Regional Action Plan Regarding Climate Change Adaptation

Phase 1: Risk and Vulnerability Assessment

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Abstract

The Chaleur Regional Service Commission (RSC) is developing a regional action plan regarding climate change adaptation with the support of the Coastal Zones Research Institutes Inc. (CZRI). An advisory committee (CRACCCA) was formed to oversee the project and advise the Chaleur RSC Board of Directors. The action plan will be developed in two phases. This report explains the completion of phase one, for which the objectives were to determine the scope and type of plan to prepare, depict the situation with respect to the impacts of climate change and analyse the risks, vulnerabilities and needs at the regional level.

To do so, three working meeting with employees of the Chaleur RSC, the CRACCCA and the CZRI took place, as well as two tabletop exercises including key stakeholders. The CZRI gathered available data and information to make a portrait of the situation regarding climate change risks and vulnerabilities. That documentary research was then validated and completed with local knowledge at the tabletop exercises.

The results are a portrait of the current and future situation. Gaps in the data and information available were identified. The identification of needs, at the community level, was done and generated a list of actions that could possibly be undertaken by the Chaleur RSC.

1. Introduction

The Chaleur Regional Services Commission (RSC) is working on developing a regional action plan to help member communities be better prepared for climate change. It retained the services of the Coastal Zones Research Institute (CZRI) to support it during the plan development process. It also formed the Chaleur Regional Advisory Committee on Climate Change Adaptation (CRACCCA) to oversee completion of the plan and advise the Chaleur RSC Board of Directors regarding climate change adaptation. The CRACCCA is made up of representatives from municipalities, local services districts (LSD) and citizens from the Chaleur RSC, along with key stakeholders such as the Department of the Environment and Local Governments (DELG), the Department of Energy and Resource Development and the Chaleur Bay Watershed Group (see Appendix 1 for the list of members). The CRACCCA agreed that the plan to be developed will be regional in scope and reflect the role of the Chaleur RSC as a provider of services and support to communities. In terms of scale, the plan will be somewhere in between a municipal adaptation plan such as that of the City of Bathurst and a provincial plan such as the New Brunswick Climate Change Action Plan (GNB 2016).

It is anticipated that the plan will be developed in two phases over a two-year period. This report deals with phase 1 of the project, i.e., the evaluation of current and future impacts of climate change on the region, and the evaluation of the risks and vulnerabilities of the region in relation to these changes. The objectives of year one (phase 1) were to determine the scope and type of plan to prepare, depict the situation with respect to the impacts of climate change; and assess the risks, vulnerabilities and needs at the regional level. The objectives of year two (phase 2) will involve choosing actions to incorporate into the plan, consulting with and informing the public, elected officials and key stakeholders regarding the proposed actions, risks and vulnerabilities; and finally developing implementation plans for the chosen actions.

2. Approach

Phase 1 required three working meetings with CRACCCA, employees of the Chaleur RSC and the CZRI, as well as two tabletop exercise sessions (see Appendix 2 for the list of participants). The CZRI was responsible for the facilitation and the presentation of necessary information during working meetings and tabletop exercises. RSC employees took care of the logistics of the meetings, the creation and printing of maps for the tabletop exercises as well as information gathered during the tabletop exercises. All meetings took place in Petit-Rocher.

The purpose of the first working meeting was to define the objectives and determine the content of the plan to be developed, validate the objectives and the steps involved in phase 1 and plan phase 2. At this initial meeting, it was agreed that the CRZI would produce a portrait of the risks confronting the entire territory at the second meeting. The CRZI conducted documentary research, gathering available data and information on climate-related hazards, vulnerabilities and infrastructures of the Chaleur RSC, and presented a portrait of the situation based on this research to the CRACCCA. Two tabletop exercises were held with key stakeholders to validate and complete this portrait with local knowledge. Geographic maps projected on screen and printed on large-format paper were used as visual supports. Participants were able to indicate their observations directly on the paper maps. In addition, places about which comments were made were noted on the electronic versions of the maps during discussions. The first tabletop exercise group (known as “Infrastructures”) targeting people with good knowledge of community infrastructures (roads, water networks and sewers, etc.) (Appendix 2), was consulted on February 14. The group discussed erosion, coastal flooding, inland flooding and drinking water supply problems. The second tabletop exercise group (known as “Utilities”) was consulted on February 15. The meeting targeted people with knowledge of regional infrastructures (transportation, telephone, electricity, ports, airport) and emergency management (police, firefighters, emergency measures organisation) (Appendix 2). The group discussed erosion, coastal and storm flooding, drinking water supply, forest fires and the impacts of temperatures, winds, freeze-thaw cycles, snow and rain on infrastructures. The information gathered during the tabletop exercises was inputted into a GIS database.

Community needs in terms of support and oversight were discussed at the third and last working meeting with the members of the CRACCCA. A brainstorming session generated ideas for actions that the Chaleur RSC could undertake to assist communities. It is important to note that the actions identified at this point are in the preliminary stage and that no decisions were made with respect to those that would appear in the final action plan.

3. Results

3.1 Preliminary risk and vulnerability assessment of the Chaleur RSC territory to climate change

Following is an overview of the current situation as pertains to the impacts and risks associated with climate change for the Chaleur RSC territory (New-Brunswick) according to information available as of February 2018. The Chaleur RSC territory covers an area of 3307 km^2, from the communities of Belledune to Pokeshaw along Baie des Chaleurs, as well as inland (Figure 1). The Chaleur RSC is therefore situated in the county of Gloucester, with the exception of a part of Belledune, which is located in Restigouche County. Member communities include the municipalities of Bathurst, Petit-Rocher, Nigadoo, Beresford, Pointe-Verte and Belledune, and 15 LSDs, including Robertville, Allardville, Saint-Sauveur, Petit-Rocher Nord, Petit-Rocher Sud, etc. Note that the Municipality of Bathurst developed its own adaptation plan in 2017 (Dietz 2017) and was therefore not included in this analysis. The territory has a total population of 36,000, most of which lives in the municipalities near the coasts. Major infrastructures are also located near the coasts, particularly the commercial port, the foundry and the Belledune thermal plant, along with fishing ports, roads, pump stations, electrical substations, water and sewer systems, water treatment basins, schools, fire stations, etc. The interior is largely wooded area, and the population is concentrated along some roads. The area is also home to a mining development site, a sanitary landfill site, a hydroelectric dam, transmission lines, an airport and railways.

To the greatest extent possible, current and anticipated risks and vulnerabilities have been identified and described at the regional scale (macro). Climate change and its effects were considered in their entirety, but the impacts and risks that relate to the Chaleur RSC’s mandate to support land use planning (urban planning and regional development) are emphasized.

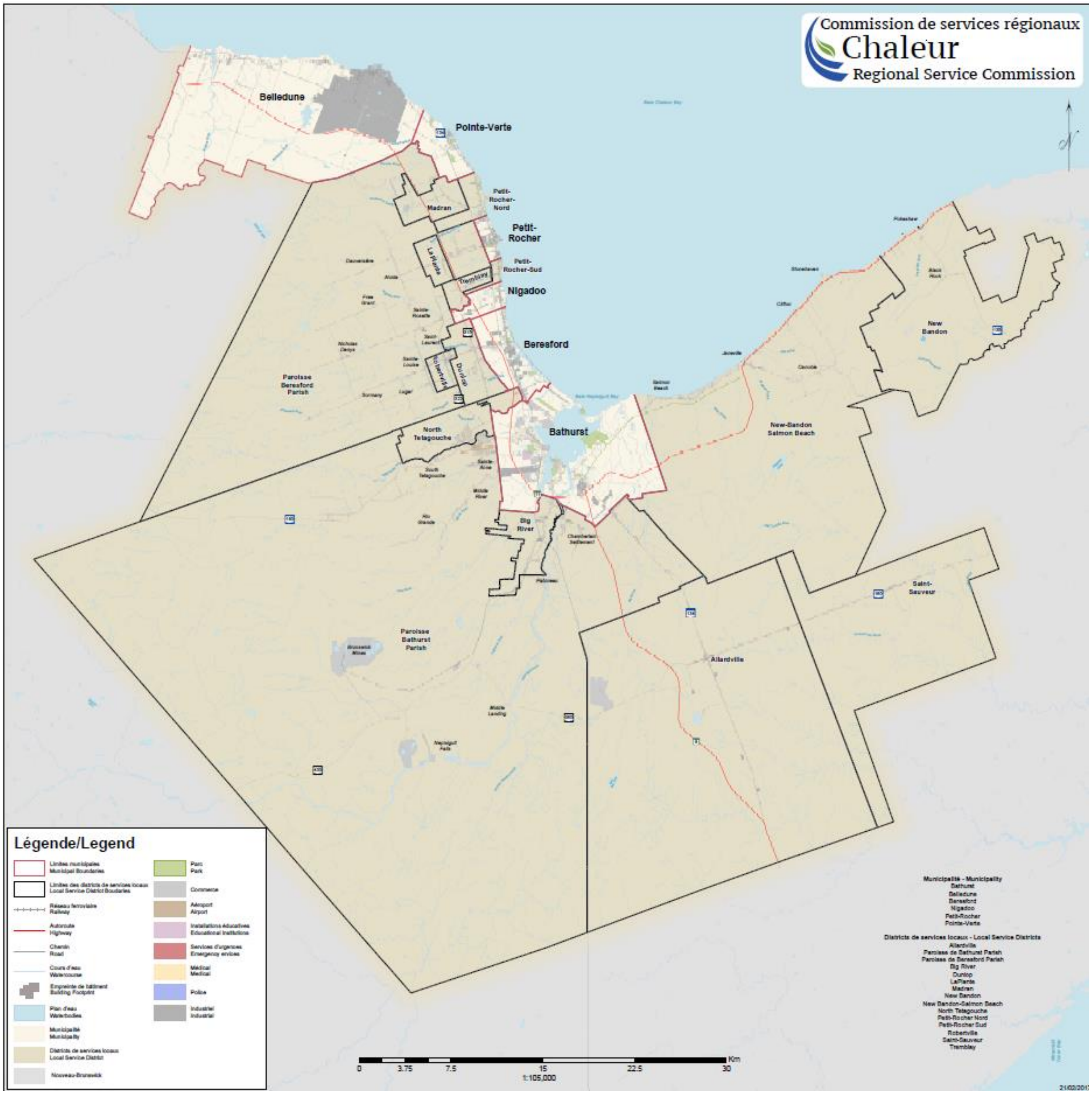

Figure 1: Chaleur RSC Territory.

