut catch over the last few years. An increase in the grey seal population from the north, which eat a lot of cod, other ground fish species, and lobster was seen as a potential threat. Spruce and larch beetles have increased in numbers throughout the island and the spread of Lyme disease has become a major issue of concern.

The working group commented that there is a delicate balance of species which allows for their fishing industry to thrive. As conditions change, they are concerned for the wellbeing of the primary industry as it has been a way of life on the island for centuries. Discussions on economic diversification were directly related to species harvesting diversification which must be passed through the DFO Species Advisory Board, located in Dartmouth, Nova Scotia.

3.5.6 RECOMMENDATIONS

The main recommendation of the working group on Grand Manan was developing a plan for economic diversification. This was specifically related to the shift from a local to a regional species advisory board by DFO. It is now more difficult to adapt fisheries policies for predators and invasive species and, the diversification of species harvesting. The species advisory board used to be based in St. George and is now in Dartmouth, Nova Scotia, and, as such, it has become difficult for Grand Manan as the policies are regionally based as opposed to local. Additionally, the DFO has examined climate change impacts on the Atlantic wide fisheries, but has not addressed issues specifically related to Grand Manan. It was suggested by the working group that further study regarding the impact of climate change on the species upon which their main industry depends is necessary.

The working group also recommended that the spread of Lyme disease and the associated increase in the tick population should be communicated to the community through an education campaign. Additionally, ways of limiting vectors for the spread of Lyme disease should be communicated to the island residents.

4. EMERGENCY RESPONSE IN CHARLOTTE COUNTY

Throughout the CCCVA process, it was observed that new information motivates discussion and the generation of ideas within the communities. It was also noted, during the course of the process, as well as in review of local media, that there is widespread frustration amongst the citizenry regarding interaction with NBEMO. However, the government decision to expand the NBEMO presence throughout the province by creating six Regional Emergency Management Coordinator positions is new and this new structure may take time to become functional.

Though it is perceived that there has been a general hesitance by NBEMO to share various information resources with the public, recently, at the behest of MLA Rick Doucet, information was released regarding work performed in Charlotte County by two contractors employed by the Department of Public Safety during the period 2011-2013. In response to the request for information, the *Charlotte County Initiative* was described in a memorandum, December 16, 2013, by Assistant Deputy Minister of Public Security and Corrections Division, Department of Public Safety, Kevin Mole. The memorandum contained documents including; various introductory power point presentations; terms of reference for two committees and a document referred to as The *Charlotte County Risk Analysis.* The *Charlotte County Initiative* was described in the memorandum as;

> "…conceived to improve community resiliency and capacity in Charlotte County by developing a robust regional emergency program. NBEMO was tasked to lead and support two interconnected projects:

- one to develop a more robust Regional Emergency Program for Charlotte County, and
- one to develop a District Emergency Program for Eastern Charlotte, covering municipalities and unincorporated areas."

Although this work is yet unfinished, it is desired by community and extensive stakeholder engagement will be necessary. This EMO planning initiative, as well as recent extreme events has brought renewed energy to emergency planning within the region. However, the Capacity Assessment/Gap Analysis did not prove to be accurate during the December 2013 winter storms and there are calls for reevaluation locally. The *Charlotte County Risk Analysis* is available for review on the St Croix Courier Facebook site.

As reported by the Telegraph Journal (Thursday December 15th, 2011) and confirmed by staff of EMO (personal communication January 28, 2014), "the Province hired the Conference Board of Canada, a not-for-profit public policy research organization, to conduct an after-action inquiry into the events surrounding the disaster," regarding the 2010 floods. The Telegraph Journal reports the document, "contains roughly 40 recommendations about lessons learned from the flood and provides insight into how New Brunswick might improve its protocols for disasters." This does indicate progressive action on the Province's behalf, but as the municipalities are responsible for emergency response for the first three days of an event, it was mentioned time and time again during the CCCVA that the Conference Board of Canada document should be, though has not yet been, shared.

Emergency management in New Brunswick follows a top-down command and control methodology. A common expression of this methodology is; those who need to know, know. This may hold true during times of emergency, but during downtime as reflected in this CCCVA report, it would be productive to engage the public. This effort could be part of the regional strategy. If citizens were better informed of the processes of emergency management or could have a defined and practiced role to play under the leadership of NBEMO, local emergency management may become more efficient.

Throughout the CCCVA process, discussion ensued regarding why the government response in Perth-Andover and Tobique First Nation provided those communities with mitigating actions and well developed plans that will lessen impacts even during the reoccurrence of a similar event, when in Charlotte County, if the area experiences an event similar to 2010 it is likely levels of impact would be a near repeat of those experienced in 2010. The monetary value of damage in Charlotte County was at least on par with damage experienced in the northern part of the province. The communities understand that there are only 17 employees in NBEMO who have recently been faced with a rash of emergencies to deal with, however, as stated in Minister Trevors' Federal/Provincial Disaster Financial Assistance Announcement on November 14, 2013, "…Residents also have a role by understanding risks…" In reply, local working group members explain, accurate communication of the risks must be provided, as well as invitations to be included in a regularly practiced emergency response.

5. CONCLUSIONS FOR CHARLOTTE COUNTY

Charlotte County, New Brunswick has experienced significant climate hazard impacts in recent years, from inland flooding to coastal erosion, shoreline inundation, and changing ocean dynamics. As climate change and variability impacts continue, adaptation is required to increase the ability of the local communities to cope with and reduce the impact of future events. The working groups in each of the participating Charlotte County communities acknowledged that climate hazard impacts have become more frequent and severe, and that appropriate long term planning is necessary for increasing resiliency in the region. The working groups indicated that localized climate hazard and disaster risk reduction information was not adequately accessible, but that the CCCVA process is the first step in advocating for this information to be developed and shared.

In communities that have experienced severe climate related impacts, recommendations for future action prioritized short term disaster risk reduction strategies, while those currently spared devastating impacts, focused on long term adaptation. It is evident that while collaboration between communities will be necessary, the municipalities will require regional, provincial and federal support to move forward with enacting planning measures, as vulnerability and adaptive capacity are unevenly distributed both geographically and socially throughout the region. The participating communities of this project have both similarities and differences regarding infrastructure conditions, socio-economic systems, and environmental surroundings, which result in varying climate hazard impacts. Each community has made recommendations unique to their area; however some recommendations can be applied regionally.

5.1 REGIONAL BARRIERS

In rural New Brunswick, access to resources is needed both for planning as well as for productive response to imminent situations. With reference to planning, rural communities are not alone, for instance; as reported in the Gulf Of Maine Climate Network's recent report, *Municipal Climate Change Adaptation around the Bay of Fundy: Status and Needs March 2014,* in over 30 Canadian municipalities around the Gulf of Maine it is a,

> "…combination of factors—limited staff time and expertise, stretched budgets, and lack of jurisdictional authority—make it difficult for municipalities to address even well-documented vulnerabilities to climate change. There is strong interest in more ecosystem-based approaches to adaptation, particularly green/living shorelines and sustainable stormwater management techniques, and some municipalities are actively pursuing the latter. In terms of the coastal zone, which falls outside their jurisdiction, municipalities seek both education and active management support from provincial government."

> "Among the 33 Bay of Fundy communities that participated in the GOMC Climate Network survey, 79 percent of respondents cited inadequate funds and 73 percent cited lack of staff time as constraints limiting progress in climate change adaptation. That finding echoed the results of a 2010 study of New Brunswick municipalities conducted

by Mount Allison University's Small and Rural Town Programme, entitled *Capacity for Climate Change Adaptation in New Brunswick Municipalities.* According to report authors Stephanie Merrill and Gwen Zwicker:

> "Almost half of municipalities felt that their municipalities could commit staff time to work on adaptation planning and staff time to implement adaptation plans, strategies and activities. Fewer were willing to commit funds for planning or implementation and some were unwilling to commit any resources at all. It is unclear, however, if municipalities are actually "unwilling" to commit, or perhaps more likely, "unable" to commit resources (p. 21)."

5.2 Local Barriers

More locally, adaptation planning barriers include issues such as; the RSC 10 responsible for regional land use planning does not currently have GIS or staff trained to use it, let alone the necessary layers which could contribute to efficient and responsible regional land use policy planning. As well, because most government stakeholder meetings and climate-related conferences are held in the province's major centres, as are many informative presentations such as academic lectures, this was identified as a barrier to some community members in expanding their knowledge. This issue of insufficient resources often coincides with the choice of rural life. However, our communities need to overcome the lack of exposure to these opportunities in order to increase knowledge and start to take on the challenges that lay ahead with respect to climate impacts and adaptation.

5.3 Provincial and Regional Solutions

5.3.1 Flood Reduction Strategy

The province is currently working on building a Flood Risk Reduction Strategy, understanding that that proactive management of flood risk yields long-term benefits that far exceed their costs. The Department of Environment and Local Government, in consultation with an inter-departmental working group, has been leading the development of the flood risk reduction strategy that aims to address both inland and coastal flooding in New Brunswick. The working group met several times during 2013 and has conducted extensive background research, resulting in the development of a set of goals, objectives, potential actions and desired outcomes that collectively represent a draft outline of a comprehensive flood risk reduction strategy.

5.3.2 Regional Emergency Plan

The development of a regional all-hazards plan was the strongest recommendation shared by all working groups, however, the severe hazards and associated emergencies that have already occurred in Charlotte County must be addressed in the planning process, ensuring that those

impacts with a high likelihood to reoccur are thoroughly planned for. Regarding access to resources for productive response to imminent situations, all working group participants agreed that the development of a regional emergency measures plan would increase resiliency. Climate hazard impacts are becoming more frequent and this plan is needed to address how these events are managed, ensuring that all existing capacity is utilized. Capitalizing on existing capacity is the most cost-efficient measure to effectively reduce vulnerability. Currently, municipal EMO planning and jurisdiction extends only as far as municipal boundaries. The most severe climate hazards in Charlotte County are watershed based, and disaster events have affected equally the municipalities and the adjacent communities. It was clear during vulnerability assessments that residents consider their communities to extend beyond the established municipal boundaries to encompass surrounding areas, and that EMO operations must transcended the established municipal jurisdictions.

Access to resources such as informative radio broadcasts including up-to-date road closure reports, stockpiles of generators and kerosene are limited in the rural communities of Charlotte County. As well, as discovered during the extreme winter precipitation events of December 2013, rural communities may be prioritized lower than urban centres in reference to telecommunications and power failure recovery during widespread events. However, a streamlined regional all hazards emergency plan would allow the communities to effectively utilize all of the available resources during an emergency event and enact standard operating procedure to facilitate communication. The regional Emergency Measures Organization (EMO) coordinator for Charlotte County commented following the December 2013 ice storm that direct communication, such as by email, phone and radio was the biggest challenge for getting information out to the public and first responders during the event. It was suggested that regional resources be created online and with physical media that address mitigation efforts, how to prepare for forecasted hazard events, and how to respond to a climate hazard crisis. This resource would also become a crucial link in EMO preparation ensuring up to date information is accessible to all involved in planning as well as relief efforts.

5.4 Local Solutions

5.4.1 Governance Initiatives

A bylaw review for climate change adaptation in all jurisdictions was recommended by community working groups. During the CCCVA, valuable downscaled climate change impact scenarios were produced. The information presented should be considered by municipalities to ensure their bylaws reflect proactive planning addressing the current projections for changes within their communities.

5.4.2 Environmental Initiatives

St Stephen and St George, communities that experienced recurring and severe climate related impacts, were eager to address locations where impacts have occurred in the past. Suggestions for hydraulic studies were put forward where communities experienced significant inland/overland flooding from rivers and streams. It was suggested that a better hydraulic understanding of these

areas would allow building and infrastructure issues to be addressed in planning for those areas. As of April 17, 2014, the Town of St Stephen released a draft version of the long-awaited Dillon study which recommends a detailed study of the Billy Weston Brook drainage catchment, complete with hydraulic assessment of the channel and all constructed crossings between Dennis Stream and NB Route 1, this would identify any bottlenecks in the drainage system and provide recommendations for improvements that would reduce the risk of overland flooding.

5.4.3 Social and Economic Initiatives

In communities such as St Andrews, Blacks Harbour and Grand Manan, where climate related hazards had not posed a significant threat in the past, but were of concern into the future; working groups indicated that safeguarding their social and economic assets was of most importance.

In the Blacks Harbour and Grand Manan communities, where impacts could pose a risk to crucial industry, economic diversification studies were recommended.

5.4.4 Immediate Action

Finally, there were recommendations made that could be instituted at low cost, almost immediately including; tracking weather forecasts leading up to high tide cycles in any year, because consideration must be given to the fact that with the potential of a 1+ metre surge, this tracking would enable maintenance of catch basins and pumps as well as allow for issuing community warnings if necessary. Another suggestion was for communities to share knowledge by preparing and producing a visual communication tool at the local wharf to indicate various tide and surge levels - past, current and expected. As well, it was proposed that communities should instigate and participate in discussion forums within the RSC as well as the NB Union of Municipalities focusing on municipal adaptation.

6. Moving forward with climate change adaptation in Charlotte County

Each of the participating communities in this project made recommendations to reduce the impact of climate related hazards in their respective municipalities. Developing a climate change adaptation strategy is a multi-step process, and participants understood that this community level advisory project was only the beginning of an ongoing effort to reduce the vulnerability of their communities to projected climate impacts. Further analysis of the recommendations suggested by the working groups is necessary in consultation with the identified groups responsible for implementation to ensure that they can be adequately incorporated into long term strategic community planning. Project facilitators aim to share the results of the vulnerability assessments and work with all parties to identify which vulnerabilities pose the greatest risk, which adaptation goals are priorities, the adaptive actions that best meet those goals, and the financial capacity to complete those actions.

Simultaneously, a regional engagement and communications strategy must be developed to ensure that an appropriate mechanism is in place through which all findings can be shared with the

residents of coastal southwestern New Brunswick. As importantly, continued interaction with community members, as well as the development of a regional climate impact database would be valuable as "residents have knowledge of changing weather and climate patterns that can be integrated with observations made by climatologists to better understand the changing climate of a community (Vodden 2012)".

To assist with the facilitation of next steps, it is recommended that a GIS resource be created featuring the results of the CCCVA. In addition, the resource should also contain economic analysis of the vulnerable physical sites, including ecosystem function and socio-economic systems, as well as a downscaling of oceanic impacts relative to the Outer Bay of Fundy. This tool will facilitate further communication with communities, industry, academia, and government, which must take place to define the feasibility and timeline for adaptation options. The creation of the GIS resource will also ensure the long term usability of the data collected during the CCCVA, and assist with the monitoring of implemented adaptive actions. Monitoring and evaluation of climate change adaptation initiatives is essential in order to ensure that they are effective and are, in fact, increasing the resiliency of the communities to the impacts of climate related hazards and long term climate impacts.

7. PROCESS EVALUATION

Feedback from participants and the community at large was sought at various points during the project to help evaluate the CCCVA process and local climate change adaptation objectives. These efforts included an introductory survey delivered to participants and interested community members (see Appendix Figure A1), a mid-term interview completed with participants and interested community members, and an exit survey conducted with working group participants (see Appendix Figure A2). The range of topics covered included personal concerns, objectives, expectations, attitude toward barriers and solutions as well as community working group member appraisal of the value of the entire process.

7.1 SEPTEMBER INAUGURAL MEETING FEEDBACK

In September, at the regional inaugural meeting, a survey was handed out and collected in order to understand the concerns of the public in relation to climate hazards. Project contributor Assistant Professor Nicole Klenk provided a short summary for facilitators of the communities represented;

- St. Stephen has localized infrastructure issues (recurrent problems with particular spots in town) as well as being vulnerable to flooding due to dam management up river, which involves multiple actors requires more town council consultation with locals and a more in-depth look at the multi-level governance aspects of their vulnerability (i.e., who controls the dams, who can be held responsible for floods if associated with the regulation of dams; who can be held responsible for upgrading local infrastructure if some of the particular problems are associated with private actors);

- St. Andrews has concerns surrounding long term planning of development and storm water infrastructure given its local tourism industry and being a retirement destination, all of which requires prioritization at the town council level with adequate public consultation;

- St. George identified governance issues regarding both the LSD and Town which also involves private actors and the lack of regulation on water level in dams, as such the context requires a further look into governing across levels of decision-making;

- Blacks Harbour indicated the community is not necessarily vulnerable with regards to floods and storms, but sea level rise and their coastal fisheries infrastructure at risk, as well as the more general risks associated with fisheries and climate change. As a very small community, their ability to plan for climate change adaptation is doubtful;

- Grand Manan residents did not attend this meeting although the meeting was specifically planned to coordinate with ferry schedules.

Professor Klenk identified that the participants of this first information gathering survey reflects a segment of resident population demographics, and therefore results of the vulnerability assessment needs to be interpreted carefully because the vulnerability picture that result may not take into consideration the view of those people that are most vulnerable.

Also, while each community might be in need of an emergency plan and facilitating access to information when there are crises, the kinds of emergencies they face are different and the spatial and social distribution of risk differs. While the vulnerability mapping process seems to include both aspects of vulnerability through the mapping exercise, the fact that the people who are involved are not the most vulnerable to climate change impacts means that the information on the map about the social dimension of vulnerability is likely biased and remains to be more fully investigated.

7.2 Feedback and Evaluation, Mid - CCCVA

In November 2013, 27 interviews were conducted by project contributor Assistant Professor Nicole Klenk. Interviews were conducted by phone and in person. During this time period, working group members interviewed had participated in the regional meeting as well as two – three community specific meetings.

Professor Nicole Klenk and her research assistant Jacinthe Briand-Racine collected and summarized the residents' perceptions of the working group objectives and/or their personal expectations of the process. She also summarized statements made regarding perspectives on governance including municipal, regional, provincial and federal jurisdictions, to be found in the Appendix under section A6.

7.2.1 Personal expectations of Working Group Members

With respect to the personal expectations of working group and community members, Professor Klenk noted that most comments spoke to the idea that the committee should be an advisory committee to the town council, as well as to other levels of government (Department of Environment of the federal and provincial governments). There is hope that reports, concrete recommendations and solutions would be given to governments so that they would then be implemented. There was some dissatisfaction expressed with the absence of significant government representation at the committee meetings (DOT, EMO, MLAs, town council, Department of Environment), thus creating concerns that politicians will be unwilling to implement any of the committee's recommendations.

On the topic of perceived challenges to attaining the objectives of the committee, comments were made regarding reaction of town officials and quality of municipal politics. The biggest challenge identified was the dynamics within town councils, and how to get messages across to legislators. Because of the way politics are done at the municipality, because of the level of awareness of members of town council, there is little confidence that they will be willing to implement the committee's recommendations. (*Note – above comments from St. Stephen and St. George participants only.)

Despite general satisfaction with the make-up of the working groups, participants often seem surprised that more people weren't involved, considering the amount of people concerned with the issues being addressed. Comments also reflected that it is a challenge to reach out to ‘‘the general public’’ to communicate information to people that are not on the committee. In respect to raising awareness on climate change, participants expected that awareness about climate change and its local impacts would be raised, an objective that by November, had been attained for most part according to interviewees. There was also an expectation that this awareness and the committee's messages would be able to reach a wider audience than just the committee members.

7.2.2 Working Group Opinions Related to Solutions

On the topic of human and financial resources needed to implement process recommendations, there was some hope that the committees would be able to find the necessary resources to implement certain projects and to follow up on the actions that they recommended should be taken.

It was also mentioned that many participants having been heavily impacted and having many frustrations, had difficulty getting into ''objective'' and ''solution-oriented'' discussions. It was noted by interviewees that the quality of conversation improved since the first meetings and had become more focused on solutions.

7.2.3 Working Group Response to Engagement in the CCCVA

Regarding the participants' appreciation of the committee's work, almost all participants interviewed pointed to the amount of interesting and relevant information they were exposed to, which helped them better understand climate change and it's local impacts. Dr. Klenk noted that it also seemed appreciated that the information provided was locally relevant and that the committee

organizers pay attention to local specificities. The information provided through LiDAR mapping was also appreciated by many.

Interviewees indicated their reasons for participating in the committee included wanting to learn more about climate change and what could be done locally, most people seemed to be getting involved because they felt that they would be learning a lot of useful information. There was an expectation that this information about climate change would translate into information about what individuals and communities could be doing. Also indicated was that those who joined the working groups felt they might be able to contribute by sharing personal knowledge and expertise. Many people answered positively to the invitation to participate because they felt they were in a good position to provide some help, and wanted to be part of the solution.

There were also reasons stated for not joining the working group when invited, these included a sense that the work being done by the committee members should be being done by government, or that without significant government participation at least, there is little hope of any concrete outcome from the process. Also noted was that the magnitude of the predicted sea-level rise makes it difficult to imagine realistic solutions. Some respondents discussed that not being fond of meetings in general, was their reason for not attending. There was also the suggestion of 'a certain skepticism,' that the magnitude of the predicted sea-level rise would be exaggerated, or too important for solutions to be realistic. Despite many comments on the appreciation of the information provided through LiDAR mapping, there was some question of the relevance of having spent so much money on this part of the project rather than investing in more urgent things, for example, assessing the adequacy of the town infrastructure.

7.3 Exit Survey

An exit survey was conducted in January 2014 utilizing the online *Survey Monkey* tool, see Appendix Figure A2 for survey design. The survey link was sent directly to working group members through a personal email, with various reminders for participation being sent weekly afterward.

7.3.1 Working Group Composition

In both the mid-term personal interviews as well as reflected in the exit survey, there was some dissatisfaction expressed with the absence of significant government representation at the committee meetings (DOT, EMO, MLAs, town council, Department of Environment), thus creating concerns that politicians will be unwilling to implement any of the committee's recommendations.

In the exit survey 64% of respondents indicated that they "agreed" the working group community representation was good, while 9% did not agree and the remaining 27% either "strongly agreed" or "somewhat agreed." There is always the challenge of getting sufficient amount of people interested and committed to attending the meetings.

7.3.2 Resources for Integration of Recommendations

As reflected in the exit survey, confidence in the fact that municipal and provincial governments have the appropriate resources to deal with the potential consequences of climate change in the

communities was medium to low, approximately 76% of respondents expressed low confidence while the remaining 24% indicated they were "mostly confident." Regarding trust in government to appropriately deal with impacts of climate change, most trust (54%) was put in the municipal government while 27% of respondents indicated that they felt no trust in any level of government to appropriately deal with impacts of climate change. Eighteen percent were unsure.

7.3.3 Process Evaluation

The exit survey indicated that 100% of participants believed that their opinions were both heard and taken seriously throughout the course of the meetings. There was much appreciation evident for the level of expertise of the people on the working groups. Notice was taken of the intent to include both people who were directly impacted by the floods and those who were not. Ninety percent of the exit survey respondents indicated satisfaction with the balance of presentation and discussion time throughout the meetings.

During mid-term personal interviews, a few comments suggested that a large part of the information presented was not new to participants, but by the exit survey two months later, over 72% of respondents indicated that their knowledge of climate hazards and impacts increased "significantly," while over 27% responded their knowledge had increased "somewhat." When asked whether or not participants felt they received enough information in order to take action to increase resiliency in their communities, 81% percent of respondents agreed they did, while the remaining 18% felt they were unsure or did not receive enough information to act.

Regarding household emergency preparedness for weather-related events, 18% of the respondents of the exit survey indicated they were extremely well prepared, 81% indicated they were reasonably well prepared.

7.3.4 Next Steps

When asked during the exit survey "what other information/next steps would you like to know/see with respect to increasing the resiliency of your community to the impacts of climate change?" responses included;

- I would like to see proactive education activities from the municipality to inform residents and businesses about risks, about emergency preparedness and planning, how to communicate and find information in an emergency, and potentially offering incentives for homeowners to install water control/flood control measures such as backflow valves, better drainage, rain gardens and gutters, etc. I'd also like to see the Assessment adopted into all municipal plans, including development plans, to reduce future risk.

- Active encouragement of community green action committee and advice on resources for collection and retention of storm water at the individual home owner level as well as municipal and provincial.

- Concrete research and plans in place to address the outcomes of that research, backed by sufficient cooperation and funding from 3 levels of government

- Municipal involvement, bylaw changes including a flood bylaw and a storm water management plan site by site as well as for the whole Town. Upgrades to infrastructure are needed as well, based on an engineering impact study/assessment.

- Good comprehensive emergency plan. And to address those known problems ASAP before it happens again and it will. EX: Billy Weston brook at the railway tracks.

- Where do I start?

- Widen the circle of participants in the discussion. Education and shared knowledge from a broader perspective.

- We've applied for funding for citizen consultation and engagement and if successful will be able to expand on what was a very good program (St Andrews)

- Better public announcements and communications

8. PROJECT PROCESS COMMENTS

The CCCVA was developed to suit the Charlotte County region, and was based on several different processes that have been used elsewhere to identify climate related vulnerabilities. Vulnerability assessments must be tailored to suit local needs, even if there are themes such as infrastructure that are relevant to all cases, *context* matters in terms of understanding vulnerability and planning for climate change adaptation.

When conducting an assessment, it is imperative to have a facilitator that is a long-time resident of the area. The preparation of the project and recruitment of the working group requires a strong relationship with the residents and municipal councils of the participating communities. The community mapping exercise that examines vulnerable areas, including infrastructure, social, economic, and environmental variables can only be effectively led by a facilitator who understands the area. The facilitator must be able to effectively explore local issues when raised, and expound upon community concerns in the reporting of the project. Results of the CCCVA indicate the importance of the identification of a local champion(s) as the first step in preparing municipalities for climate change adaptation planning.

For any parties interested in duplicating the methodology of this project, it is important to highlight some lessons learned. With experience, some aspects of the project would have been developed differently. The primary improvement would be making a distinction between communities in which climate hazard impacts were tangible and those where they were not. This classification may then change the tools necessary to properly address vulnerabilities, increasing the effectiveness of the assessment and realizing cost savings.

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APPENDIX

FIGURE A1: COMMUNITY VULNERABILITY ASSESSMENT SURVEY GIVEN TO ALL ATTENDEES OF THE CHARLOTTE COUNTY GENERAL MEETING HELD SEPTEMBER 24, 2013, DEVELOPED WITH NICOLE KLENK.

Community Vulnerability Assessment of Climate Change Impacts in Charlotte County

4. In your community, what are the future impacts of climate change that concern you? (Please select all that apply and add others that do not appear on the list)

☐ Flooding ☐ Coastal erosion ☐ Loss of species

☐ Invasive species ☐ Sea-level rise ☐ Heat waves

☐ Ocean acidification ☐ Drought ☐ Increase in precipitation

☐ Access to safe drinking water ☐ Increased duration of storm events

☐ Increased frequency of storm events ☐ Increased frequency of freeze-thaw events

☐ Other (Please specify)

_____
_____
_____

5. Which of the following social impacts of climate change are you concerned about in your community? (Please select all that apply and add others that do not appear on the list)

☐ Economic loss ☐ Damage to personal property

☐ Damage to public infrastructure ☐ Hazards to human health

☐ Access to emergency services ☐ Other (Please specify)

_____
_____
_____

6. Do you know where to go to access information on climate change impacts and related climate change adaptation options and strategies?

☐ Yes ☐ No

7. How knowledgeable are you about climate change adaptation?

☐ Very knowledgeable

☐ Somewhat knowledgeable

☐ Not very knowledgeable

☐ Not at all knowledgeable

8. Please provide any further information that you consider relevant in the context of this survey and indicate any additional persons that you believe should be contacted in your community to participate in this Community Engagement Initiative.

_____
_____
_____
_____
_____
_____

9. Are you willing to have a further half hour interview, by phone or in person, to discuss your experience with severe weather events, how they have affected your day-to-day activities, your livelihood, your relationships to others in your community, and political or governance responses to these events? All responses will remain confidential.

☐ Yes ☐ No

IF YOU ARE PART OF AN ORGANIZATION

10. Has climate change adaptation been discussed in your organization?

☐ Yes ☐ No

If so, at what level has it been discussed? (Please check all that apply)

☐ Employee/Staff ☐ Management

☐ Board of Directors ☐ Elected official(s)

☐ Other _____

11. Has your organization been involved in any climate change adaptation planning in or for your community?

☐ Yes ☐ No

If so, at what stage is the planning? (Please check all that apply)

☐ Forming teams ☐ Assigning tasks

☐ Reviewing climate data ☐ Creating plans

☐ Presenting plan to decision-makers ☐ Implementing plans

12. Has your organization encountered any obstacles or barriers in its adaptation activities?

☐ Yes ☐ No

If so, please describe briefly.

_____
_____
_____
_____
_____
_____

13. Are there any specific areas of your responsibility that would benefit from a climate change impact assessment?

☐ Yes ☐ No

If so, please describe briefly.

_____
_____
_____
_____
_____
_____

Eastern Charlotte Waterways Inc. and The St. Croix Estuary Project look forward to working with you throughout this project and appreciate the time you have taken to complete this survey.

FIGURE A2: COMMUNITY VULNERABILITY ASSESSMENT EXIT SURVEY GIVEN TO ALL WORKING GROUP MEMBERS.

Community Vulnerability Assessment Participant Survey

1. Which community Working Group did you participate in?

☐ St. Stephen ☐ Blacks Harbour ☐ St. George

☐ St. Andrews ☐ Grand Manan

2. Has your knowledge of climate hazards and impacts increased with respect to your community?

☐ Significantly increased ☐ Not at all increased ☐ Somewhat increased

3. Please rate your level of agreement with each of the following statements.

	I do not agree	I somewhat agree	I agree	I strongly agree
Community representation was good in the Working Group	○	○	○	○
The presentations helpful to inform discussions	○	○	○	○
The mapping exercise was useful to inform discussions	○	○	○	○
The quality of the discussions met your expectations	○	○	○	○
The Working Group has adequate municipal representation	○	○	○	○
The Working Group should have had provincial representation	○	○	○	○

4. Do you feel there was a good balance of presentation and discussion time at the Working Group meetings?

☐ Yes

☐ No, would have preferred to spend more time on the discussions

☐ No, would have preferred to spend more time on the presentations

☐ Would have preferred to spend more time on something else entirely (Please explain)

5. Do you feel you have received enough information throughout the presentations in order to take action to increase the resiliency of your community to the impacts of climate change?

☐ Yes ☐ No ☐ Don't know/ No opinion

6. Do you feel as though your voice was heard/opinions were taken seriously in Working Group discussions? Please explain.

_____

_____

_____

_____

7. How confident are you that government has the appropriate resources to deal with any potential consequences of climate change in your community?

	Completely confident	Mostly confident	Not that confident	Not at all confident	Don't know/ No opinion
Municipal	○	○	○	○	○
Provincial	○	○	○	○	○

8. Which level of government do you have the most trust in to appropriately deal with the impacts of climate change?

☐ Your local municipal government ☐ The provincial government

☐ The federal government ☐ None of the above

☐ Don't know/No opinion

9. How would you rate the level of emergency preparedness of your household for weather-related events?

☐ Extremely well prepared ☐ Reasonably well prepared

☐ Not that well prepared ☐ Not at all prepared

☐ Don't know/No opinion

10. What other information/next steps would you like to know/see with respect to increasing the resiliency of your community to the impacts of climate change?

_____

_____

_____

_____

A1. ST. STEPHEN

TABLE A1.1: LIST OF PHYSICAL AND INFRASTRUCTURE IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. STEPHEN.