The following major impacts of climate change were considered:

- Temperature increases and changes to precipitation regimes resulting in droughts and heat waves, more frequent heavy rain events and freeze-thaw episodes, which increase the risk of flooding due to surface water accumulation and overflowing of watercourses, the risk of forest fires, the migration of various species and diseases that can affect human health, the risk of drinking water shortages, as well as increase the deterioration rate of roads, bridges and other structures.

- Sea level rise and ice cover reduction that increase coastal flooding and erosion risks, as well as the risks of salt water intrusion into drinking water sources.
- “Extreme” events associated with a rising sea level, temperature increases and changes to precipitation regimes such as strong winds, flooding, fires, freezing rain, snowfalls, heat waves, etc., which disrupt transportation, electricity, telephone services, etc., and compromise public health and safety.

3.1.1 Summary of knowledge

3.1.1.1 Changes in air temperature and precipitation

According to analyses and modelling conducted by Ouranos (Roy and Huard 2016), the annual temperature is getting warmer (in comparison with historical data), a trend expected to continue into the future (projections until 2080) all over New Brunswick. This has been noted in every season and slightly more so in the winter time.

Based on the RCP 8.5 greenhouse gas emissions scenario of the IPCC[1] (IPCC 2013), the average winter temperature in the Chaleur region will reportedly rise from averages of -12.6 to -8.7°C and -8.7 to -4.9°C to averages between -8.7 and -4.9°C and -4.9 and -1.0°C in 2050. In 2080, the average winter temperature of the entire Chaleur region is anticipated to be between -4.9 and -1.0°C (Figure 2). Since 1981, the Chaleur region has had between 14.3 and 21.5 days where the average temperature has been lower than -10°C. Based on projections, this region could expect between 7.2 and 14.3 such days in 2020. In 2050, part of the Chaleur region is projected to have between 0 and 7.2 days of cold (<-10°C), whereas in 2080, the entire region would have the same number of days (Figure 3). Historically, some of the Chaleur region has had a few days (0.9 to 1.8) where the maximum temperature has fallen to under -20°C. Judging from projections, the number of such days would fall to almost zero (0 to 0.9) starting in 2020.

The number of freeze-thaw days, defined as the number of winter days (in December, January and February) where the maximum temperature is equal to or greater than 0°C and the minimum temperature is less than 0°C, should be increasingly more numerous. The number of such days is

[1] Intergovernmental Panel on Climate Change

expected to be somewhere between 20 and 35 for the entire Chaleur region in 2020 and between 35 and 49 in 2050 for almost the entire region (Figure 4). Freeze-thaw days bring on periods of winter thaw and conditions favourable to the occurrence of freezing rain and ice accumulation.

During the summer, the Chaleur region will have more days with temperatures greater than 30°C, i.e., from 0 to 29.5 days (now) to between 29.5 and 58.9 days on part of the territory in 2050 and possibly the entire territory by 2080 (Figure 5). However, any days in excess of 35°C should be a rare occurrence, and only starting in 2080.

Projections also suggest that the growing season (agricultural indicator) will be longer, i.e., more days where the average temperature is greater than 5°C. Since 1981, most of the Chaleur region has had a growing season lasting between 148 and 186 on average, a range expected to increase to 186 and 223 days in 2020, stay at this level in 2050 and then rise to 223 to 261 days in 2080. A tiny part of the region could even have between 261 and 298 growing days in 2080 (Figure 6).

Total annual precipitation in the Chaleur region could increase starting in 2020, rising from 926 to 1112 mm annually on average to 1112 to 1298 mm (Figure 7).

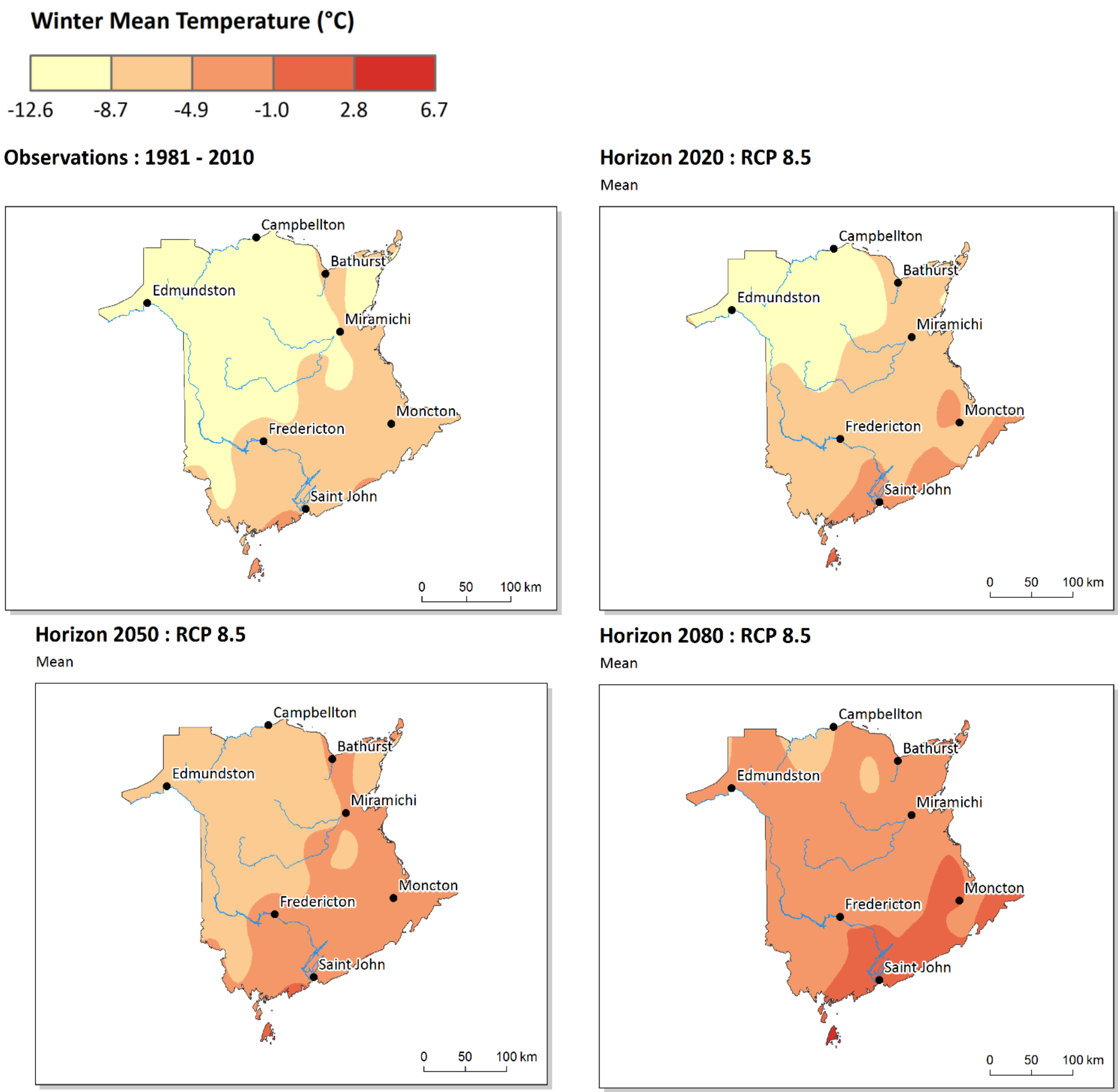

Figure 2: Projected changes in winter mean temperatures (December, January and February) across New Brunswick for 2020, 2050 and 2080 based on the RCP 8.5 scenario, as compared with 1981-2010 (excerpted from figures from Roy and Huard 2016).