Dot Number	Explanation of Physical and Infrastructure Impact
1	Irving Gas Station, 231 King Street; severe flooding in both 2010 and 2013 flood events Milltown Irving Gas Station, 419 Milltown Blvd; stayed open late for emergency services
2	Stationary Plus, 16B Route 1; business shut down for a month and a half following December 2010 flood event, business disruption following July 2013 flood event
3	Charlotte Mall; severe flooding following December 2013 flood event, closed for a few hours following July 2013 flood event
4	Traffic Circle; road closure
5	Milltown Blvd/Queensway Way; flooding, road closure
6	Complete road disruption
7	Entry route for Fire Department; no access during flood events
8	Entry route for Fire Department; no access during flood events, ramp to major highway
9	CIBC Bank; closed during flood events, flooded (discussion of business continuity planning)
10	Bell Subdivision; basements flooded
11	Brook filled with sediment, impact on homes, wildlife
12	Hawthorne Street, King Street, Ledge Road; flooding (unable to indicate on digital map)
13	Milltown Dam; impact to dam, impacts due to dam
14	Dennis Stream; flooding at Heelis' House
15	Home #3; flood event in 2010 there was severe flooding, 2013 flood event not as severe, still flooded
16	Sweeny's House; no flooding in 2010, 18 inches of flood water in basement during July 2013 flood event
17	Major basement flooding in both years
18	New Border Crossing under water in 2013, Milltown Border Crossing damage
19	Two miles from Ledge Road/Old Bay Road; water treatment runoff into wells
20	Downey Ford; basement flooding, sump pump necessary
22	During December 2010 flood event there were issues with access to food; only access to the Atlantic Superstore when there was power and if you were already in town
24	Flooding December 2010 and July 2013
25	Brook behind house becomes a torrent, about a foot of flooding, neighbour lost their furnace, driveway, oil tank and oil was split (dot missing on digital map)
26	43 Marks Street; basement flooding
27	Union Street home with four feet of flood water in basement during both 2010 and 2013 flood events
28	Corner King Street and Victor Street; basements flooded
29	Duplicate of 194 King Street; red dot 103
30	Basement flooding
31	Duplicate of 31 Spring Street; red dot 87
32	Basement flooding

33	Basement flooding
34	Had to evacuate, were out for three weeks
36	Milltown Blvd to Hawthorne Street; water was there for days and did not dissipate following flood
37	Milltown Blvd to Riverside Drive
38	Milltown Blvd to Riverside Drive
39	Spring Street
40	The old Thomas Farm to Valley Road
41	Ditch overflows impacting homes
42	21 Wall Street (2010)
43	18 School Street (2010)
44	43 Main Street (2010)
45	Duplicate; red dot 99
46	31 1/2 Hill Street (2010)
47	54 Elm Park (2010 and 2013)
48	12 Thompson Avenue (2010)
49	388 Milltown Blvd (2010)
50	62 Prince William Street (2010)
51	61 Hawthorne Street (2010)
52	9 Riverside Drive (2010)
53	195 King Street (2010)
54	33 Spring Street (2010)
55	57 Pleasant Street (2010)
56	48 Spring Street (2010)
57	87 Prince William Street (2010)
58	99 Queensway Way (2010)
59	11 Ross Avenue (2010 and 2013)
60	34 Elm Street (2010 and 2013)
61	21 Queensway Way (2010)
62	47 Boundary Street (2010)
63	29 Elm Street (2010)
64	18 Elm Street (2010 and 2013)
65	131 Union Street (2010)
66	196 King Street (2010 and 2013)
67	25 Spring Street (2010)
68	17 West Street (2010)
69	7 Queen Street West (2010)
70	17 Thompson Avenue (2010)
71	2 Oaks Way (2010)
72	20 Spring Street (2010)
73	Hill Street at Queensway Way (2010)
74	45 Main Street (2010)
75	44 Union Street (2010 and 2013)
76	37 Princess Street (2010)
77	41 Union Street (2010)
78	17 Schoodic Street (2010)
79	30 School Street (2010)
80	27 Union Street (2010 and 2013)

81	20 Thompson Avenue (2010)
82	65 Prince William Street (2010)
83	5 Queen Street East (2010)
84	198 King Street (2010)
60, 63, 64, 99	Elm Street from tracks to Parkwood Drive (2010)
85	57 Princess Street (2010)
86	9 Sprucewood Court (2013)
87	31 and 33 Spring Street (2013)
88	27 Spring Street (2013)
89	27 Elm Park (2013)
90	17 Hawthorne Street (2013)
91	53 Pleasant Street (2013)
92	20 St. Croix Street (2013)
93	Phillips Furniture, 11 Milltown Blvd (2013)
94	Orchard Paint & Paper Ltd., 162 Milltown Blvd (2013)
95	Vogue Optical & Hearing Aids, 160 Milltown Blvd (2013)
96	Family Resource Centre of Charlotte County, 126 Milltown Blvd (2013)
97	Wool Emporium, 164 Milltown Blvd (2013)
98	98.1 the Tide Radio Station, 112 Milltown Blvd (2013)
99	103 Queen Street West (2013)
100	74 Brewers Lane (2013)
101	42 West Street (2013)
102	129 Pleasant Street (2013)
103	194 King Street (2013)
104	Hyland Clipper, 168 Milltown Blvd (2013)
105	11 Bell Avenue (2013)
106	39 Riverside Drive (2013)
107	61 Union Street (2013)
108	44 Budd Avenue (2013)
109	24 Pine Street (2013)
110	38 Schoodic Street West (2013)
111	194 King Street (2013)
112	20 School Street (2013)
113	40 Queen Street West (2013)
114	17 School Street (2013)

TABLE A1.2: LIST OF SOCIAL AND ECONOMIC IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. STEPHEN.

Dot Number	Explanation of Social and Economic Impact
1	High School; in 2013 recreational field was shut down for three weeks due to flooding, shut down of recreational activities
2	Boys and Girls Club
3	New location of eye doctor
4	Elementary School; in 2010 calls were made to parents to make sure someone was there to greet them school children, school was closed for four days in 2010, loss of wages, lunch and breakfast programs were shut down and are very important to lower income families, shut down of recreation

5	Sobey's was closed for four months, treated their employees well, said that if flooding happened again, they would close forever
6	Liquor store shut down for a couple of days following 2010 flood event; had to dispose of spoiled product
7	Shopper's Drug Mart; closed for months following 2010 flood event, had to relocate the store
8	CIBC, Dollar Store, and bargain shop; closed for months in 2010 following flood event, loss of wages for employees
9	Winsome Inn; had no insurance coverage, sewer backup
10	Ganong Chocolate Factory; during both 2010 and 2013 flood events there was temporarily no rail delivery of ingredients while the culverts behind Downey Ford were being replaced/impacted
11	Middle School; kids are considered at risk if they are not in school, loss of recreational activities, skating rink in the winter, auditorium
12	Town Hall; houses historical records and antiques, were all destroyed, every time there is an extra high tide it floods, it is being considered for being taken down, cost of repairs is estimated at over $2 million
13	Sweeney International; have had issues every very high (lunar) tide
14	Information centre has some impacts during flood events, library has never been impacted
15	Bell Aliant
16	The Tide 98.1 radio station; communications disruption if closed
17	Family Resource Centre
18	Food bank; located beside Fire Station, access was cut off in during 2010 and 2013 flood event, Fire Dept. has gas and diesel for emergency vehicles only
19	Downtown Border Crossing; closed during flood events
20	Civic Centre
21	New Hotel
22	Meals on Wheel headquarters; access is a huge issue
23	Old sewage lagoon; in 2010 it remained unfilled, there was a horrible smell, has since been filled in, potential buffer or park zone or turf field (something permeable)
24	Walking trail; there have been washout impacts, there are still areas that have not been repaired
25	Trail behind Clark building; close to seniors centre, well used trail
26	Walking trail behind Orchards
27	Granville Park apartment building
28	Multiple unit housing
29	Riverside apartment building
30	Condominiums; high density housing
31	High density seniors housing
32	Home care agency; family support work, facilitates supervised visits
33	A number of businesses behind Riverside Park
34	Basement of apartment building is the storage for all of the apartment dwellers on the lower side
35	Brownfields land; contaminated area
36	Ledge Road had shoulder and ditch damage due to runoff, a lot of basement flooding, access to the area impacted in flood events, many older citizens in the

	area. On the high side of Ledge Road in 2013 was the first time some residents flooded. If that road is inaccessible, there is no access to homes and the Ganong Park
37	Oak Bay; potential for entire area to be isolated from resources
38	Hospital; critical cases could not get to Saint John during flood events, has generator power when needed, access to medication in the case of road closures/washouts
39	Lynncourt Seniors Complex; has backup power source, assisted living and care
40	Chipman Apartment Seniors Complex; independent living
41	Doctor's Offices
42	Lonicera Hall – Seniors Complex
43	Extramural headquarters; issues leaving town
44	Point Lepreau nuclear generating station
45	Old Ridge Nursing Home
46	Special Care home
47	Little Acres; special care facility
48	St. Croix vocational
49	Annie's Place; special care facility
50	Twin Towers; adult special care
51	Fundy Regional Transition House
52	Charlotte County group home
53	Low income seniors housing
54	RCMP
55	Ambulance Bay – Heathland
56	Milltown Elementary School
57	Charlotte County Museum
58	Generating station
59	Milltown Border crossing
60	Deacon Lane; seniors housing
61	Drug house
62	Water tower
63	Corner of Pleasant Street and Milltown Blvd; low income housing
64	Maple Street; subsidized housing
65	Subsidized, low income, and seniors housing in Ganong building; if power goes out they cannot access elevator, may not be able to leave
66	Recreational area; children's play pad was impacted
67	Wharf; tourist site closed
68	Maxwell Crossing bridge; direct access to water pumping station
69	War memorial across from Milltown border
70	St. Stephen University
71	Todd Manor; multi-unit housing
72	Industrial park
73	DOT

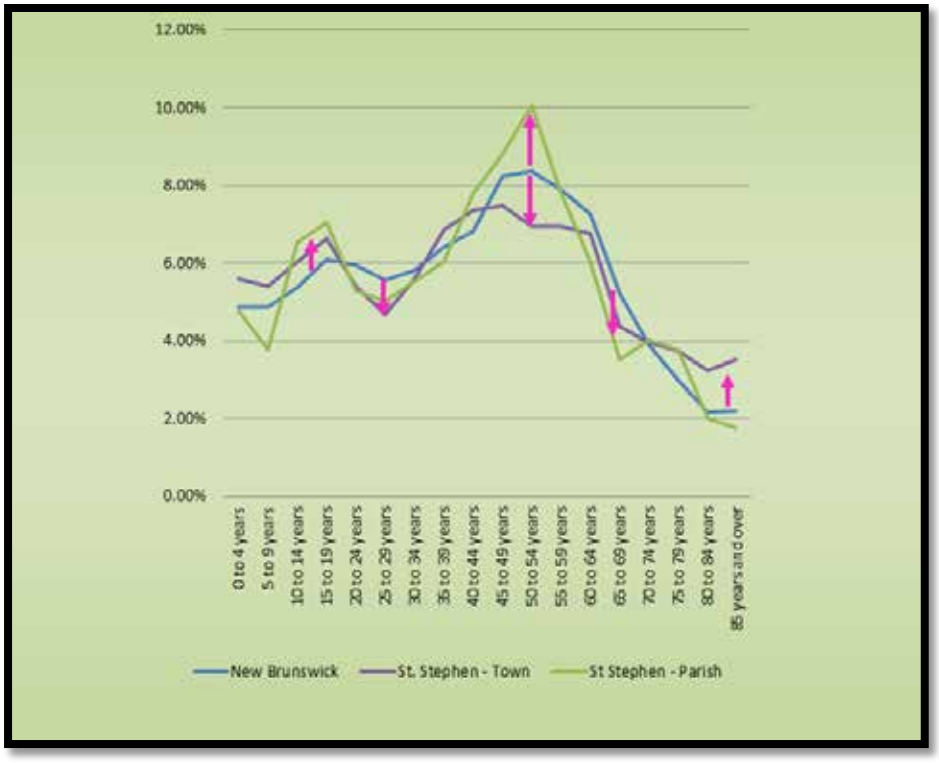


FIGURE A1.1: AGE CLASS DISTRIBUTION OF ST. STEPHEN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

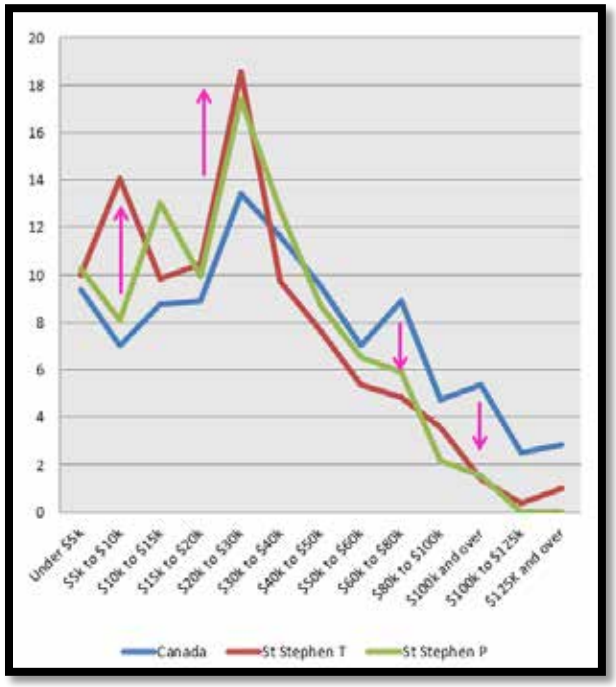
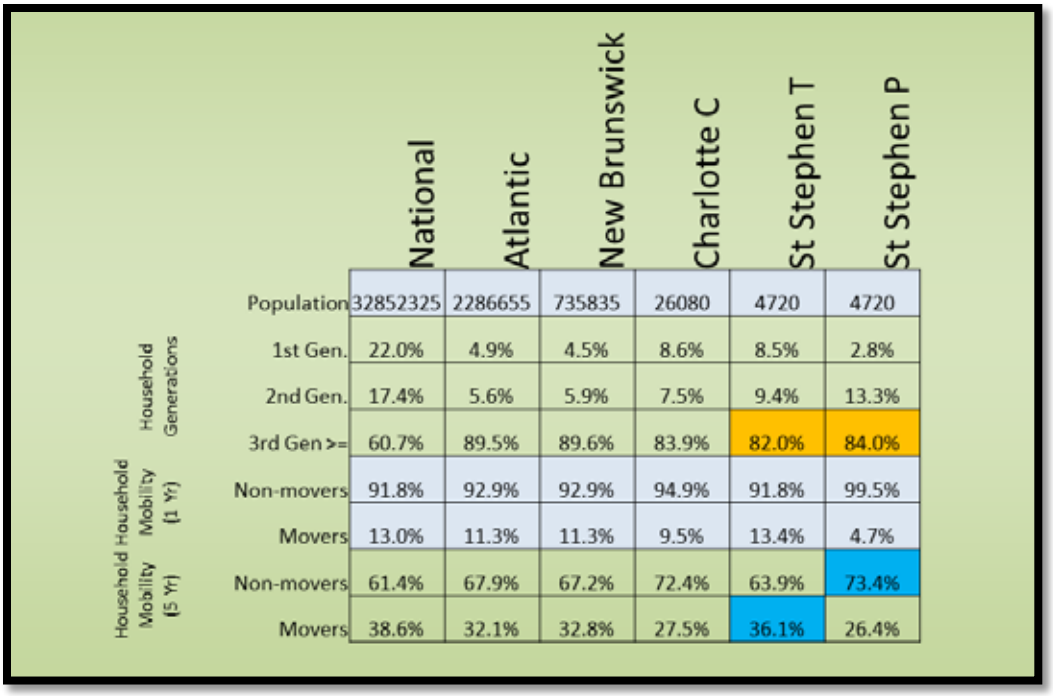
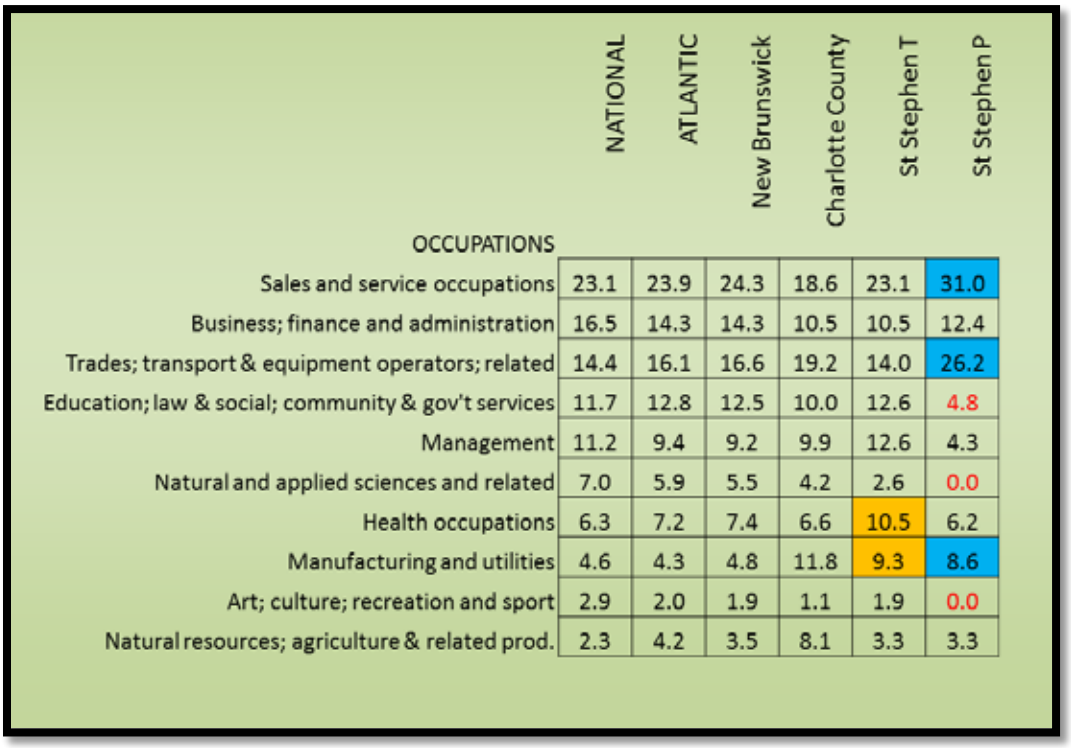


FIGURE A1.2: INCOME DISTRIBUTION EXPRESSED AS A PERCENTAGE FOR ST. STEPHEN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY OF THE 2010 TAXATION YEAR (SOURCE: DR. JAMES MACLELLAN).