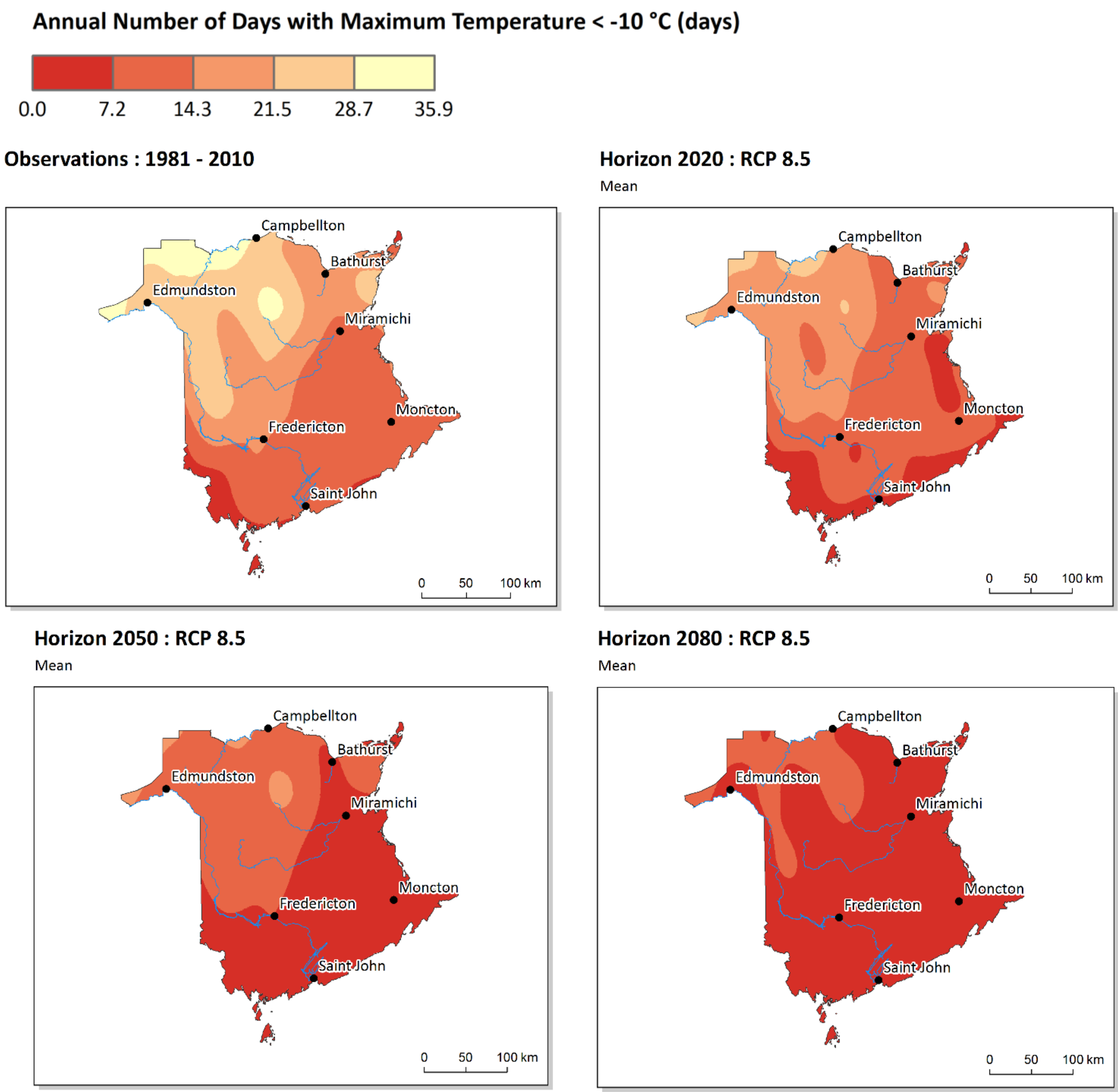

Figure 3: Projected changes in the annual number of days with maximum temperature <-10°C across New Brunswick for 2020, 2050 and 2080 based on the RCP 8.5 scenario, as compared with 1981-2010 (excerpted from figures from Roy and Huard 2016).

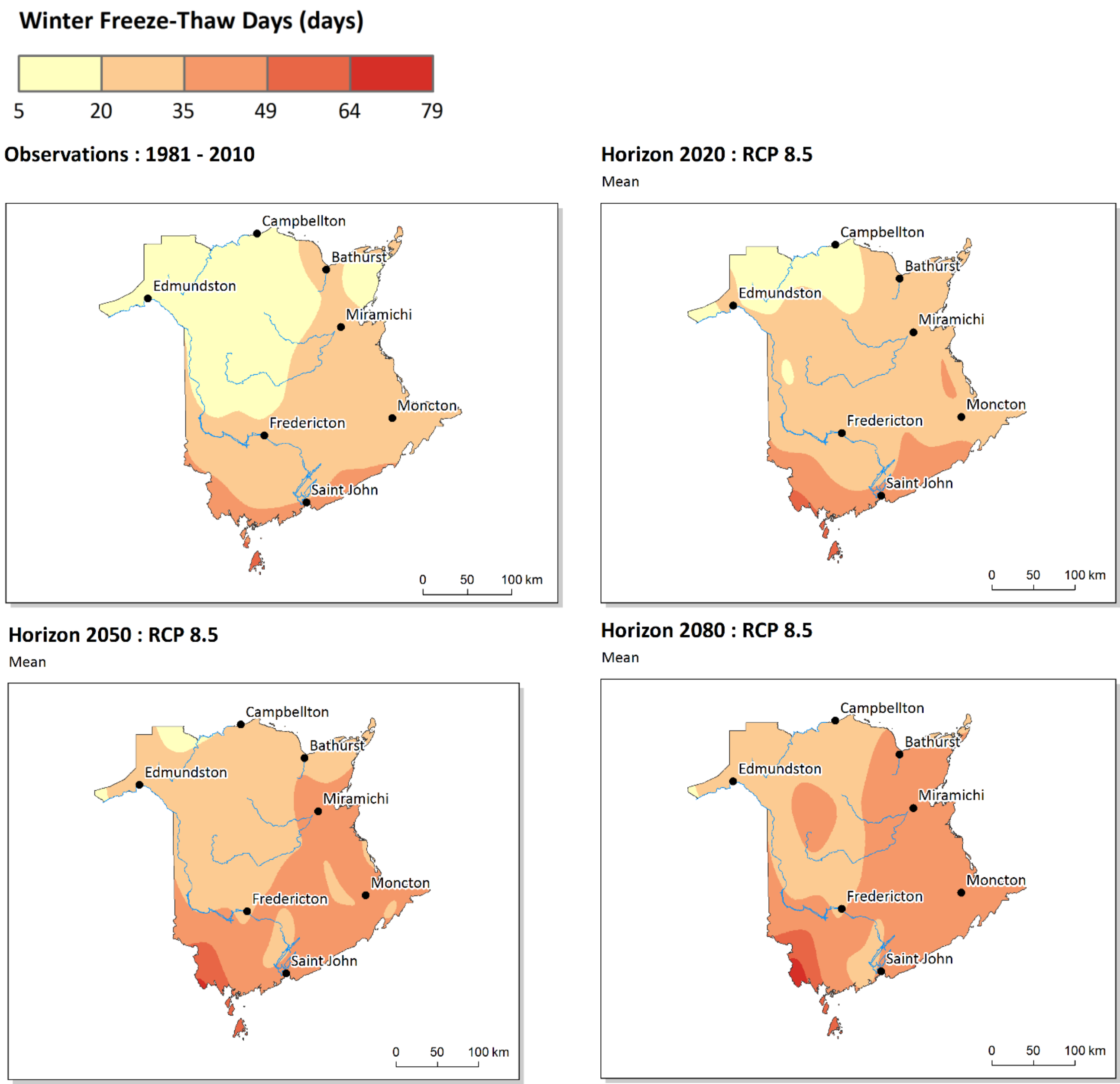

Figure 4: Projected changes in the number of winter freeze-thaw days (December, January and February) (days where the maximum temperature is ≥0 °C and the minimum temperature is <0°C) across New Brunswick for 2020, 2050 and 2080 based on the RCP 8.5 scenario, as compared with 1981-2010 (excerpted from figures from Roy and Huard 2016).

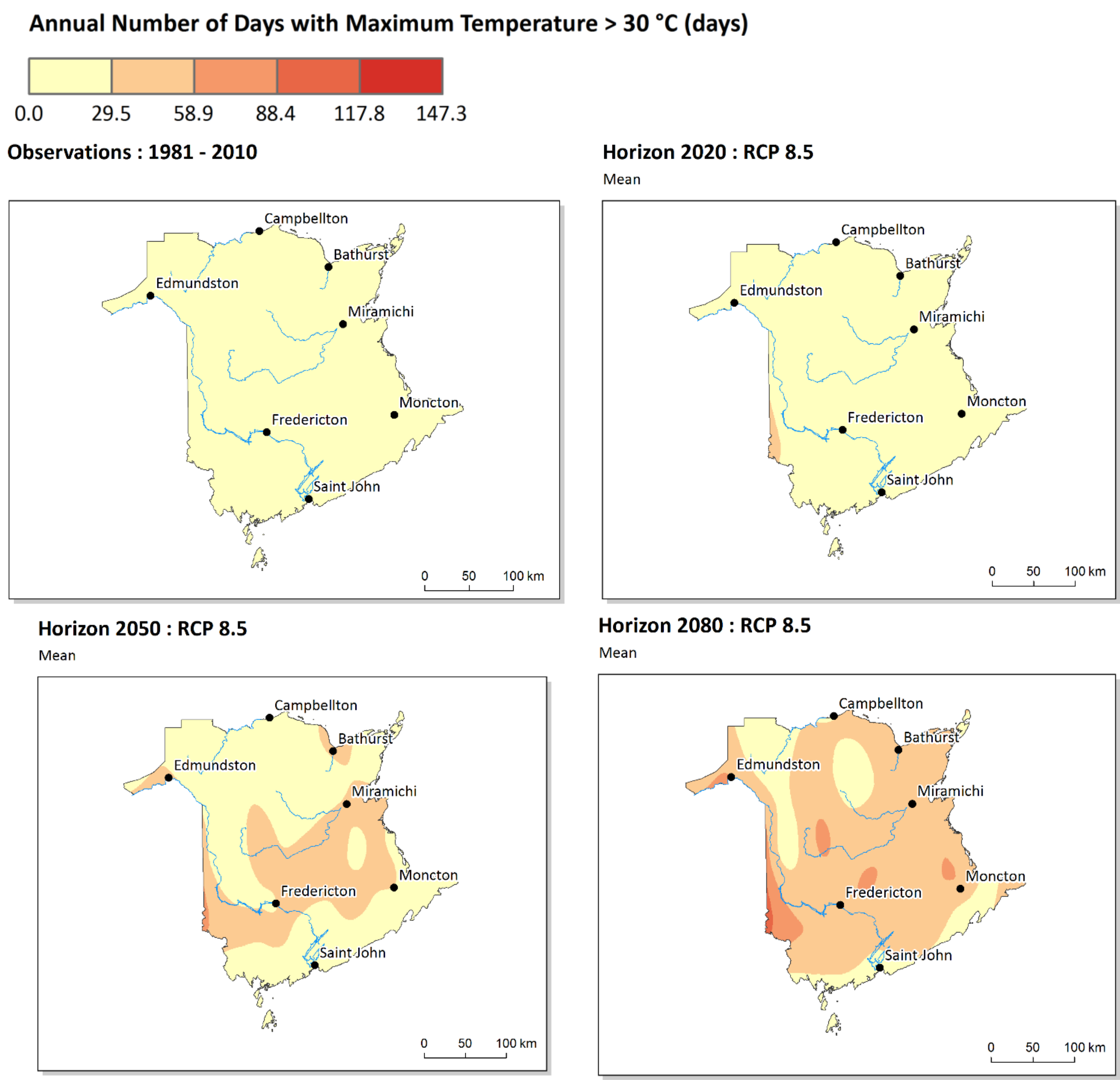

Figure 5: Projected changes in the annual number of days with maximum temperature >30°C across New Brunswick for 2020, 2050 and 2080 based on the RCP 8.5 scenario, as compared with 1981-2010 (excerpted from figures from Roy and Huard 2016).

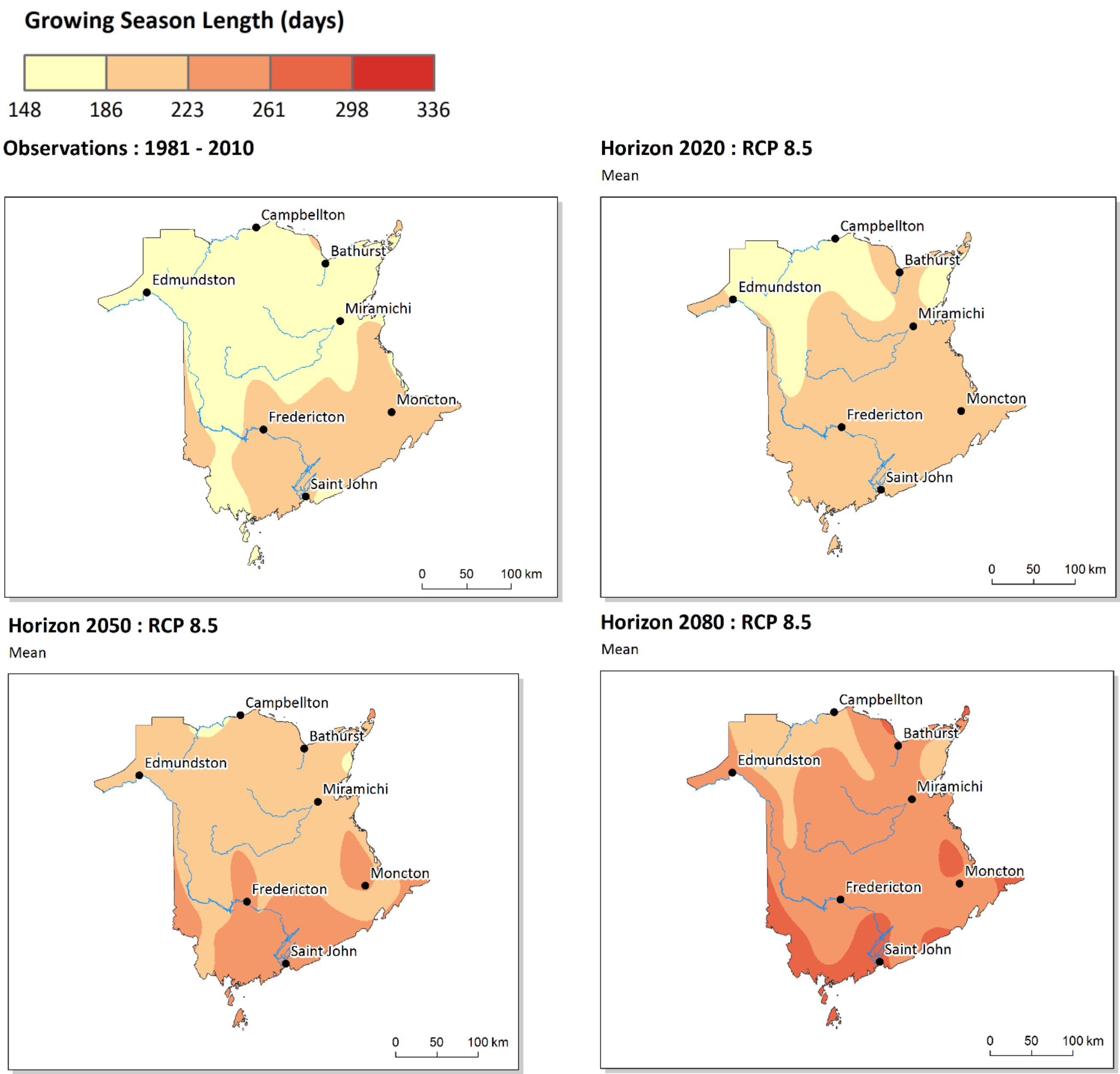

Figure 6: Projected changes in the growing season length in days across New Brunswick for 2020, 2050 and 2080 based on the RCP 8.5 scenario, as compared with 1981-2010 (excerpted from figures from Roy and Huard 2016).

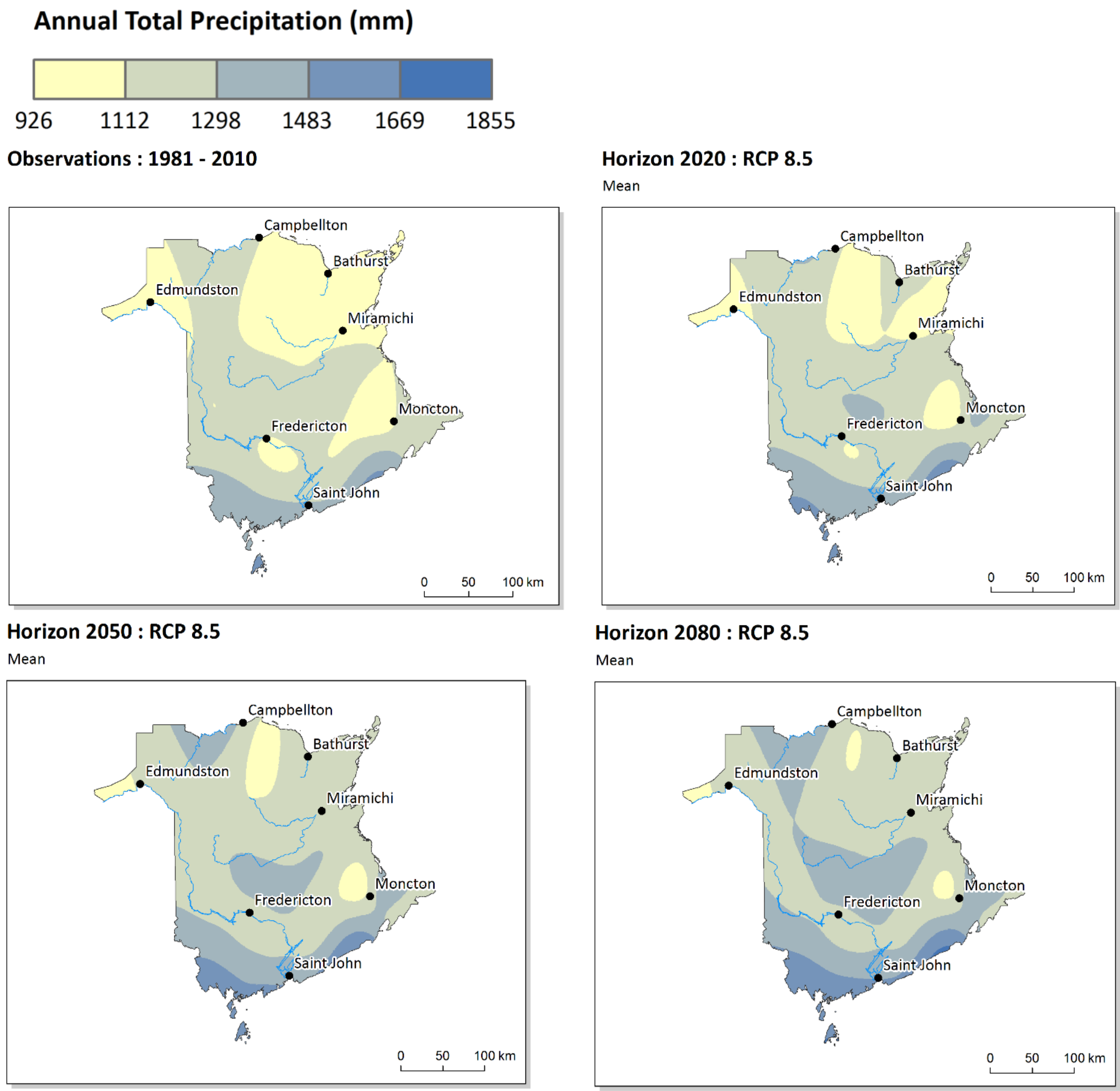

Figure 7: Projected changes in annual total precipitation in millimetres across New Brunswick for 2020, 2050 and 2080 based on the RCP 8.5 scenario, as compared with 1981-2010 (excerpted from figures from Roy and Huard 2016).

3.1.1.2 Rising sea level

According to the most recent projections, mean sea level could increase by 1 metre by 2100. Given the movement of the Earth's crust, the distribution of glacial melt water and a potential reduction in the Gulf Stream, the projected relative increase in sea level for the Chaleur region, according to the RCP 8.5

scenario is 0.66 ± 0.38 m (Daigle 2017). The increased sea level will mean that water levels reached during storm surges will be higher, thereby increasing the expanse of the zones at risk of coastal flooding.

3.1.1.3 Reduction of the sea ice cover

Sea ice cover projections specific to the Chaleur region are not yet available. However, according to the data from the Canadian Ice Service (Figure 8; Senneville *et al.*, 2014), the annual average sea ice cover on the east coast region has been decreasing by 0.27% a year on average. That reduction increases to 1.53% per year for the 1998 to 2013 period. Moreover, the ice coverage period has been declining since 1960. On average, there had been 80 days/year of sea ice coverage of 30% or more coverage from 1960 to 1995 (Savard *et al.,* 2008), but these numbers dropped to 55 days/year from 1995 to 2007. Models indicated that this trend in reduced ice coverage and duration will continue until sea ice disappears completely by the end of the century (Senneville *et al.,* 2014). It is therefore expected that the ice cover in Baie des Chaleurs will grow increasingly smaller.

A concentration higher than 30% of sea ice cover inhibits wave formation (Savard *et al.* 2008). The reduction in ice cover will therefore change the wave regime and amplify the energy of storm waves. For example, Neumeier *et al.,* (2013) modelled the wave regime in the estuary of the Gulf of St. Lawrence subjected to the effect of climate change. They estimate that average waves will rise in height from 5 cm to 1 m by 2100 and that wave energy will also increase slightly.