		National	Atlantic	New Brunswick	Charlotte C	St Stephen T	St Stephen P
	Population	32852325	2286655	735835	26080	4720	4720
Household Generations	1st Gen.	22.0%	4.9%	4.5%	8.6%	8.5%	2.8%
	2nd Gen.	17.4%	5.6%	5.9%	7.5%	9.4%	13.3%
	3rd Gen >=	60.7%	89.5%	89.6%	83.9%	82.0%	84.0%
Household Mobility (1 Yr)	Non-movers	91.8%	92.9%	92.9%	94.9%	91.8%	99.5%
	Movers	13.0%	11.3%	11.3%	9.5%	13.4%	4.7%
Household Mobility (5 Yr)	Non-movers	61.4%	67.9%	67.2%	72.4%	63.9%	73.4%
	Movers	38.6%	32.1%	32.8%	27.5%	36.1%	26.4%

FIGURE A1.3: HOUSEHOLD MOBILITY AND GENERATIONS FOR ST. STEPHEN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).



OCCUPATIONS	NATIONAL	ATLANTIC	New Brunswick	Charlotte County	St Stephen T	St Stephen P
Sales and service occupations	23.1	23.9	24.3	18.6	23.1	31.0
Business; finance and administration	16.5	14.3	14.3	10.5	10.5	12.4
Trades; transport & equipment operators; related	14.4	16.1	16.6	19.2	14.0	26.2
Education; law & social; community & gov't services	11.7	12.8	12.5	10.0	12.6	4.8
Management	11.2	9.4	9.2	9.9	12.6	4.3
Natural and applied sciences and related	7.0	5.9	5.5	4.2	2.6	0.0
Health occupations	6.3	7.2	7.4	6.6	10.5	6.2
Manufacturing and utilities	4.6	4.3	4.8	11.8	9.3	8.6
Art; culture; recreation and sport	2.9	2.0	1.9	1.1	1.9	0.0
Natural resources; agriculture & related prod.	2.3	4.2	3.5	8.1	3.3	3.3

FIGURE A1.4: OCCUPATION PERCENTAGE BY TYPE FOR ST. STEPHEN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

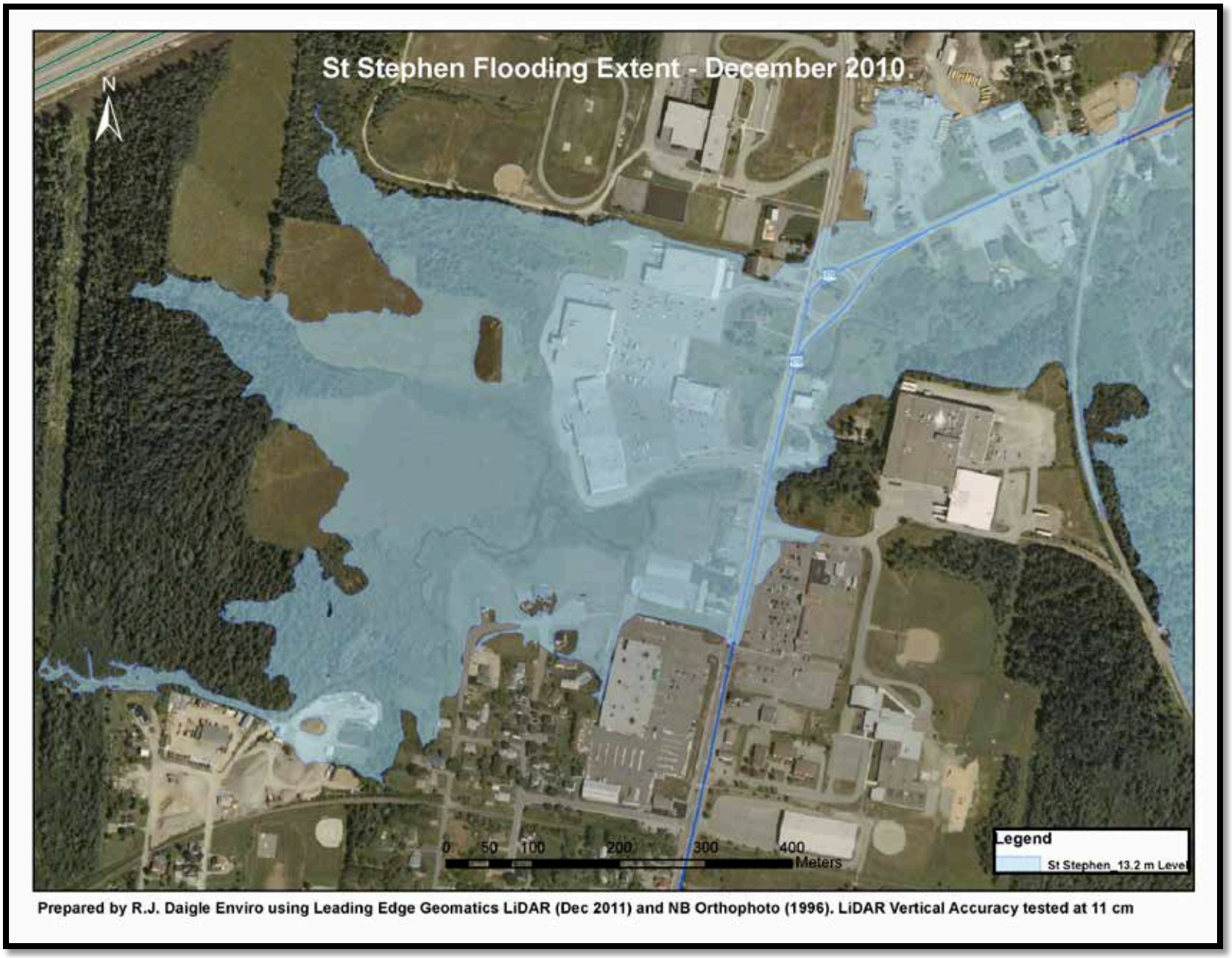


FIGURE A1.5: EXTENT OF DECEMBER 2010 FLOODING IN ST. STEPHEN (SOURCE: DAIGLE 2014).

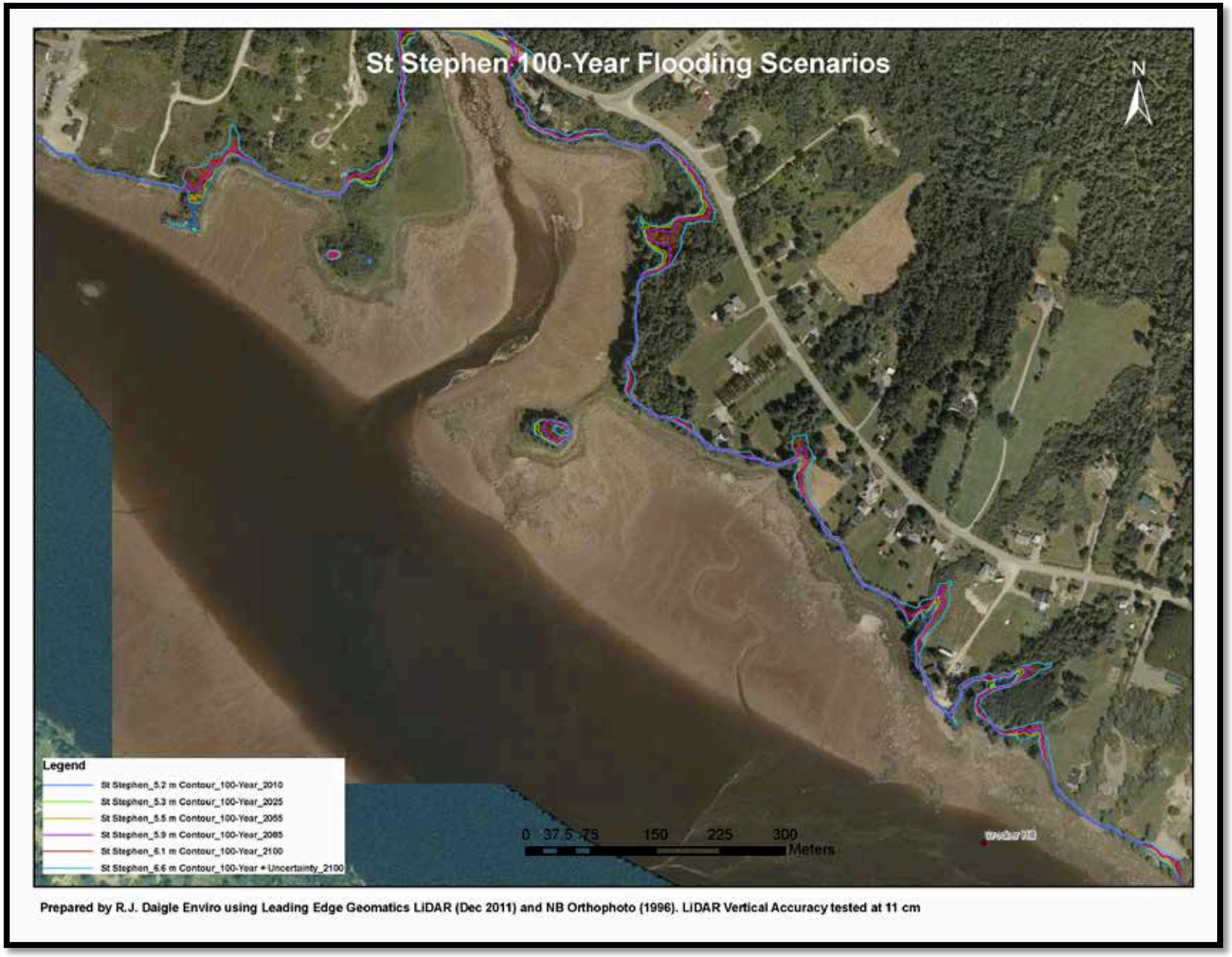


FIGURE A1.6: ST. STEPHEN EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR STORM SURGE RETURN PERIOD (SOURCE: DAIGLE 2014).

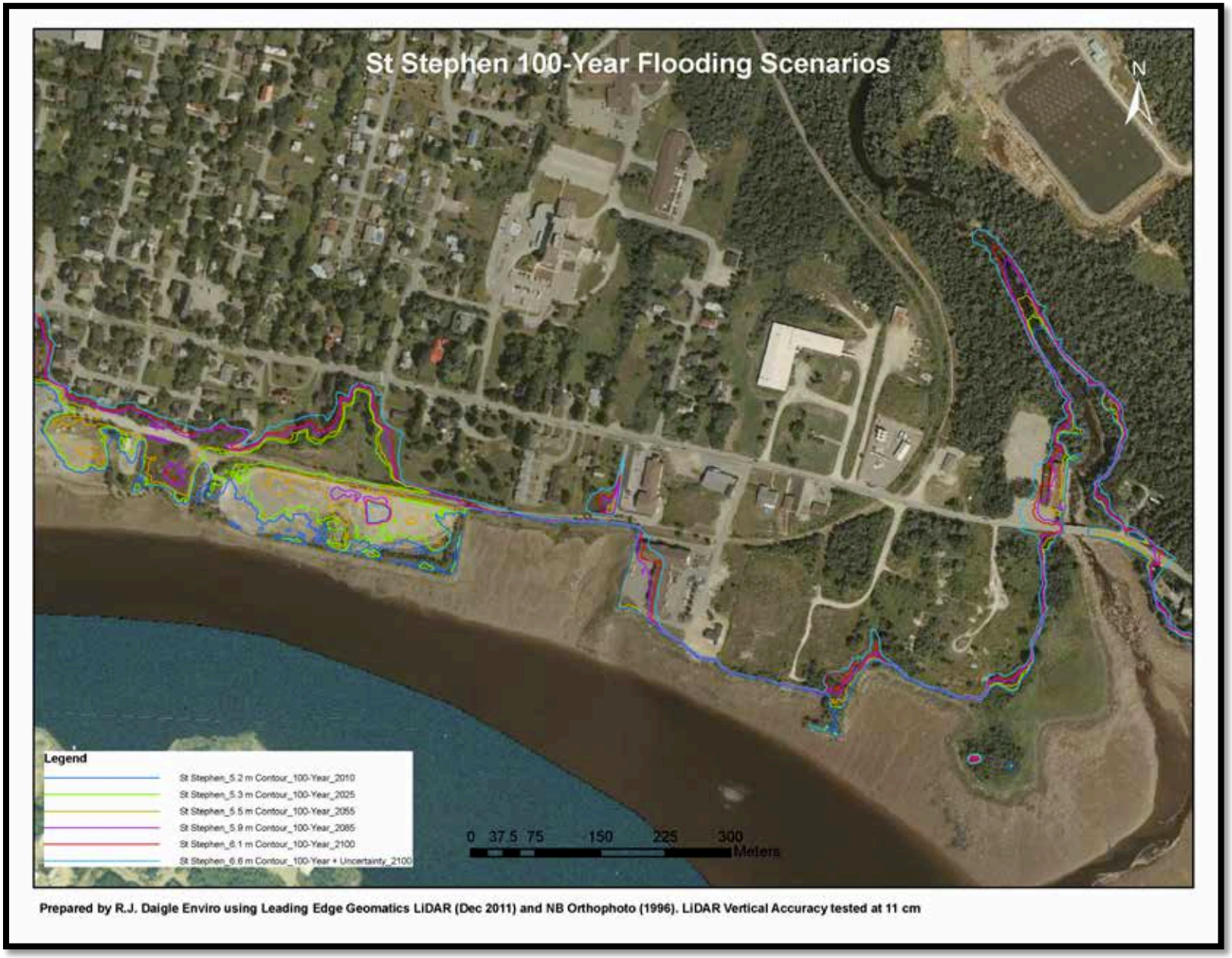


FIGURE A1.7: ST. STEPHEN EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR STORM SURGE RETURN PERIOD (SOURCE: DAIGLE 2014).

TABLE A1.3: LIST OF ENVIRONMENTAL IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. STEPHEN.

Dot Number	Explanation of Environmental Impact
1	West Street and Union Street; forested area Hawthorne
2	Wooded area behind elementary school
3	Endangered inner Bay of Fundy Salmon and American Eel
4	Endangered IBoF Salmon and American Eel in Dennis Stream (Ecologically Sensitive Area (816))
5	Tan House Brook buffer
6	Buffer between Boundary Street and West Street
7	Fish passage, protected by DFO for Alewives Milltown Hydro Dam
8	Dover Hill Creek; the bank is forested & the home lots are forested, buffer control
9	Outfall of Dennis Stream
10	Eagle nesting area
11	Forested area on Old Bay Road and Ledge Road
12	Irving had storage tanks; Brownfields contaminated land, old fertilizer plant
13	Sealed and buried industrial dump site, behind Flakeboard Co. Ltd.
14	Elm Street Park/unsealed old dump site
15	Sealed dump site on the Mohannes Stream/St. Croix River, left side of Pleasant St.
16	Historical site for salmon in Mohannes Stream
17	Maxwell Crossing bridge and wooded covered bridge close to water supply, surface water protection area
18	Donahue Park, boat launch
19	Forested area between Abbot Street and Thompson Avenue
20	Canada Goose habitat, Gore farm
21	Canada Goose habitat, right side of highway at Hall Road and Haymen Hill exit
22	Canada Border (third) fields, Canada Goose habitat
23	Irving, propane and gas
24	Carr's Automatic Transmission Ltd.
25	Old sewage lagoon (potential hazard), buffer zone
26	Old Milltown sewage lagoon, potential buffer, tree planting could be done here
27	Extreme erosion under house, compromising the house/old sewage lagoon
28	DOT, there used to be a Texaco station there with underground petrol tanks, tanks have been removed, but DOT is still monitoring, impervious surface
29	Underground storage tanks for fuel (still there) between Downey Ford and Stationary Plus
30	Old gas station, tanks have been removed
31	Vacant lot, there used to be a gas station there, gas contaminated soil, cleaned up on Kent Building Supplies side of the property, but not cleaned up on the other side; between Carmen's Diner and Kent Building Supplies
32	Chocolate Park; used to be a gas station, contaminated, lot was given to the town
33	The St. Croix Courier; used to be a gas station, was partially cleaned up, but not on the Milltown Blvd side
34	Clark Building; used to do automotive repair and oil changes
35	Milltown Garage; potentially contaminated

A2. St. Andrews

Table A2.1: List of physical and infrastructure impacts and their explanation from the community mapping exercise for St. Andrews.