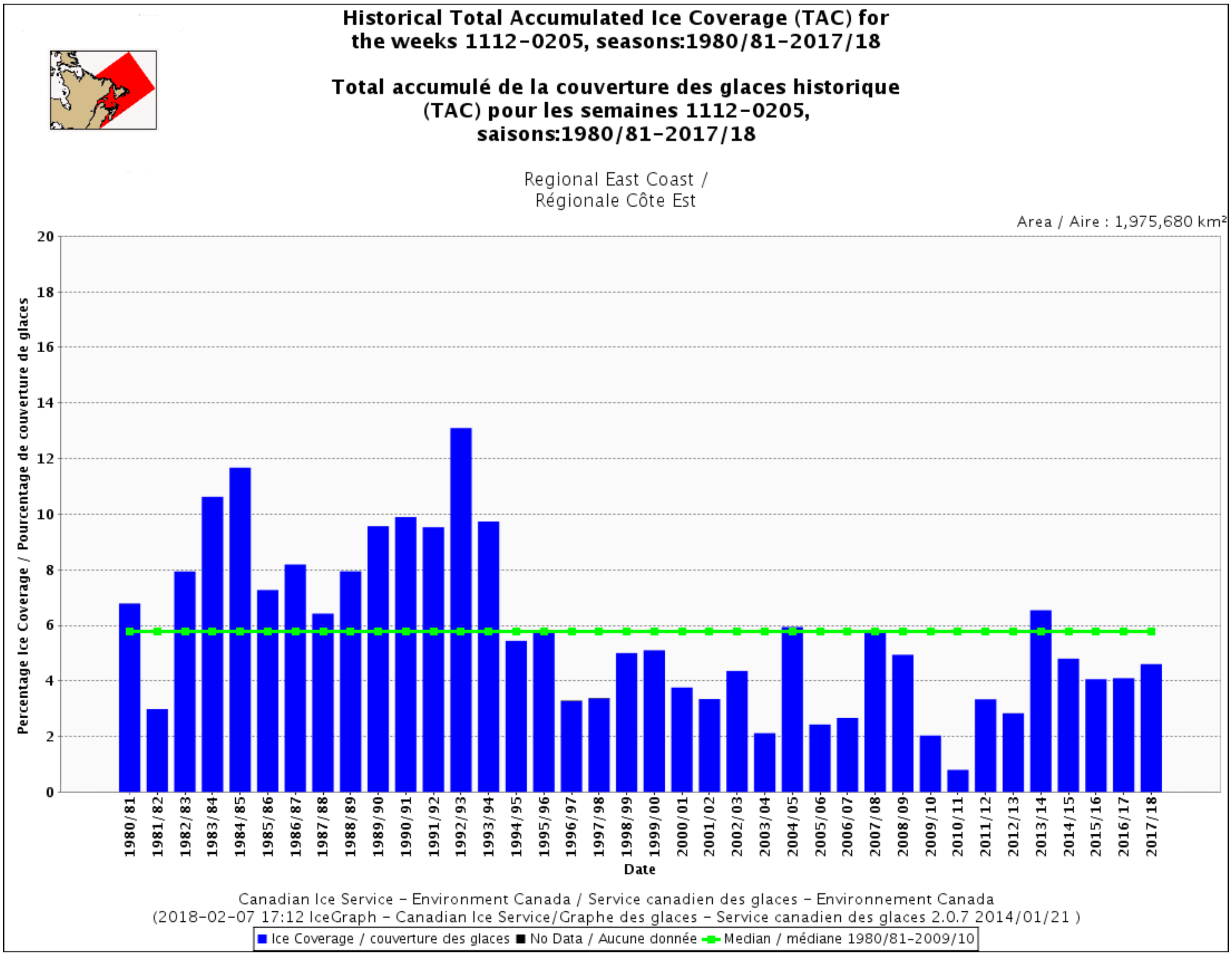

Figure 8: Historical total accumulated ice coverage for the weeks from December 11 to January 29 from 1980 to 2018 in the Canada East Coast region (Environment Canada Figure, 2018).

3.1.1.4 Coastal erosion

There is limited data available to assess coastal erosion. According to existing information, however – a study of the northern and eastern coastal zone of New Brunswick dating back to 1975 (Hunter 1975) and the average erosion rates provided by the provincial government (Figure 9) – the coasts of the Chaleur region are less subject to erosion than the east coast of New Brunswick.

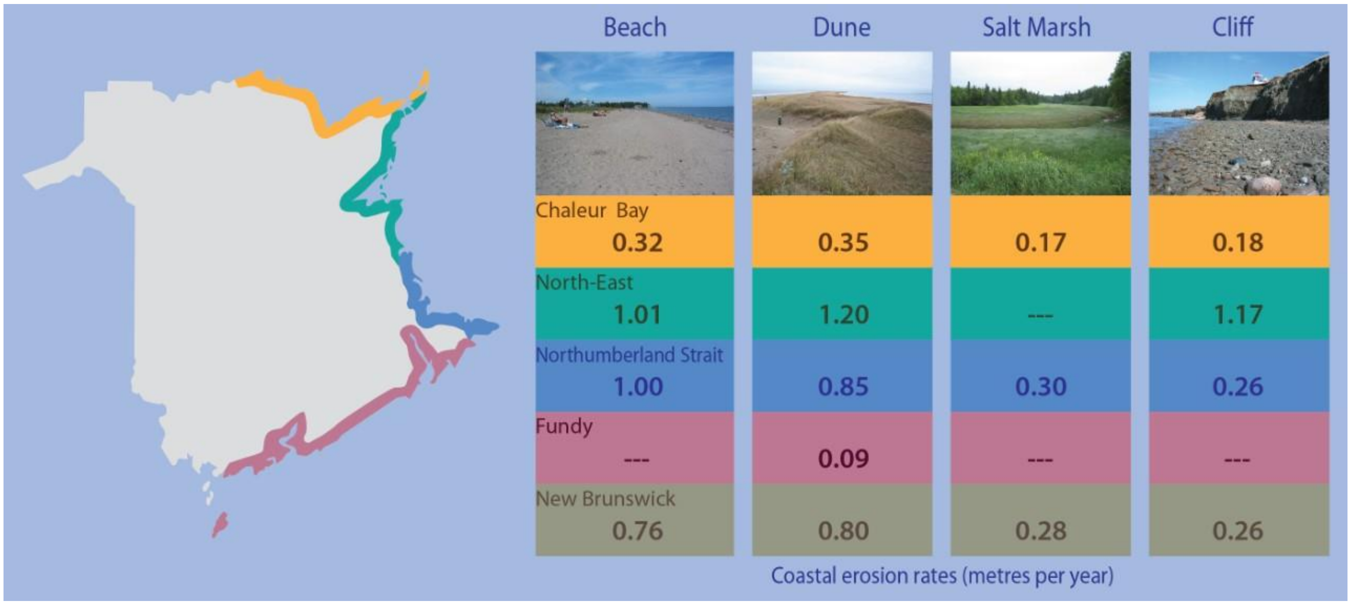

Figure 9: Average coastal erosion rates in metres per year for New Brunswick coasts (GNB Figure, 2018).

According to Hunter (1975), the coasts from Stonehaven to Salmon Beach, east of Bathurst, consist of cliffs 23 to 30 m high with no beaches, followed by steep banks and beaches of sand, gravel and cobbles. Historically, the erosion rates in that region have ranged from 0.3 to 0.6 m per year. In the Stonehaven sector, cliffs have been subject to uniform and moderate erosion, unlike the Salmon Beach area where erosion has been rapid. The Salmon Beach area seems to have had the most coastal erosion in the Chaleur region (Figure 10).

From Bathurst to Beresford, the littoral mainly consists of sandy and gravel beaches and spits. Historically, erosion has been moderately rapid. Starting around Petit-Rocher, the littoral once again consists of steep banks and low cliffs with gravelly and rocky beaches up to the Belledune area. Historically, erosion has been moderate in the Petit-Rocher area, low in the Pointe-Verte area (less than 0.3 m per year) and around 0.3 m per year in the Belledune area (Hunter 1975) (Figure 10).

According to Hunter's descriptions (1975), the Salmon Beach area has sustained the highest erosion rates. Though occupied, this area is less densely populated and developed than the coast immediately west of Bathurst, which means fewer challenges. The erosion rates in coastal areas west of Bathurst are perhaps lower, but there are more properties and infrastructures that are potentially at risk. They could therefore be the first ones to be the subject of a more detailed analysis of historical erosion rates to come up with projections of the future coastline and the risks posed to infrastructures similar to those done for the Bathurst territory (Chelbi *et al*. 2015; Simard *et al*. 2015).

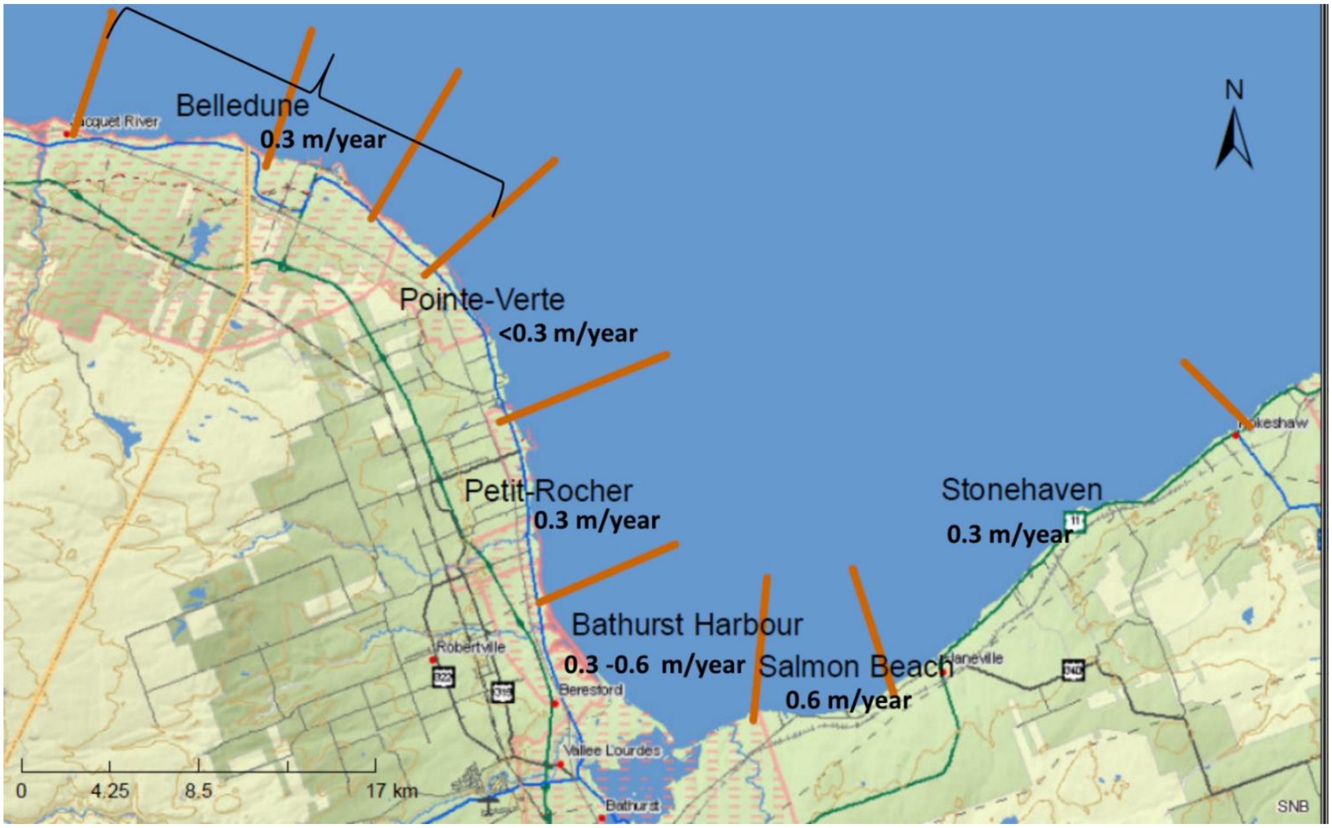

Figure 10: Average coastal erosion rates in metres per year for Chaleur region coasts (Hunter 1975).

Participants in the tabletop exercises made comments indicating that the communities are already grappling with erosion problems. In general, erosion is reportedly affecting roads near the coast in the Chaleur region. Examples include Gagnon and Fenderson Streets in Belledune; streets between Arseneau and Maurice Streets in Petit-Rocher; Chaleur Street in Nigadoo and Martin Street and several coastal alleys in Beresford. Some cemeteries near the coasts, in particular, two in Belledune and one in Pointe-Verte, are losing ground and graves. The Beresford beach must be built up with sand (using land deposits) every year to ensure its conservation. Other locations with erosion are Roherty Point in Belledune, the Nigadoo coast in general, the land of the N.B. Mining and Mineral Interpretation Centre and the coast from the Beach Park to the wharf in Petit-Rocher, as well as the west side of Miller Brook wharf in Salmon Beach. More frequent freeze-thaw episodes are accelerating cliff erosion from Salmon Beach to Grande-Anse by inducing fractures in the rocks.

3.1.1.5 Flooding

Historical events

According to the provincial flood history database (GNB 2012), the Chaleur RSC has been the scene of river and coastal flooding in the past. Historical events serve as a point of reference and are an indication of where actual areas at risk are located. Damages described in the database refer to, among others, commercial and residential buildings, roads and bridges. The Nepisiguit and Middle Rivers are the rivers most likely to cause flooding, having five and four reported events respectively between 1923 and 1997 (Table 1). However, the Town of Beresford was flooded by the Millstream River in 1979 (Table 1). For the most part, these flooding events were caused by heavy rain and mild temperatures, which melted the snow and ice and caused ice jams. Note that the database has no events after 2014. However, Radio-Canada reported that Mathilda Street was closed following an ice jam on the Middle River in 2017 (Radio-Canada 2017). The Acadie Nouvelle reported that the road had been impassible for two days and compared the situation to an even worse event that took place in 2015. According to Acadie Nouvelle reports, the Middle River has breached its banks about six times in 30 years (Acadie Nouvelle 2017).

The only location appearing in the database and affected by storm surges is the boardwalk and Younghall beach in Bathurst. They were flooded several times by water from Baie des Chaleurs, affecting the road and cottages in the vicinity (Table 1). A portion of the Beresford territory may also have been affected by these same tides.

Table 1: Floods in the Chaleur region as listed in the provincial flood history database (GNB 2012).

DATE	WATERCOURSE	PLACE AFFECTED	DESCRIPTION	CAUSE
1923 (29 April - 9 May)	Nepisiguit River (Narrows Creek)	Nepisiguit Falls	Several buildings at the mine sustained damage.	Ice jam
1934 (16 - 24 April)	Nepisiguit River	Rough Waters	Damage was done to a power transmission tower. The power outage combined with the high water level resulted in the closure of the pulp and paper plant.	Ice jam
1940 (17 - 20 September)	Baie des Chaleurs	Youghall Beach	Several cottages were swept away by the tide.	Storm surge
1950 (1 - 31 January)	Nepisiguit River	Nepisiguit Falls	The road near the falls was flooded, blocking traffic.	Ice jam
1976 (2 - 3 February)		Bathurst	The basements in several houses were flooded.	Groundhog Day storm, strong winds and heavy rain
1979 (26 March - 5 April)	Millstream River	Beresford	Nine properties were flooded.	Ice jam
1986 (29 April)		Bathurst	The bridge between Bathurst and East Bathurst was damaged by the ice. Traffic was rerouted for at least a month.	Spring freshet and moving ice floes
1987 (2 April)	Middle River	Middle River Road	3 houses and 4 campgrounds were flooded and the families evacuated for 6 days	Ice jam
1988 (21 November)	Baie des Chaleurs	Bathurst	The bridge was closed for several hours. Huge waves struck some cottage along the Youghall Beach.	Storm surges and strong winds
1989 (2 - 3 April)		Youghall Drive	A section of Youghall Drive was flooded.	Spring freshet
1991 (4 - 5 May)	Nepisiguit River	Pabineau Reserve	The approach to a bridge across the Pabineau River was flooded by 0.3 m of water. There was flooding in the reserve, and the flooding came close to the well that supplies the reserve. The terrains of the Nepisiguit River Camps sustained damage.	Flooding, ice jam, heavy rain
1991 (4 - 5 May)	Middle River	Middle River Road	Flooding on the road.	Flooding, heavy rain
1996 (25 - 30 January)	Middle River		Not available	2 ice jams
1996 (23 - 24 April)	Middle River	Roberts Road	About 5 basements in houses along Roberts Road and the road were flooded.	Ice jam
1997 (17 - 24 May)	Nepisiguit River		Exceptionally high water levels. Only one minor flood was reported.	Flooding, heavy rain
2000 (20 January)		Bathurst	No details for the region. Flooding of coastal areas and low-lying land.	High tides due to a storm surge

On the topic of inland flooding, the tabletop exercise participants confirmed that the Nepisiguit and Middle Rivers are the most likely to cause flooding. Residents on Mathilda Street have to be evacuated practically every year because the Middle River overflows at that point. Participants provided numerous other examples of flooding (Figure 11).

For example, it was related that the Millstream River has flooded about fifteen houses in Dunlop in the past and that the event appearing in the provincial historical database concerning the flood caused by the Millstream River in Beresford really took place in Dunlop. The Middle River doesn't only flood Mathilda Street – it has also flowed on to Theriault Road. Moreover, two of its tributaries – the Cherry Brook and the Six Miles Brook – are also prone to flooding when ice jams occur in the spring. Residents could be isolated if bridges crossing them on the Middle River Road were to become impassable. As for the Nepisiguit River, outside Bathurst city limits, it is the area of the Pabineau Reserve that seems to be of greatest concern, because the bridge crossing the Pabineau River where it joins up with the Nepisiguit River is flooded almost every spring. Aside from these three rivers, flooding reportedly occurred in Belledune where the Big Hole Brook has twice flooded and destroyed a section of the road and a bridge in the past two years. In addition, water has washed away a bridge on the Little Bass River in Allardville and another bridge is often close to being submerged on the Bass River.

Some culverts, ditches and stormwater drainage systems get plugged by snow, ice or debris, or cannot handle new water flows. Changes had to be made in several locations (Belledune, Pointe-Verte, Tremblay and Beresford) to improve these structures. Furthermore, municipalities and the Department of Transportation and Infrastructure must be proactive by cleaning out ditches and unclogging drains in several locations (Alcida, Chamberlain Settlement, Dunlop and Petit-Rocher) that are known to be problematic.

According to participants, inland flooding problems have been made worse by human activity such as clear cutting and quarry operations. For example, a quarry located close to the Comeau Brook in Tremblay is believed to be the cause of a change in the course of the brook, which has resulted in spring flooding on Tremblay Road and a dozen houses along that road.