Dot Number	Explanation of Physical and Infrastructure Impact
1 (1-1.8)	Armour stone that has been replaced along the coastline
2	Patrick Street – significant flooding; concern for sea-level rise
3	Ocean View Campground; flooding in 2010 and 2013, low area, seaweed in Kiwanis Campground
4	Passamaquoddy Park flooding
5	Pagan Point flooding and erosion
6	Pagan Point flooding and erosion
7	Current erosion
8	End of Queen Street; significant flooding
9	Lower area; evacuation from homes
10	At the foot of Augustus – manhole discharge; concern for sea-level rise
11	Beach erosion
12	Concern for sea-level rise
13	Water Street; flooding in the past
14	Queen Street; flooding and sewer back up
15	Coastal erosion
16	Water Street; flooding in the past
17	Flooding concern into the future
18	Queen Street; flooding and sewer back up
19	Passamaquoddy Lodge, seniors residence; has generator
20	Water Street; flooding in the past
21	Concern for sea-level rise
22	Storm surge
23	Wharf and breakwater
24	Water Street; flooding in the past
25	Water Street; flooding in the past
26	Concern for sea-level rise
27	Ross Museum; flooding in basement
28	Queen Street; flooding and sewer back up
29	High School field
30	United Church; flooding in 2010 and 2013, low area, storm water issues
31	Sewage in basement
32	Flooded basement
33	Water Street; flooding in the past
34	Queen Street; flooding and sewer back up
35	Water Street; flooding in the past
36	Water Street; flooding in the past
37	Sand continually needs replacing at Katy's Cove; possible water contamination
38	Coastal erosion
39	Ditch erosion
40	Arena; emergency centre

41	Green space, Block house; coastal erosion, armour stone has been replaced
42	Green space, Block house; coastal erosion, armour stone has been replaced
43	Green space, Block house; coastal erosion, armour stone has been replaced
44	Basement flooding, fixed by going on septic field – disconnected from town
45	Fire Hall
46	Ambulance
47	Basement and yard flood
48	Recreation area closed for use
49	Golf course closed often
50	Flooding in cluster of homes and streets
51	Subdivision floods out, but ditching in place now (basements, roads) along Diana Drive
52	Blue Moon Hotel; big puddle
53	Champlain Avenue
54	Thomas Avenue; one incident of flooding, storm water mitigation has been done, flooding on street of more concern than basements after mitigation
55	Thomas Avenue; one incident of flooding, storm water mitigation has been done, flooding on street of more concern than basements after mitigation
56	Thomas Avenue; road flooding, storm water mitigation has been done, flooding on street of more concern than basements after mitigation
57	Thomas Avenue; storm water mitigation has been done, flooding on street of more concern than basements after mitigation
58	Bar Road/Highway; washout – Tara Manor
59	Water over main road in front of 686 Bayview Drive
60	If road were opened, possibility of getting to emergency centre at Biological Station
61	New building/Wet lab – DFO building sea-level rise and run off concern
62	Biological Station – emergency centre

TABLE A2.2: LIST OF SOCIAL AND ECONOMIC IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. ANDREWS.

Dot Number	Explanation of Social and Economic Impact
1	Younger families with children
2	Patrick Street; damage from November 5, 2010 storm surge
3	Kiwanis Campground
4	Block House; armour stone rocks washed out, took two years to get the funding for replacement, issues with Red Tide
5	New armour stone only cost approximately $45-50,000, about one tenth of normal cost, had government funding
6	Huntsman Marine Science Centre is a huge economic driver
7	Golf course; large economic driver, potential for development, driving range has been closed this summer (2013) as it has been very wet
8	Development potential, however, no storm water management
9	Development potential, however, no storm water management
10	Thomas Avenue, (basement flooding), legal suits, incurred personal costs,
11	Elementary school, on high ground, system in place to alert parents of kids being sent home

12	Queen Street, Quinn House and Quoddy Breeze – all seniors housing - food is often delivered, even outside of storm events
13	Community College; on storm days, students may not be able to get to class, school may be closed, students come from all over Charlotte County
14	Rose Lane area, Hansen Development; there was a stormwater management plan, CBCL reviewed it, outcome – new stormwater plan approved and in place
15	Passamaquoddy Lodge, Meals on Wheels
16	Kingsbrae Garden; large amount of visitors seasonally
17	The Wharf; may need to replace wharf with sea level rise
18	Katy's Cove; important tourist and recreational area, impacts to water quality
19	Call centre; many employees may have difficulty getting to work due to access during flooding
20	Chamcook Lake – town water supply
21	ASF – Atlantic Salmon Federation
22	W. C O'Neill Arena, hockey, curling recreation, theatre
23	Water tower; water restrictions in 2010 when Chamcook Lake dropped by four feet, cyanobacteria appeared

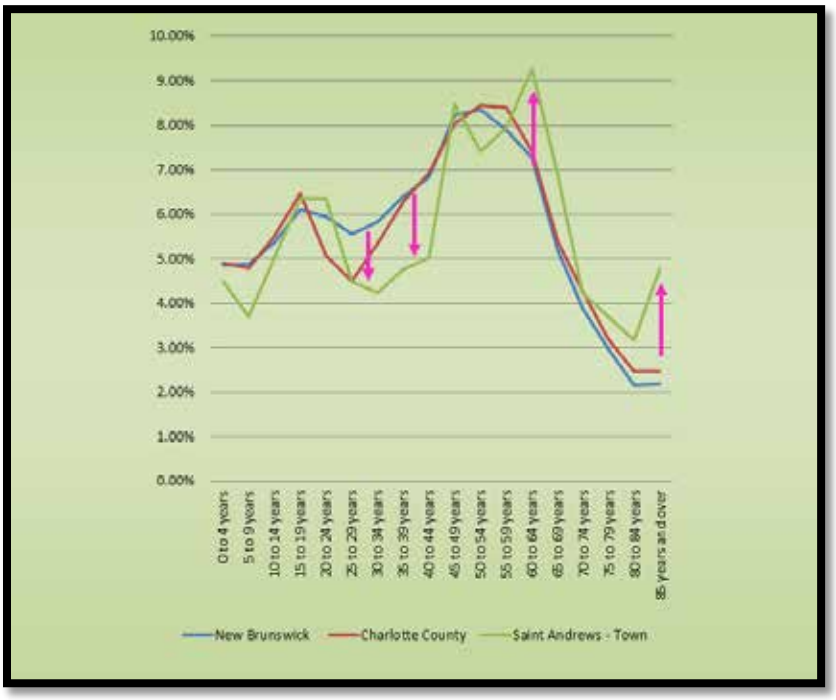


FIGURE A2.1: AGE CLASS DISTRIBUTION OF ST. ANDREWS BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

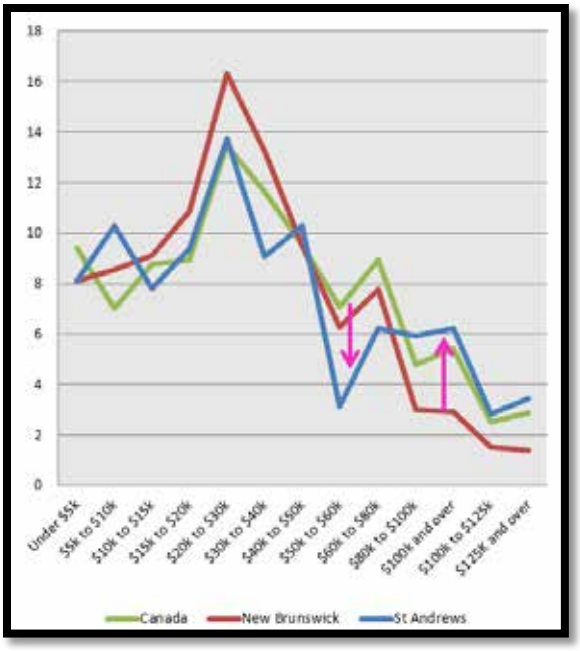


FIGURE A2.2: INCOME DISTRIBUTION EXPRESSED AS A PERCENTAGE FOR ST. ANDREWS BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY OF THE 2010 TAXATION YEAR (SOURCE: DR. JAMES MACLELLAN).

		National	Atlantic	New Brunswick	Charlotte C	St Andrews T
	Population	32852325	2286655	735835	26080	1800
Household Generations	1st Gen.	22.0%	4.9%	4.5%	8.6%	14.4%
	2nd Gen.	17.4%	5.6%	5.9%	7.5%	6.4%
	3rd Gen >=	60.7%	89.5%	89.6%	83.9%	79.2%
Household Mobility (1 Yr)	Non-movers	91.8%	92.9%	92.9%	94.9%	84.2%
	Movers	13.0%	11.3%	11.3%	9.5%	19.4%
Household Mobility (5 Yr)	Non-movers	61.4%	67.9%	67.2%	72.4%	60.4%
	Movers	38.6%	32.1%	32.8%	27.5%	39.9%

FIGURE A2.3: HOUSEHOLD MOBILITY AND GENERATIONS FOR ST. ANDREWS BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

OCCUPATIONS	NATIONAL	ATLANTIC	New Brunswick	Charlotte County	St Andrews T
Sales and service occupations	23.1	23.9	24.3	18.6	23.8
Business; finance and administration	16.5	14.3	14.3	10.5	10.6
Trades; transport & equipment operators; related	14.4	16.1	16.6	19.2	14.4
Education; law & social; community & gov't services	11.7	12.8	12.5	10.0	14.4
Management	11.2	9.4	9.2	9.9	17.5
Natural and applied sciences and related	7.0	5.9	5.5	4.2	7.5
Health occupations	6.3	7.2	7.4	6.6	6.9
Occupations in manufacturing and utilities	4.6	4.3	4.8	11.8	0.0
Art; culture; recreation and sport	2.9	2.0	1.9	1.1	1.9
Natural resources; agriculture & related prod.	2.3	4.2	3.5	8.1	1.9

FIGURE A2.4: OCCUPATION PERCENTAGE BY TYPE FOR ST. ANDREWS BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

FIGURE A2.5: ST. ANDREWS EAST EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR STORM SURGE RETURN PERIOD (SOURCE: DAIGLE 2014).

FIGURE A2.6: ST. ANDREWS WEST EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS FOR A 1 IN 100 YEAR STORM SURGE RETURN PERIOD EXTREME (SOURCE: DAIGLE 2014).

TABLE A2.3: LIST OF ENVIRONMENTAL IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. ANDREWS.

Dot Number	Explanation of Environmental Impact
1	Old dump leaches at the Point
2	Across the street from Armstrong's garage, oil storage, homes built there, at Patrick and Water Street
3	Patrick street to the lighthouse, used to be the Haughn garage, homes built there
4	Lobster plant burnt/in-filled industrial site
5	Fire Station
6	There used to be a gas station where the parking lot of the Motor Inn is now
7	Gas station, now cleaned up
8	Old gas station at the Tim Horton's site, has been cleaned up
9	Current gas station on Harriet Street
10	Armstrong's service station
11	Town garage
12	Old and current lagoon
13	NBCC; college uses diesel, has a mechanic shop
14	Huntsman Marine Centre; chemical dumping (appropriate protocols)
15	Biological Station, chemical dumping (appropriate protocols)
16	Past location of dry cleaners
17	Wharf/vessels
18	Song bird monitoring
19	Greenlaw Mountain Hawk Migration Watch (monitoring)
20	Sunbury Shores Two Meadows Nature Trail; could be considered a buffer
21	Golf course
22	Kingsbrae Gardens
23	Katy's Cove
24	End of cemetery road; armoured stone is holding back erosion
25	Salt marsh
26	Campground, town owned land
27	Centennial Park
28	Wetland area by Mallory Field
29	New area of development; has a developed stormwater plan
30	Between the new subdivision and Rose Lane; approved area of development, six lots and has a developed storm water plan

A3. BLACKS HARBOUR

TABLE A3.1: LIST OF PHYSICAL AND INFRASTRUCTURE IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR BLACKS HARBOUR.

Dot Number	Explanation of Physical and Infrastructure Impact
1	Connection to Greenlaw Valley, no flushing, if sea-level rises, it may become an island
2	Connection to Deadman's Harbour, washout in the past
3	Salt water pump house, (Back Shore) has been taken out by a couple of storms recently

4	6” sewer and water washout feeding Wellington
5	Potential for washout, cannot handle heavy rain events
6	Flooded residential basements
7	Connors Bros. Reservoir
8	Supply line
9	Water line junction to Beaver Harbour
10	Town water storage tank
11	Old Ferry Wharf, used by Cooke Aquaculture, and the new wharf for the Grand Manan Ferry
12	Connors Bros. Wharf
13	Small craft harbour, maintained by the provincial government
14	Old wharf in Beaver Harbour
15	Sewer pipes that are starting to show their age, in need of repair
16	End of Mill Street basement flooding
17	Basement flooding in Mackay Loop Road
18	Flooding issues during heavy rain events
19	The hospital/nursing home show no impacts to date, crucial infrastructure
20	Old dump site
21	Old car dump site
22	Old industrial site for fish and sardines
23	Pump house, not suitable for large scale use
24	Sewage lagoon, town impacts lagoon, overflow pumped out into the bay, danger of sea level rise and sewage flooding
25	Mountain Road all on personal water wells
26	Beach Road Connors Bros. water line
27	Beaver Harbour Community Centre, has a generator and is used as an emergency shelter
28	Jackson intake from the Pennfield aquifer

TABLE A3.2: LIST OF SOCIAL AND ECONOMIC IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR BLACKS HARBOUR.

Dot Number	Explanation of Social and Economic Impact
1	Blueberries, potential impact: longer growing season, drought, new pests
2	Blueberries
3	Blueberries
4	Fishing weir
5	Fishing weir
6	Fishing weir
7	Fishing weir
8	Terry Harris' Weir
10	Connors Bros. Seafood Processing Plant, connected to drinking water supply
11	Cooke Seafood Processing Plant, connected to the drinking water supply
12	Cooke Aquaculture maintenance site
13	Cooke Aquaculture hatchery
14	Buckmans Creek Hatchery Ltd.

15	Northern Harvest Net mending facility
16	Grand Manan Ferry Wharf
17	Beaver Harbour wharf
18	Blacks Harbour fishing wharf
19	Acadian Sea plants
20	Caviar Plant
21	Collingwood Nursing Home/Special Care Home
22	Low income housing
23	Hospital/Nursing Home
24	Blacks Harbour School K - 6
25	Pennfield School – Kindergarten through grade 5
26	Blacks Harbour Arena
27	Main road in and out of Beaver and Blacks Harbour
28	Alternate route in and out of Beaver and Blacks Harbour
29	Water source
30	Aquaculture site, salmon: disease and lice (for example: ISA) as a result of warmer water
31	Aquaculture site, salmon
32	Aquaculture site, salmon
33	Aquaculture site, salmon
34	Aquaculture site, salmon
35	Aquaculture site, salmon
36	Town Hall, Sentinel Service, high tax rate

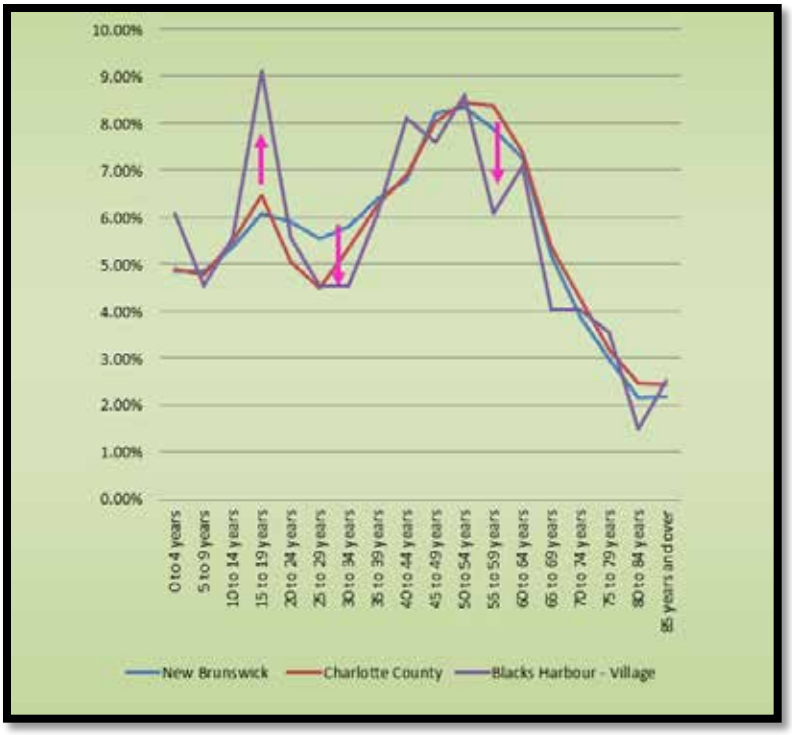


FIGURE A3.1: AGE CLASS DISTRIBUTION FOR BLACKS HARBOUR BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: SR. JAMES MACLELLAN).