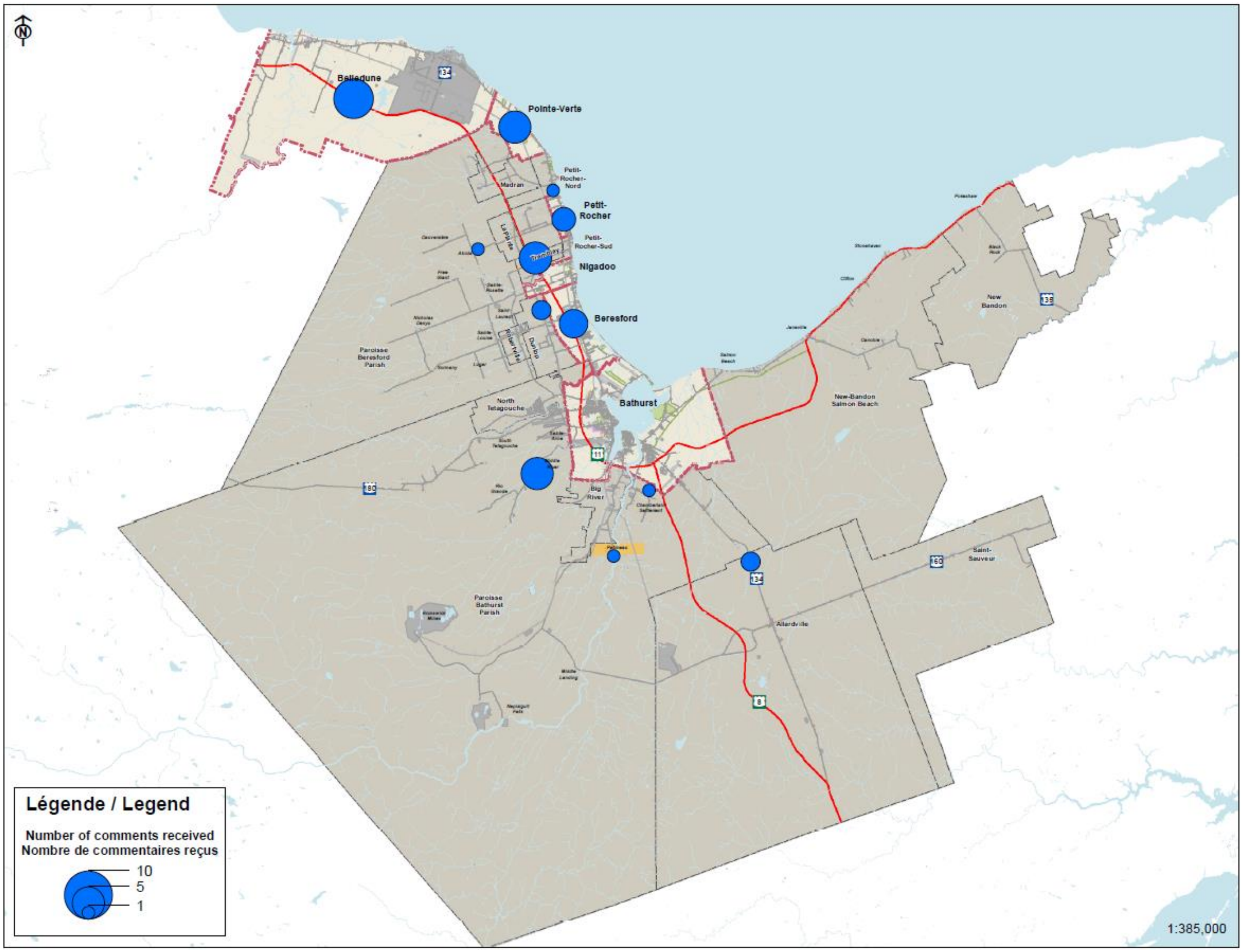

Figure 11: Number of comments (by approximate location) regarding inland flooding received during the tabletop exercises.

For the time being, these brief descriptions of past events are the only information available to evaluate the risk of flooding due to surface water on the territory. Other avenues to be pursued include modelling work conducted by Paul Arp's team at the University of New Brunswick (UNB) on flood plains and the depth of underground water in comparison with the surface, which is commonly known as wet areas mapping.

According to tabletop exercise participants, several communities in the Chaleur Region are already being affected by coastal flooding. For example, the Ocean Drive in Belledune is flooded regularly. The B.N.P.P. regional police, serving the municipalities of Beresford, Nigadoo, Petit-Rocher and Pointe-Verte, has had to intervene at least twice during coastal flooding in Pointe-Verte, particularly on des Chalets Street and du Parc Est Street. In Petit-Rocher Nord, the Camp Ectus Road is flooded occasionally, and several homes are threatened by flooding during storms. Streets and houses are also at risk in Petit-Rocher, including Arsenault and Maurice Streets. The latter had to be rebuilt following a flood in 2010. In addition, some sections of the sewer system have been affected during storms such as the section from Doucet Street to du Havre Street.

Beresford is the community of greatest concern. It has several principal and secondary residences that have been flooded during storms. The Beresford dune is one of the worst locations. The John Cormier and Jacques Cartier Streets and several residences have been flooded previously. In addition, the extremities of the bridge leading to the dune on Kent Lodge Street have been flooded, making the street impassible. The Beach Park, as well as des Chalets and Baie Streets have also experienced flooding. Houses at the intersection of Thomas and Bel Air Streets are also at risk. There has been at least one event where sea water infiltrated into the stormwater drainage system, causing back-ups in the basements of houses on Christie Street. To avoid having sea water come in during flooding, covered manholes were installed on des Chalets Street. Marie Street was raised. All of the pump stations along the coast are up in years (1975). They are too low and operate at full capacity, except for the one on des Chalets Street.

On the other side of Bathurst, only one part of Salmon Beach is considered at flood risk. Cottages there are flooded regularly. The main road has been raised to prevent flooding, and a culvert was changed and replaced with an improved version on Eagans Street.

Risk of coastal flooding

Since GIS (Geographic Information System) data[2] showing the expanse of flooded zones based on various water levels does exist for the Chaleur RSC territory, an analysis was performed to evaluate the potential impact of a specific storm surge scenario on the territory. The scenario consists in a storm surge with a 1 in a 100 (1%) chance of occurring annually, which would take place during higher high water large tide following the projected rise in sea level for 2100 (Daigle 2017). This scenario is commonly used both provincially and nationally in risk assessment exercises. For the Chaleur region, this event corresponds to a sea level of 3.7 m compared to the geodesic zero without the effect of waves and wind.

This water level would not cause any flooding along the coast in the Stonehaven area and would flood only some small spots in the Salmon Beach area. Coastal communities west of Bathurst would be most

[2] Flooding polygons traced from a numerical altimetric model based on LiDAR data dating from 2014 and layers representing various infrastructures that include buildings, roads, pump stations, electrical stations, etc.

affected. Beresford would be the municipality with the largest flood area under this scenario. Close to 19% of the buildings in the municipality (557) are in the flooded area, along with 10 km of roads (Figures 12 and 13). Some of the properties and buildings affected include the Beresford Beach, 3 community centres, the school, 9 businesses, 2 specialized care centres, a park and a Department of Fisheries and Oceans Canada building.

Though only 3.5% of the buildings (a total of 78) in the municipality of Belledune are located in the flooded area (Figure 12), the commercial port and its terminals lie within this zone. Some 12% of buildings (Figure 12) in the municipality of Pointe-Verte (107) are in the flooded area along with 1 km of road (Figure 13).

Slightly more than 16% of buildings (73) in Petit-Rocher Nord are in the flooded area (Figure 12). Around 5% of the buildings in Petit-Rocher (64) and Petit-Rocher Sud (18) are affected (Figure 12). These three communities have slightly more than 3 km of roads in the flooded areas (Figure 13). The buildings and properties affected include Camp Ectus, two campgrounds, a school, a museum, a motel, a restaurant and two waste water treatment infrastructures. Only 2 buildings would be affected in the municipality of Nigadoo, i.e., 0.3% of the total (Figure 12). Meanwhile, the New Bandon-Salmon Beach LSD could be faced with flooding of 0.75 km of road and 1.3% (20 of 1737) of its buildings (Figures 12 and 13).

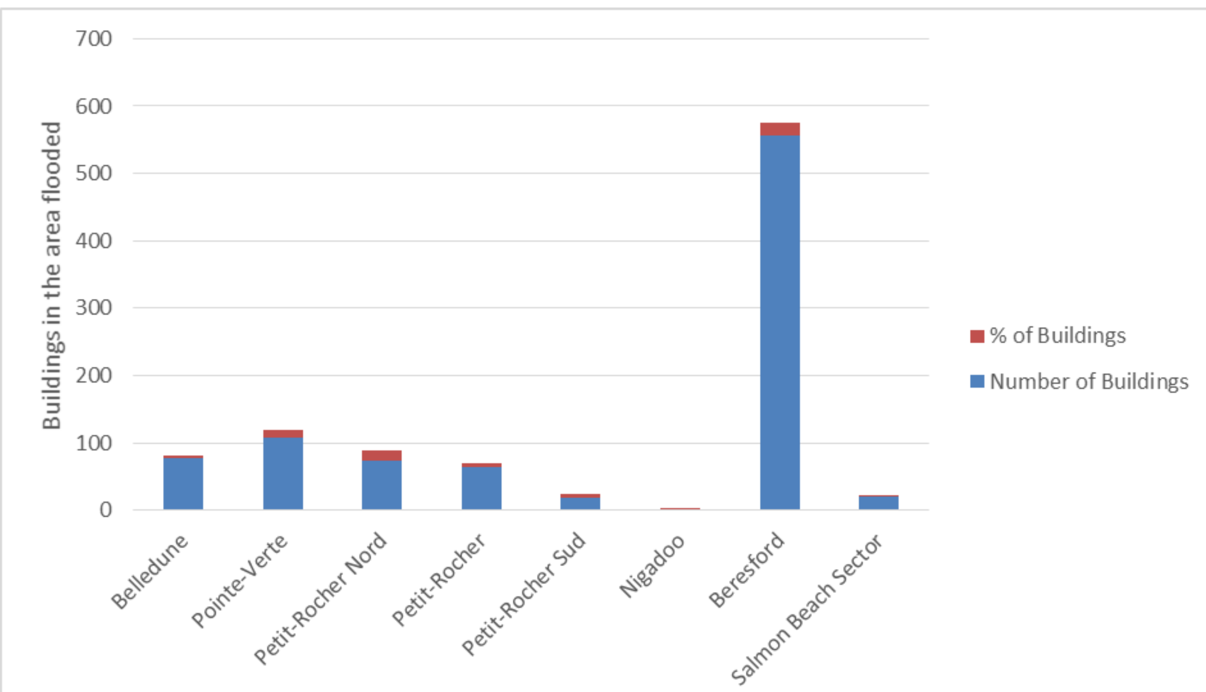

Figure 12: Number of buildings in the area flooded by a water level of 3.7 m.