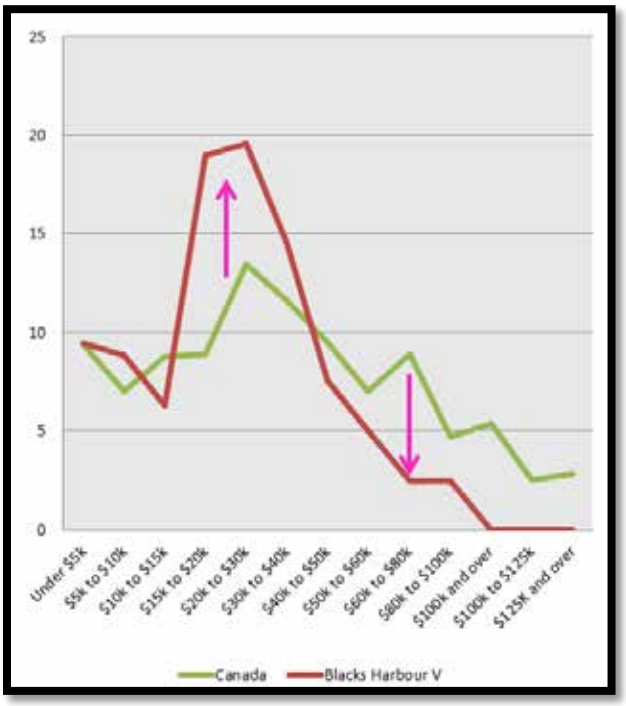


FIGURE A3.2: INCOME DISTRIBUTION EXPRESSED AS A PERCENTAGE FOR BLACKS HARBOUR BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY FOR THE 2010 TAXATION YEAR (SOURCE: DR. JAMES MACLELLAN).

		National	Atlantic	New Brunswick	Charlotte C	Blacks Harbour V
Household Generations	Population	32852325	2286655	735835	26080	935
	1st Gen.	22.0%	4.9%	4.5%	8.6%	7.5%
	2nd Gen.	17.4%	5.6%	5.9%	7.5%	6.4%
	3rd Gen >=	60.7%	89.5%	89.6%	83.9%	86.6%
Household Mobility (1 Yr)	Non-movers	91.8%	92.9%	92.9%	94.9%	93.9%
	Movers	13.0%	11.3%	11.3%	9.5%	10.1%
Household Mobility (5 Yr)	Non-movers	61.4%	67.9%	67.2%	72.4%	70.4%
	Movers	38.6%	32.1%	32.8%	27.5%	29.6%

FIGURE A3.3: HOUSEHOLD MOBILITY AND GENERATIONS FOR BLACKS HARBOUR BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

OCCUPATION Type	NATIONAL	ATLANTIC	New Brunswick	Charlotte County	Blacks Harbour V
Sales and service occupations	23.1	23.9	24.3	18.6	12.8
Business; finance and administration	16.5	14.3	14.3	10.5	12.8
Trades; transport & equipment operators; related	14.4	16.1	16.6	19.2	7.4
Education; law & social; community & gov't services	11.7	12.8	12.5	10.0	0.0
Management	11.2	9.4	9.2	9.9	4.3
Natural and applied sciences and related	7.0	5.9	5.5	4.2	0.0
Health occupations	6.3	7.2	7.4	6.6	0.0
Manufacturing and utilities	4.6	4.3	4.8	11.8	46.8
Art; culture; recreation and sport	2.9	2.0	1.9	1.1	0.0
Natural resources; agriculture & related prod.	2.3	4.2	3.5	8.1	7.4

FIGURE A3.4: OCCUPATION PERCENTAGE BY TYPE FOR BLACKS HARBOUR BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

TABLE A3.3: LIST OF ENVIRONMENTAL IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR BLACKS HARBOUR.

Dot Number	Explanation of Environmental Impact
1	The dump behind the ferry dock, not currently in use, concern of contamination
2	Old army base dump site across from the Pennfield Lions Club
4	Old dump site for Connors Bros. and Buckmans Creek Hatchery Ltd.
5	Old dump site used by the community
6	Bog

A4. ST. GEORGE

TABLE A4.1: LIST OF PHYSICAL AND INFRASTRUCTURE IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. GEORGE.

Dot Number	Explanation of Physical and Infrastructure Impact
1	Culvert at Mill Lake; can't handle heavy precipitation, put in a larger culvert
2	Covered Bridge; impacted during 2010 flood
3	Intersection of Old St. Andrews Road and Hwy 770 flooded; choke point in river
1,2,3	Choke points, no phone to the north, impassable during flood events
4	Between point 3 and 4; flooding
5	Between 4 and 5; flooding
6	Manor Road connector culvert
7	Everything between point 6 and 7 floods
8	Park's Brook Bridge
9	Points 8 to 9, road was impassable
10	Park's Brook floods
11	River View Ave – impassable during flooding events
12	Pinch point that vehicles cannot cross during flooding; no access to 13 homes
13	River bank erosion; road had to be rebuilt
14	Curling club destroyed by flooding, closed for a year, sewage lift station potential for loss during flood events
15	North Portage, intersection, roads and homes flooded
16	Day Adventure Centre flooded, came close to losing water well #2
17	Aliant telephone switch box; was raised after 2010 as it was submerged during flood, should be raised higher for 100 – year flood events
18	Town water wells #4 and #5 were close to being closed, within about a foot
19	Sewage facility; increased bacteria levels in the river after heavy precipitation
20	Significant erosion as a result of heavy precipitation
21	Brunswick Street bridge lift station is at risk during flood events
22	Sewage lift station at risk during flood events
23	Potential road washout at Sealy's Brook during floods, serious choke point - Back Bay, Mascarene & Deer Island isolated, prone to flash flooding, high levels of erosion
24	St. George marsh; flooding on the Trans Canada
Drawn on	Projected travel of lake overflow in the event of heavy precipitation
25	Ice flow jams

TABLE A4.2: LIST OF SOCIAL AND ECONOMIC IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. GEORGE.

Dot Number	Explanation of Social and Economic Impact
1	DFO, CFIA, DAAF, DOT – large portion of the public administration statistics
2	RCMP
3	Northern Harvest fish processing facility
4	True North (Cooke) fish harvesting facility
5	GMG Fish Services
6	Corey Feeds, provide feed for the aquaculture industry
7	Rainbow Nets, net repair company
8	New Leaf (formerly known as Fero) refuse, garbage collection
9	Lake Utopia Paper Mill; the flood in 2010 shut them down
10	Lake Utopia water intake (employs about 140 people)
11	Cooke Aquaculture hatchery
12	Digdeguash Lake hatchery; had to shut down in 2010
13	Fishing wharves
	13.1 Back Bay Wharf
	13.2 Limekiln Road Wharf
	13.3 Granitefield Road Wharf
	13.4 Fishing Wharf
	13.5 Fishing Wharf
14	Northern Harvest net manufacturer
15	Future Nets, net manufacturer and repair; affected by the rain, let alone flooding issues
16	Sturgeon aquaculture, produce caviar
17	Granite Town farms, blueberry operation
18	Cranberry/Blueberry operation
19	Blueberry fields
20	Fundy High School, grades 7 – 12; closed for four days during floods in December 2010
21	St. George Elementary; closed for four days during floods in December 2010
22	St. George Mall
23	Tim Hortons Complex
24	Service New Brunswick building
25	Russell Hawkins blueberry field
26	Call Centre
27	Granite Court seniors housing, doctors' offices, public nursing
28	Brunswick Court
29	Seniors home on Williams Street
30	Community Health Services
31	Maxwell Campground; in December 2010 the road to the campground was washed out
32	Granite Town Camping; totally submerged during 2010 flood event
33	Canal Beach, popular recreation spot; erosion due to heavy rain and flooding events

34	Access road to the Fundy High sports field, becomes impassible during heavy rain events
35	Blueberry fields
36	Many cottages were destroyed and damaged during the 2010 flooding event
37	From 37 – 38 (Brockway) all the mortgages are uninsurable and difficult to sell
39	39 – 40 Woodbury's Cove; homes and camps are uninsurable, making them difficult to sell or buy
41	Hatt's Beach; homes and camps are uninsurable, making them difficult to sell or buy
42	St. George golf course
43	Day Adventure Centre, boat launch into the river, business centre that is now empty; unable to get liability insurance
44	Magaguadavic clam flats; susceptible to closure during heavy rains
45	L'etang clam flats; susceptible to closure during heavy rains
46	Choke point
47	Tailings pond of the Mount Pleasant Mine; if there was a heavy rain event, pollution could make its way down the river towards the community
48	Salt water aquaculture pens; water temperature has an effect on sea lice which leads to an impact on production and raises costs of production

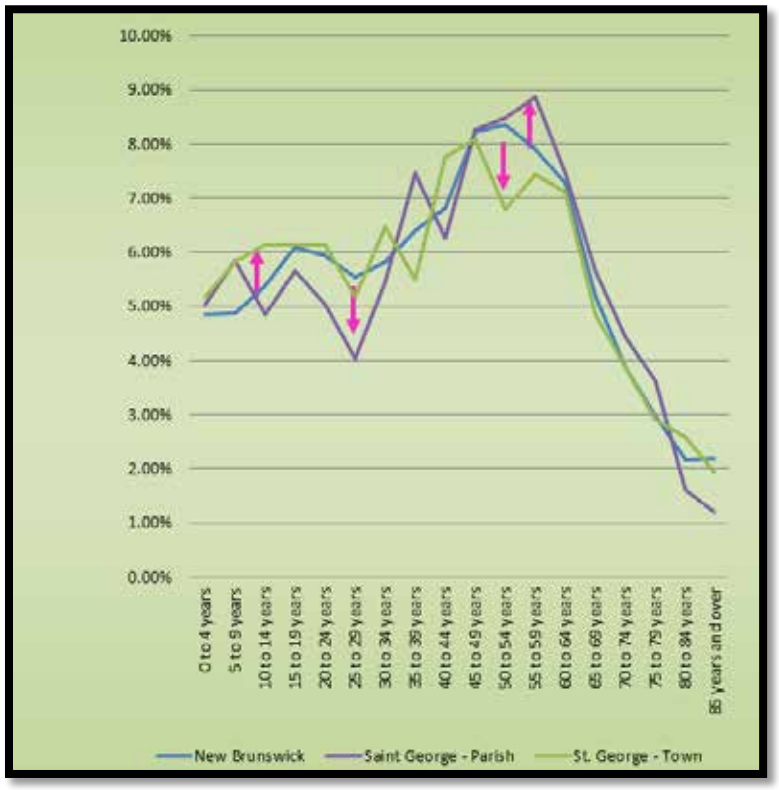


FIGURE A4.1: AGE CLASS DISTRIBUTION FOR ST. GEORGE BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: SR. JAMES MACLELLAN).

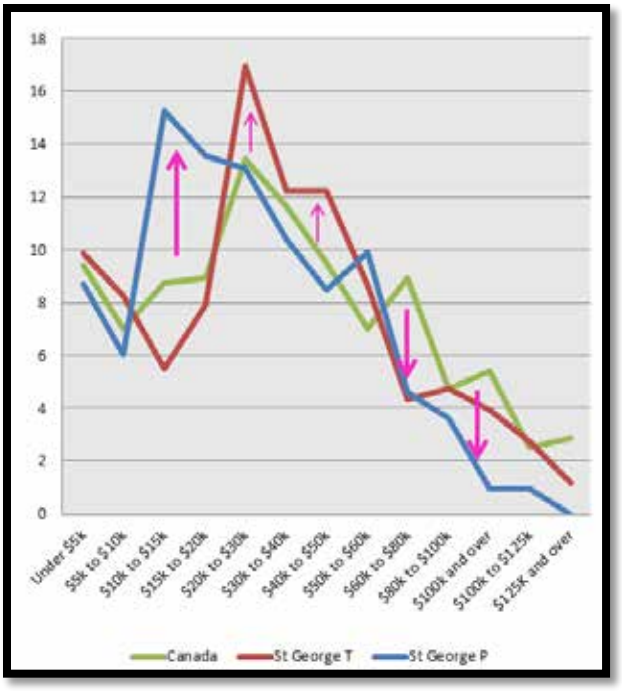
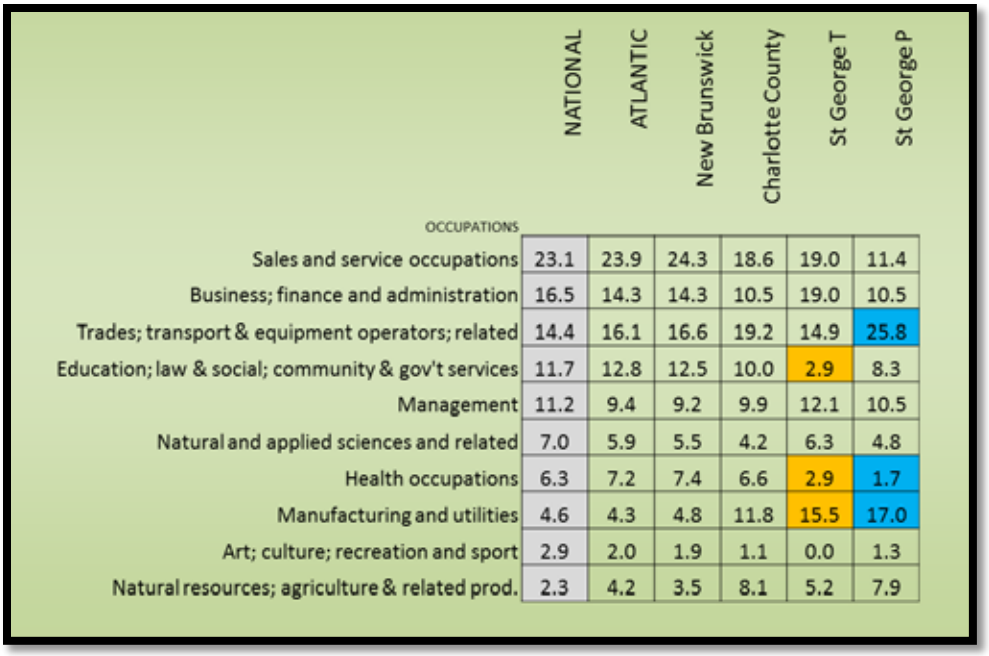


FIGURE A4.2: INCOME DISTRIBUTION EXPRESSED AS A PERCENTAGE FOR ST. GEORGE BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY FOR THE 2010 TAXATION YEAR (SOURCE: DR. JAMES MACLELLAN).

		National	Atlantic	New Brunswick	Charlotte C	St George T	St George P
	Population	32852325	2286655	735835	26080	1490	2410
Household Generations	1st Gen.	22.0%	4.9%	4.5%	8.6%	13.1%	2.7%
	2nd Gen.	17.4%	5.6%	5.9%	7.5%	5.0%	7.1%
	3rd Gen >=	60.7%	89.5%	89.6%	83.9%	82.2%	90.0%
Household Household Mobility (1 Yr)	Non-movers	91.8%	92.9%	92.9%	94.9%	91.9%	96.0%
	Movers	13.0%	11.3%	11.3%	9.5%	12.0%	9.0%
Household Household Mobility (5 Yr)	Non-movers	61.4%	67.9%	67.2%	72.4%	67.1%	76.7%
	Movers	38.6%	32.1%	32.8%	27.5%	33.2%	23.3%

FIGURE A4.3: HOUSEHOLD MOBILITY AND GENERATIONS FOR ST. GEORGE BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).



OCCUPATIONS	NATIONAL	ATLANTIC	New Brunswick	Charlotte County	St George T	St George P
Sales and service occupations	23.1	23.9	24.3	18.6	19.0	11.4
Business; finance and administration	16.5	14.3	14.3	10.5	19.0	10.5
Trades; transport & equipment operators; related	14.4	16.1	16.6	19.2	14.9	25.8
Education; law & social; community & gov't services	11.7	12.8	12.5	10.0	2.9	8.3
Management	11.2	9.4	9.2	9.9	12.1	10.5
Natural and applied sciences and related	7.0	5.9	5.5	4.2	6.3	4.8
Health occupations	6.3	7.2	7.4	6.6	2.9	1.7
Manufacturing and utilities	4.6	4.3	4.8	11.8	15.5	17.0
Art; culture; recreation and sport	2.9	2.0	1.9	1.1	0.0	1.3
Natural resources; agriculture & related prod.	2.3	4.2	3.5	8.1	5.2	7.9

FIGURE A4.4: OCCUPATION PERCENTAGE BY TYPE FOR ST. GEORGE BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

TABLE A4.3: LIST OF ENVIRONMENTAL IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. GEORGE.

Dot Number	Explanation of Environmental Impact
1	Wetland
2	Wetland
3	Wetland
4	Wetland
5	Wetland on the South side of Lake Utopia
6	Canal wetland
7	Trout Lake
8	Spawning habitat for Lake Utopia Rainbow Smelt
9	Spawning habitat for Lake Utopia Rainbow Smelt
10	Mill Lake Brooke spawning habitat for Rainbow Smelt
11	Mount Pleasant Mine tailings pond
12	Manor Road buffer of trees and vegetation for ice flows and flooding

A5. GRAND MANAN

TABLE A5.1: LIST OF PHYSICAL AND INFRASTRUCTURE IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR GRAND MANAN.

Dot Number	Explanation of Physical and Infrastructure Impact
1	Old ferry dock (getting old, will be very unsafe if it is lost)
2	North Head fisherman's wharf
3	Ingles Head fisherman's wharf (most vulnerable of the wharves)
4	Seal Cove fisherman's wharf
5	White Head ferry terminal/fisherman's wharf
6	New ferry dock
7	Decreased number of right whales
8	Disruption of the weir fishery
9	End of the shut off herring fishery (Meredith Houseworth Memorial Seashore)
10	Ball diamond floods in heavy precipitation events in Castalia
11	Man-made seawall
12	New nursing home
13	Hospital
14	Back-up generator
15	Electrical cable to White Head Island
16	Long eddy where the electrical cable arrives from the mainland
17	Fire department
18	Medi-vac airport
19-20	Long Bank, has recently been reinforced
21	Drug store
22	Scotia Bank in Grand Harbour
23	Police station
24	Community school
26	Chaney Island all the trees are dead due to invasive beetle species
27	Seal Cove ball diamond, impact to pine trees due to invasive beetle species
28	Rocky Corner, hot spot for ticks

TABLE A5.2: LIST OF SOCIAL AND ECONOMIC IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR GRAND MANAN.

Dot Number	Explanation of Social and Economic Impact
1	Kinghorn Lobster holding tank
2	CR Fisheries
3	MG Fisheries in Woodwards Cove
4	Bensons Tank House in the thoroughfare
5	Foggy Cove in Woodwards Cove in the thoroughfare
6	Cooke Maintenance facility in Woodwards Cove
7	Aquaculture site
8	Aquaculture site
9	Aquaculture site
10	Aquaculture salmon site
11	Aquaculture site

12	Aquaculture site
13	Aquaculture site
14	Aquaculture site Outer Wood Island and Wood Island
15	Clam flats
16	Clam flats
17	Dulse collection (the Passage, the thoroughfare, and Dark Harbour)
18	Salmon hatchery – out of commission
19	Cooke fish processing facility (not sure if it is still active)
20	Seal Cove wharf
21	Ingalls Head Harbour (Whitehead ferry, boat haul/boat yard and fuel station)
22	Anchorage Provincial Park, bird sanctuary, recreation spot
23	Hole in the Wall campground
24	Castalia Marsh Retreat
25	New nursing home
26	Seniors apartments
27	Dark Harbour retail
28	Save Easy, Irving, Greco
29	Village Centre including arena
30	DFO/ambulance service
31	Curling club
32	Garbage transfer station
33	Lobster pens
34	Lobster pens
35	Public swimming pool
36	Dutchman contracting, deer farm, aquaculture, transportation, and septic tanks
37	Airport
38	Dulse drying facility
39	Dulse drying facility
40	Dulse drying facility
41	Deer farm
42	DNR office
43	Dulse plant; works with the drying facility at # 38
44	Surf Side Motel (tourism)
45	Whale Cove Cottages (tourism)
46	Bird sanctuary
47	Grand Manan Museum
48	Grand Manan Art Gallery
49	Whales and Sails (whale watching) and Top of the Island (sightseeing)
50	Sea Watch (whales and puffins)

FIGURE A5.1: AGE CLASS DISTRIBUTION FOR GRAND MANAN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: SR. JAMES MACLELLAN).

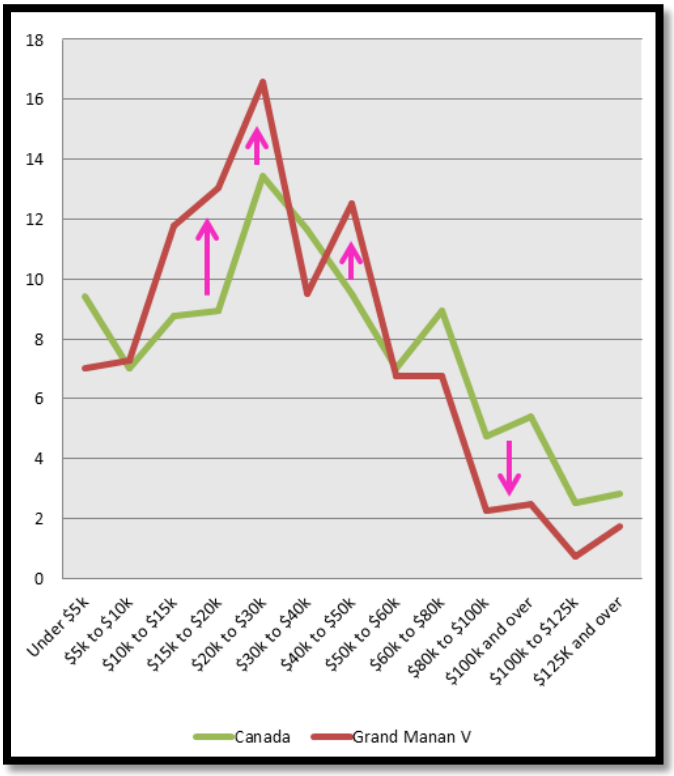
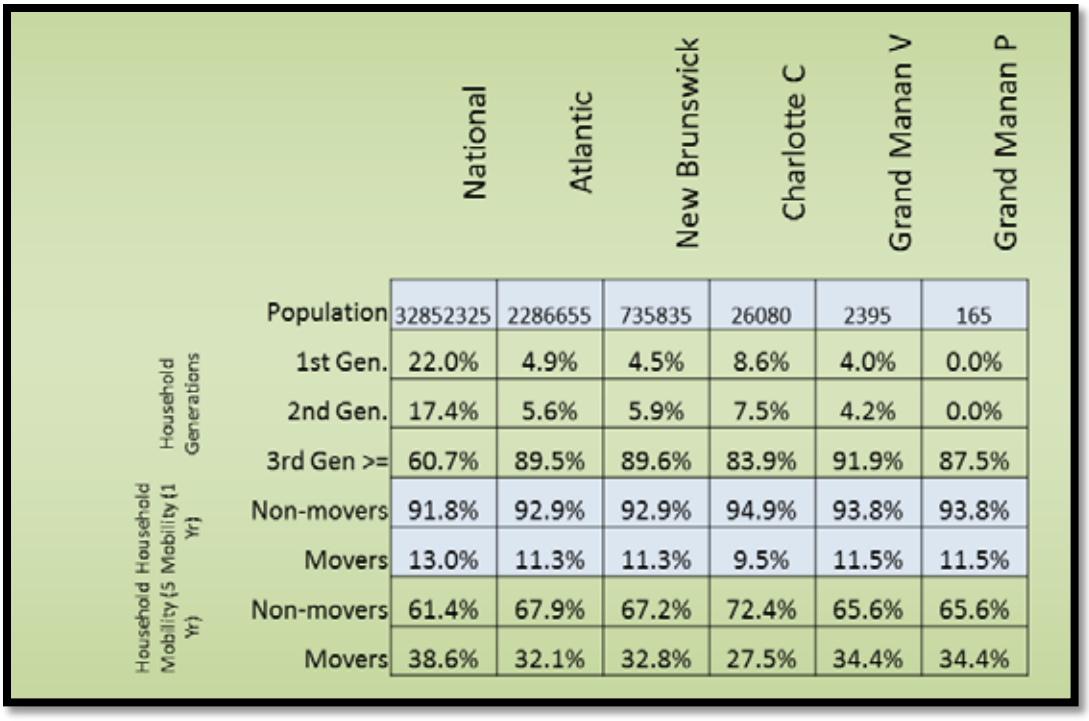
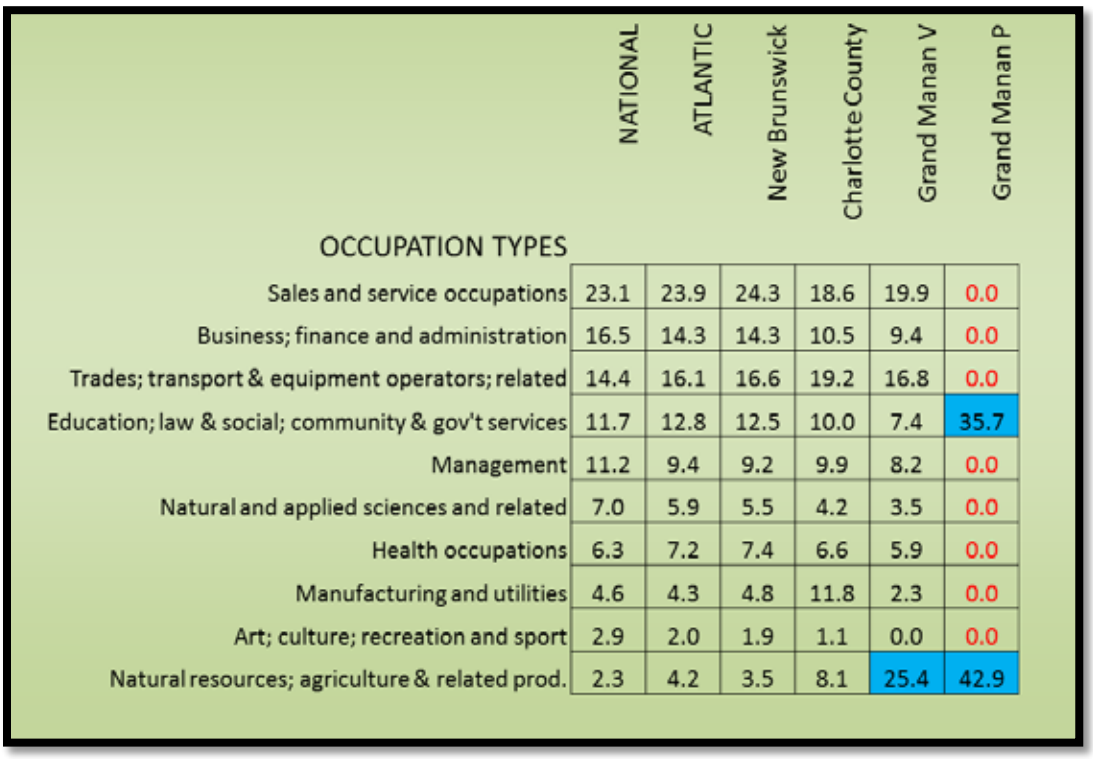


FIGURE A5.2: INCOME DISTRIBUTION EXPRESSED AS A PERCENTAGE FOR GRAND MANAN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY FOR THE 2010 TAXATION YEAR (SOURCE: DR. JAMES MACLELLAN).



		National	Atlantic	New Brunswick	Charlotte C	Grand Manan V	Grand Manan P
	Population	32852325	2286655	735835	26080	2395	165
Household Generations	1st Gen.	22.0%	4.9%	4.5%	8.6%	4.0%	0.0%
	2nd Gen.	17.4%	5.6%	5.9%	7.5%	4.2%	0.0%
	3rd Gen >=	60.7%	89.5%	89.6%	83.9%	91.9%	87.5%
Household Mobility (1 Yr)	Non-movers	91.8%	92.9%	92.9%	94.9%	93.8%	93.8%
	Movers	13.0%	11.3%	11.3%	9.5%	11.5%	11.5%
Household Mobility (5 Yr)	Non-movers	61.4%	67.9%	67.2%	72.4%	65.6%	65.6%
	Movers	38.6%	32.1%	32.8%	27.5%	34.4%	34.4%

FIGURE A5.3: HOUSEHOLD MOBILITY AND GENERATIONS FOR GRAND MANAN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).



OCCUPATION TYPES	NATIONAL	ATLANTIC	New Brunswick	Charlotte County	Grand Manan V	Grand Manan P
Sales and service occupations	23.1	23.9	24.3	18.6	19.9	0.0
Business; finance and administration	16.5	14.3	14.3	10.5	9.4	0.0
Trades; transport & equipment operators; related	14.4	16.1	16.6	19.2	16.8	0.0
Education; law & social; community & gov't services	11.7	12.8	12.5	10.0	7.4	35.7
Management	11.2	9.4	9.2	9.9	8.2	0.0
Natural and applied sciences and related	7.0	5.9	5.5	4.2	3.5	0.0
Health occupations	6.3	7.2	7.4	6.6	5.9	0.0
Manufacturing and utilities	4.6	4.3	4.8	11.8	2.3	0.0
Art; culture; recreation and sport	2.9	2.0	1.9	1.1	0.0	0.0
Natural resources; agriculture & related prod.	2.3	4.2	3.5	8.1	25.4	42.9

FIGURE A5.4: OCCUPATION PERCENTAGE BY TYPE FOR GRAND MANAN BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

TABLE A5.3: LIST OF ENVIRONMENTAL IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR GRAND MANAN.

Dot Number	Explanation of Environmental Impact
1	Long Pond Migratory Bird Sanctuary, Federal Government designation
2	Big Pond on Wood Island is a bird sanctuary
3	Castalia Marsh
4	The Whistle, long eddy rip, upwelling area where there is an abundance of sea life
5	Flagg's Cove, lobster nursery, one of the largest on the East Coast
6	Machias Seal Island, area of importance for bird life, specifically puffins
7	Deep Cove – increase in ticks
8	North Head – increase in ticks
9	Impact to pine trees due to disease (beetles)
10	Stand of dead spruce trees
11	Miller's Pond
12	Duck's Unlimited Canada wetland area
13	New Brunswick and Federal Nature Trust site
14	Eel Lake – habitat for small mouth bass and trout
15	North Head waste oil storage
16	Ingles Head waste oil storage
17	Seal Cove waste oil storage

A6. GOVERNANCE COMMENTS COLLECTED DURING NOVEMBER 2013 INTERVIEWS

Dr. Nicole Klenk conducted 27 interviews during November of 2013 throughout Charlotte County, the summaries provided below were produced by Jacinthe Briand-Racine of the University of Toronto. Funding for this research was provided through a Partnership Development Grant to Nicole Klenk, the co-applicant, from the Social Science and Humanities Research Council of Canada (SSHRC) for the research project and associated conference *Living with Climate Change Canada*.

A6.1 ROLES FOR DIFFERENT LEVELS OF GOVERNMENT IN PLANNING FOR ADAPTATION TO CLIMATE CHANGE

Note that most of the enumerated roles are roles that speakers suggest should be taken by different actors, but that for the most part are not being accomplished.

The town's responsibilities

- Managing the town's infrastructure in order to mitigate damage from future floods;
- Having a good emergency plan in place/ being ready for future extreme weather events;
- Having a plan for better communication with citizens in the case of another flood event;
- Help individuals take the necessary adaptation measures by providing educational information;

- Enforcing by-laws on construction in areas at risk of flooding;
- The town should mandate someone to take part of the climate change adaptation committee meetings;

The province's responsibilities

- The province's participation in adaptation planning is suggested to be necessary if any change is going to be taking place.
- Setting policy for planning is considered to be mostly of provincial jurisdiction;
- The province should participate in the climate change adaptation meetings (particularly important would be the participation of Department of Transportation);
- The province, should receive the reports of the committees and facilitate the implementation of their recommendations;
- Providing resources to citizens and to the province so that they can take the necessary adaptation measures (resources include money, expertise and information)
- The province should set requirements for municipalities to put adaptation plans in place (for example through the Municipality's Act);
- The province should implement regulations for dam operations;

The federal government's responsibilities

- The federal government's role is scarcely mentioned, except by people in Grand Manan, who observe that the wharves and the harbour infrastructure are of federal responsibility.
- They also suggest that the federal government is not ready to take the adaptation measures that need to be taken.
- The only other mention of the role of the federal government is as a potential provider of resources for answering local needs;

EMO's responsibilities

- It is EMO's responsibility to anticipate problems and take measures to try and mitigate them;
- In St-George, there is a sense that local EMO has been active (more so than town council) in taking measures for preparing for other flood events in the future.

Local Service District's responsibilities

- Little is mentioned here, except the fact that rural areas outside of town are their responsibility. In St. George, during the flood, the municipality ended up voluntarily taking responsibility for these areas that weren't officially under their responsibility.

Potential role for the Regional Service Commission

a) Suggested roles

- Comments suggest that climate change adaptation planning would potentially be an area where the Regional Service Commission could have a role.
- Another such area would be emergency planning, which has started to be discussed by

EMO.

b) Impediments to the Commission fulfilling these roles

- The Regional Service Commission is young, it is not functional yet. The mandate of the Commission still has to be clarified. There is a sense that the commission is ''going nowhere''.
- Considering the importance of St. Stephen's contribution to the Regional Service Commission, certain problems within the municipal government are also identified as having some impacts on the slowness of the Regional Service Commission's development.

Areas for shared responsibility between different levels of government

- The particularity of each local context, and the need for locally-relevant policies will make it necessary for the town to take part in planning processes that operates at a provincial level;
- Shared ownership of impacted areas entails the need for cooperation between the town and the province (provincial roads, parts of the watershed outside of the municipality) for upgrading and managing municipal infrastructure;
- The large majority of interviews point to the need for multilevel (or multi- jurisdictional) governance of climate change adaptation planning;
- There is suggestion for more cooperation and for more discussions to be had across all different levels of government and across localities;
- Many times it was mentioned - the need to include in the discussions everybody who has an impact on the dams up-river.

A6.2 PARTICIPANTS' ASSESSMENTS OF THE QUALITY OF LOCAL AND PROVINCIAL GOVERNANCE

The majority of comments point to a general dissatisfaction with the quality of formal governance in the area of planning for adaptation to climate change. The same conclusions were made in terms of the quality of governance during the flood events.

Assessing the quality of local governance of adaptation planning

- In St. Andrews, there is satisfaction with the efforts and the actions of the town personnel;
- In St. Stephen, people find that there has been some recent improvement in the level of awareness and preparedness of the town council; but more generally, adaptation measures taken by the municipalities seem to be absent, insufficient or inappropriate;
- There seems to be a problem of inertia, and a fair amount of corruption in the way decisions are taken locally;
- There seems to be a general lack of awareness on the part of town council: awareness about climate change, its impacts, and about the long-term benefits of investing in adaptation measures;
- There seems to be no willingness to consider reports and recommendations given to the town;

The resources that the town lacks for effective planning of adaptation measures to take place

Although part of the problem seems to be lack of leadership, proactivity, and receptivity to recommendations for solutions, there is also a tendency to associate bad governance to a lack of needed resources, especially by the municipality.

- Money: Adaptation measures need to be financed, and the town is on a tight budget;
- Expertise and information: Comments clearly point to the municipalities lacking the expertise and the information that would be necessary for including climate change in local decisions and community planning, as well as for having an effective emergency plan in place;
- Human resources: A lack of ''experts'' and ''planners'', but also just not enough people: ''one person doing too many things''.

Assessing the quality of provincial governance of adaptation planning

The problems surrounding provincial governance were discussed in less detail, and less frequently than those concerning local governance.

- What participants' comments point to is that not much is currently being done by the province in terms of planning adaptation measures.
- Whereas the role of the province seems necessary, comments also point to the fact that there is little confidence in the possibility of the province providing the needed support. There is also mention of the fact that provincial policies would probably be inadequate for specific local contexts.

Resources needed by the province

Only very little is mentioned concerning the resources that the province does not have. There is a sense that the province, like the municipalities, does not have the money needed to fund all the adaptation measures that should be taking place, but not as much emphasis is put on the province's needs, in comparison with the widely mentioned needs for the municipalities.

A6.3 Roles for non-governmental actors in planning adaptation to climate change

Whereas the roles of governmental actors listed above are mostly ''roles that should be'', the spheres of action that are associated to individuals' responsibilities are for the most part things that are currently being done by at least some people. From the content of the interviews, we get a sense that more is being done by non-governmental actors than by the different levels of government involved.

It also appears clearly that some of the roles attributed to individuals are influenced by the general dissatisfaction with formal governance. That is, certain roles are relegated to individuals because there is little or no confidence that the government will fulfil them adequately, and in a timely manner. This is not to say that it is the case for all the roles attributed to individuals. As mentioned below, there

is also a sense of a necessary involvement from citizens in complementarity with the involvement of different governmental actors.

Individuals' responsibilities

- There is a responsibility for individuals to educate themselves and the community to climate change;
- There is a responsibility for individuals to make responsible choices, and to be held responsible for their choices;
- Certain lifestyle choices to make in order to mitigate the effects of climate chance;
- People should remain vigilant of:
  - -Weather changes and upcoming weather events;
  - -Problematic areas in town/ problematic infrastructure in town/
  - -Actions that are being taken by the town;
- Communicating with authorities/ communicate one's preoccupations to the town (i.e., complain until things get done!)
- People shouldn't always depend on others/ leadership from the government has to be complemented by actions from individuals;

Responsibilities for home-owners specifically

- Being aware of one's home environment and of the potential risks inherent to one's location;
- Consider the risks of flooding when building a new house/ when choosing a site for building
- Fixing and adapting houses to be ready for future floods (building higher or elsewhere)
- Have the resources in place in prevision of more extreme weather events (eg. a back-up generator; a sump pump)

Resources required

- Awareness needs to be raised concerning what individuals *can* do (providing information as a role for the government or the town)
- Financing adaptation measures: monetary investments are necessary for many adaptation measures that are considered as roles for individuals (eg. Installing better drainage, sewer and pumping systems; purchasing a generator; hiring an architect to adapt house plans, etc.)

Responsibilities for the people who operate dams

When relating the reasons for the importance of the damage from flooding, the partial responsibility of dam operators came into question. It is widely mentioned that there needs to be more awareness on the part of dam operators all along the river, as well as a need for them to take part in discussions about adaptation planning.

Role for private enterprises

A few people mentioned some enterprises that had backup plans ready in prevision of floods, or that have adapted their sites to prevent flooding (in St. Stephen - Canadian Tire, Sobeys, Shoppers);

Role for the climate change adaptation committee

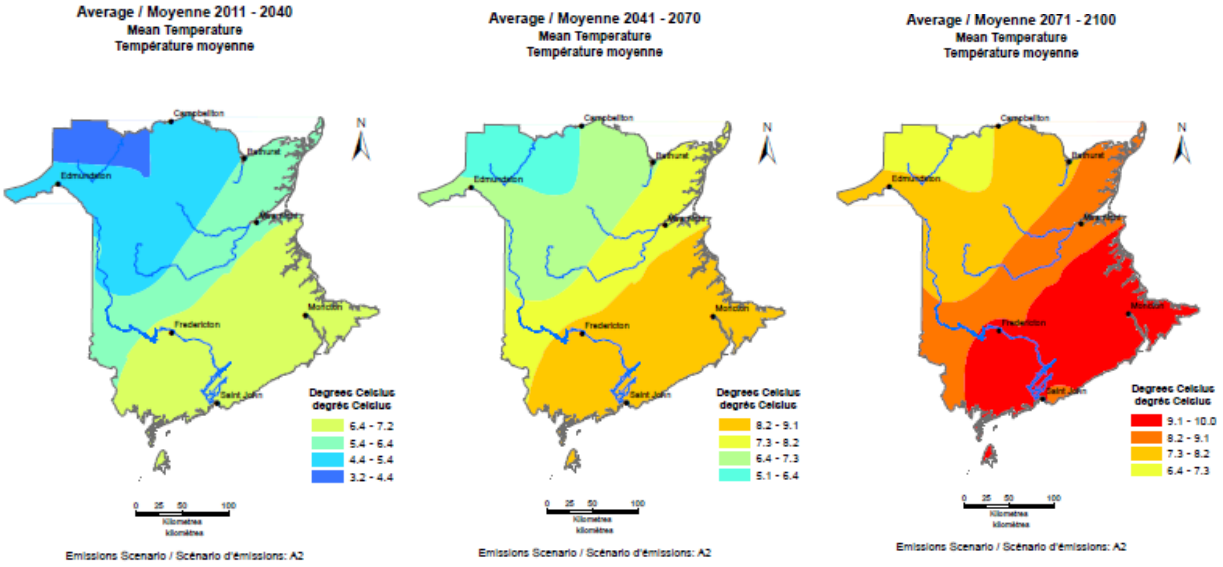
To the non-governmental actors listed above, we might also add the climate change committee, and consider the roles or objectives of the committee as roles for non-governmental actors in planning for adaptation.

A7. ACASA FUTURES MAPS

The New Brunswick Climate Futures page, available on the ACASA website at http://www.acasamaps.com/ presents information on the climate of New Brunswick, both present day, and future projections to 2100. Access is provided, not only to the maps but also to the raw data utilized in devising the maps. In describing maps accessible on this site, ACASA states, "Current climate is defined by measurements made over the period 1971-2000 at weather stations across the province. Projections of future climate were made using the output from 24 climate models developed by national weather services and research organizations in nine countries worldwide. Their results have been pooled and analyzed to provide the most up-to-date and reliable estimates possible. Future projections are presented using higher and lower estimates of future greenhouse gas emissions. Both current and future climate information is presented in the form of maps, which show current and future climate patterns expected across the province."

Select map series below have been chosen to provide examples of the types of resources available through the ACASA site. The selected series are representative of New Brunswick under the High – A1 emissions scenario in three time periods. The interactive query mapping process also enables inquiries regarding; mean temperature - annual, spring, summer, autumn and winter; annual cooling degree days, annual heating degree days, annual growing degree days > 5° and > 10°, annual corn heat days, annual, spring, summer, autumn and winter freeze-thaw days, annual number of days with maximum temperature of >25°, >30°, >35°, 0, <-10°, <-20°, annual total rain days, annual total snow days, annual freeze free days, annual growing season length, as well as annual, spring, summer, autumn and winter precipitation. The query function also allows for inquiries based on time, including; 1971 – 2000, 2001 – 2040, 2041 – 2070 and 2071 – 2100. The final two variables that can be controlled are the province as well as the emissions scenario with the choices of; High – A2, Low – B1 or current.

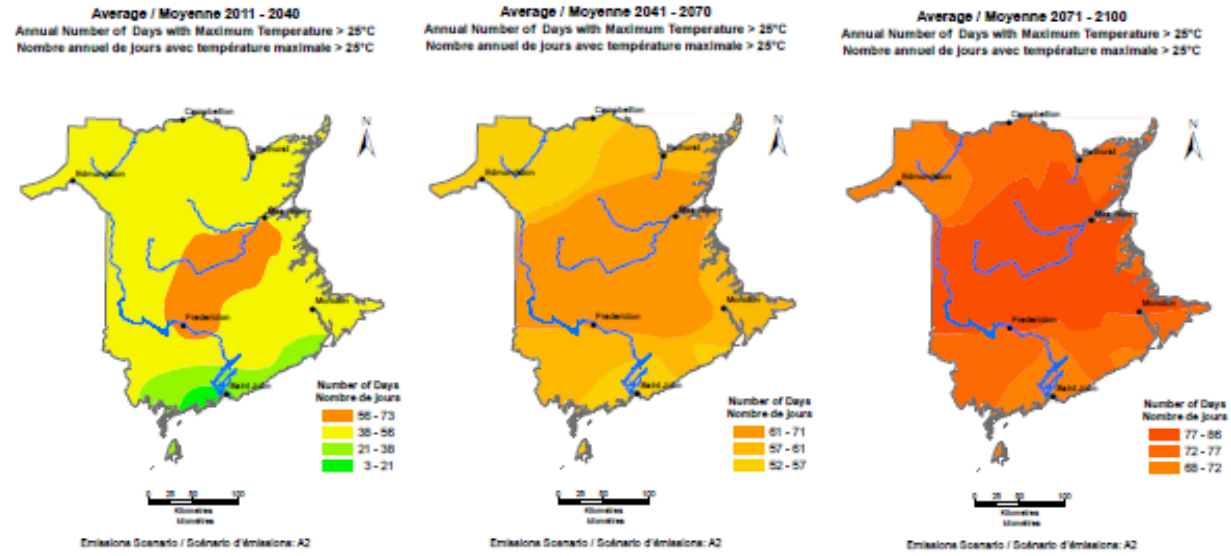
Annual Temperature



Data Type Explanation and Potential Effects

Mean temperature over the year is a measure of how hot or cold the climate is at a given location. Mean temperatures in New Brunswick currently range from around 5 degrees C in the south to 2 degrees C in the north. By the 2080s, mean temperatures are predicted to increase by around 3-3.5 degrees C. This will mean that northern areas of the province will have a temperature climate similar to that in southern New Brunswick today, while southern areas will become as warm as it is currently is in parts of southern Ontario.

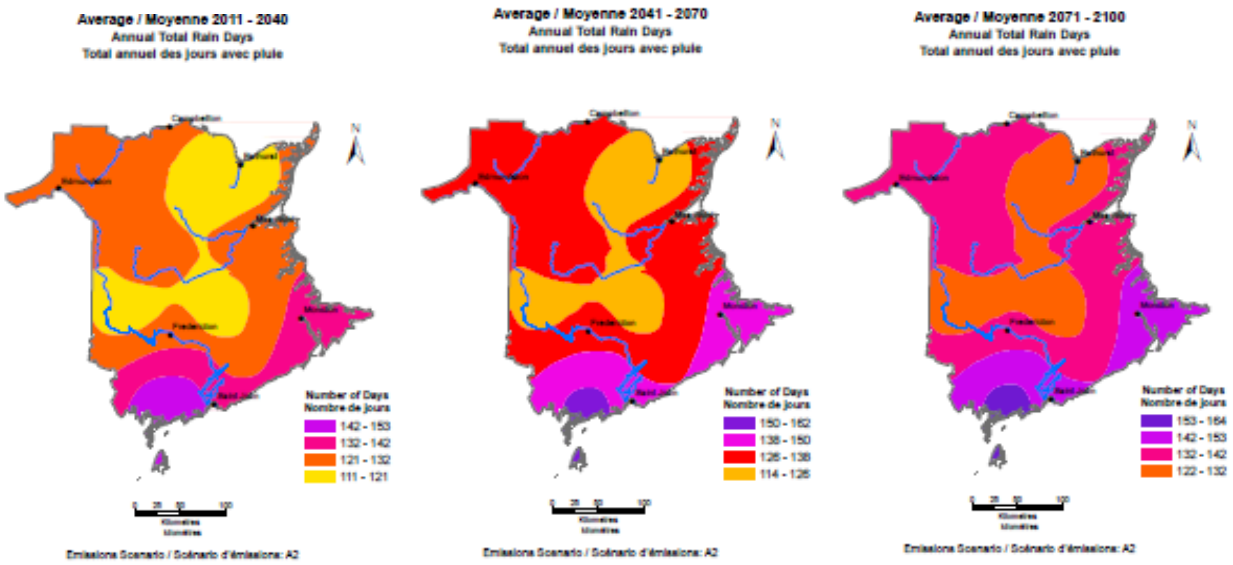
Days with maximum temperature over 25 degrees Celsius



Data Type Explanation and Potential Effects

Annual Number of Days with Maximum Temperature greater than 25 degrees C is the average number of days per year when the temperature exceeds this threshold. The number of days per year with a daily maximum temperature exceeding 25 degrees C is predicted to increase in all areas. By the 2080s Edmundston and Saint John can be expected to have more such days than Fredericton does now. A shift in average temperature of a few degrees may not seem like much, but the impact of the increase become easier to appreciate when considering how the frequency of hot or cold days will change. Warm, hot and very hot days will become much more common under future climate in New Brunswick. The increase in frequency of days above 30C is especially dramatic. On one hand this may make New Brunswick destinations more appealing for tourists, but it will also bring a demand for access to effective air conditioning in buildings, and shade areas and drinking water in public spaces. Heat stress is a well-known human health concern, and management of health impacts during heat waves is likely to require increased attention in future. Increasing demands for space cooling will result in potential increases in electricity demand and a shift in seasonal demand patterns. It may also drive changes in building design, placement, the need for shade, and locations to find refuge from the heat in public spaces.

Annual total rain days



Data Type Explanation and Potential Effects

Annual Total Rain Days is the average number of days per year with at least 0.2 mm of rainfall. The number of days with measurable rain shows a general increase in future scenarios. The greatest totals remain close to southern coasts and the lowest totals at inland locations. Temperature change across the freezing point can directly affect materials and infrastructure (e.g. paint, road surfaces). There are also indirect effects. More freeze-thaw cycles can require increased use of road salt, for example. Increased freeze-thaw activity in winter can be harmful for plants and wildlife by breaking dormancy and increasing the damage caused by subsequent cold spells. The full range of impacts is hard to predict, but effects are likely on the maple syrup industry, forest management, road maintenance and weight restriction periods.