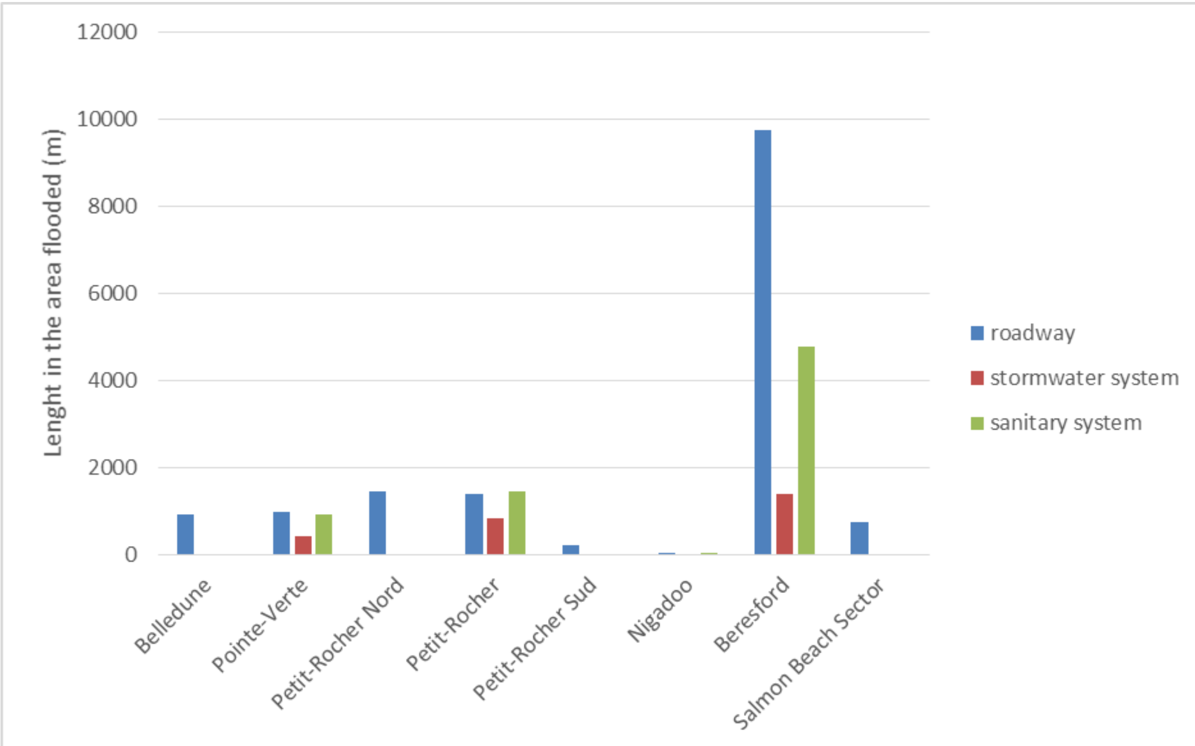

Figure 13: Length of roadway, stormwater system and sanitary system in the area flooded by a water level of 3.7 m. Only Pointe-Verte, Petit-Rocher, Nigadoo and Beresford have a stormwater and sanitary system. Nigadoo stormwater system coverage (GIS layer) is not available.

Table 2: Number of buildings and length of roadway, stormwater system and sanitary system in the area flooded by a water level of 3.7 m. Only Pointe-Verte, Petit-Rocher, Nigadoo and Beresford have a storm water and sanitary system. Nigadoo stormwater system coverage (GIS layer) is not available.

Communities	**Buildings**			**System affected (m)**		
	total	**total affected**	**% affected**	**Sanitary**	**Stormwater**	**Roadway**
Belledune	2219	78	4			933
Pointe-Verte	880	107	12	917	410	982
Petit-Rocher Nord	447	73	16			1454
Petit-Rocher	1184	64	5	1441	842	1399
Petit-Rocher Sud	335	18	5			220
Nigadoo	713	2	0	26		33
Beresford	2970	557	19	4795	1386	9747
Salmon Beach Sector	1737	20	1			748

3.1.1.6 Water supply: shortage, salt water intrusion and contamination

Most of the Chaleur RSC territory does not have drinking water treatment and supply service. Water comes from private wells, with the exception of Bathurst, Beresford and Petit-Rocher, which have a treatment and supply system. Bathurst's and Beresford's water comes from the Middle River watershed and Carter Creek, while Petit-Rocher's water comes from the Nigadoo River watershed.

In general, climate change could affect drinking water availability and quality, whether from wells or watersheds. Increased temperatures and changes to precipitation regimes will bring about periods of drought that could affect water availability. Rises in sea level and flooding could contaminate surface and underground water through the intrusion of salt water or other contaminants, for example.

For the time being, however, there are few indications that water availability during droughts and contamination caused by the intrusion of salt water or other agents during flooding pose a problem in the Chaleur RSC (Guitard, personal communication). If problems have occurred, they apparently weren't documented. Sources of written information that were consulted on an indicative basis were evaluations conducted for new developments (Frenette, personal communication) and maps[3] illustrating provincial data from a wells database (location, depth and analyses) since 1990 (Figures 14 to 17). Note that the Chaleur RSC does not currently have access to that database.

The maps indicate there are wells in areas at risk of coastal flooding in Beresford, Pointe-Verte and Salmon Beach. Moreover, some wells in Pointe-Verte and Salmon Beach, located very close to the coast in a flood risk zone, already have rather high sodium (Na) concentrations (+500 mg/l), as compared with the aesthetic guideline of less than 200 mg/l (GNB N/A).

Tabletop exercise participants confirmed that the water supply issue has not yet become a concern. Nonetheless, a few problematic cases were raised. Low water levels in the Nigadoo River were observed in the past, but this reportedly did not cause any problems. However, a water boil advisory was issued twice due to high turbidity following heavy rain combined with snow melt. The situation warrants further attention. In Allardville, there have been recent cases of dry wells due to a drought.

[3] Maps were prepared specifically for this exercise by the regional water planning officer of the Department of the Environment and Local Government.

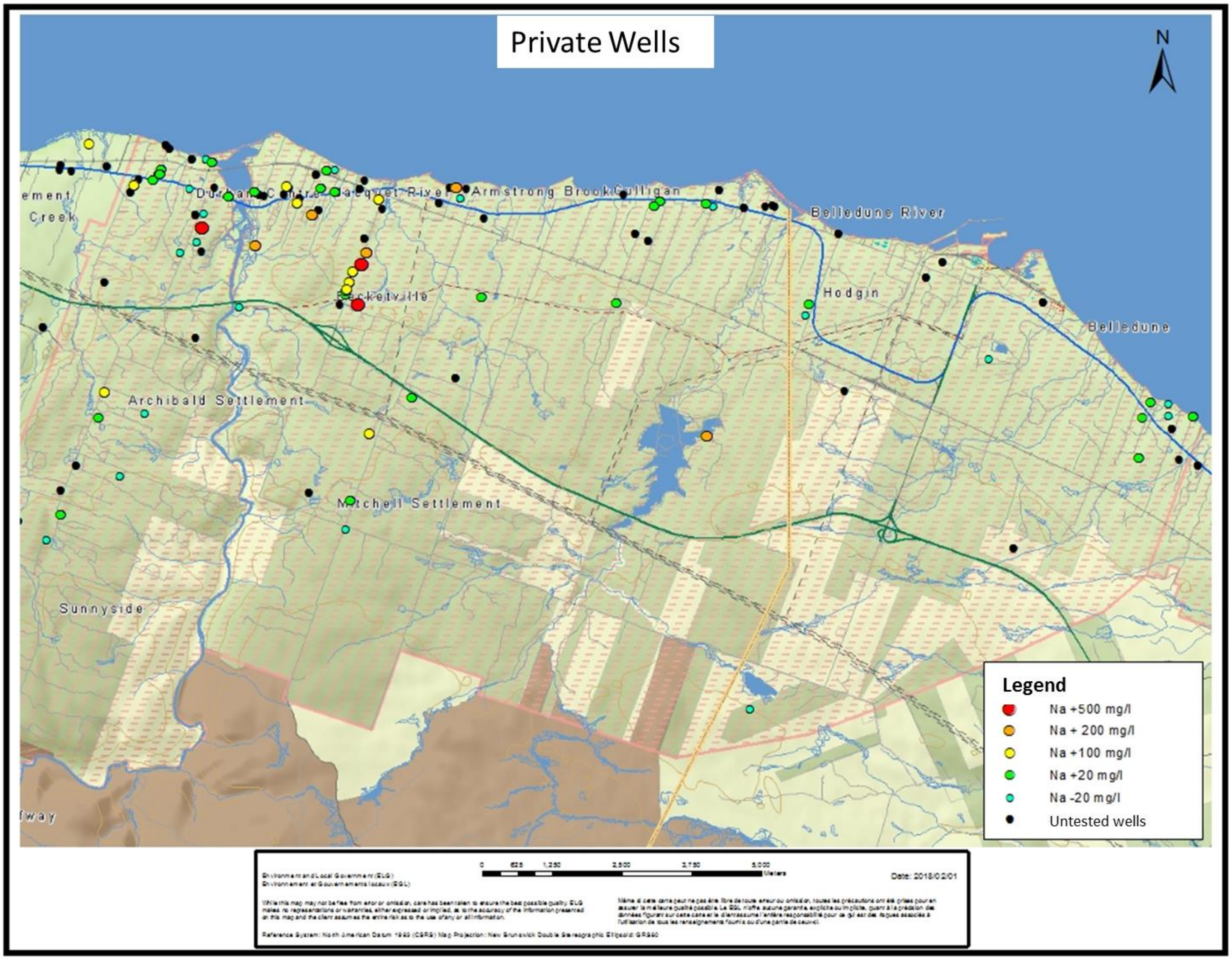

Figure 14: Location of wells dug after 1990 in the Belledune area, and indications of sodium (Na) concentrations (Source: DELG, provincial wells database).

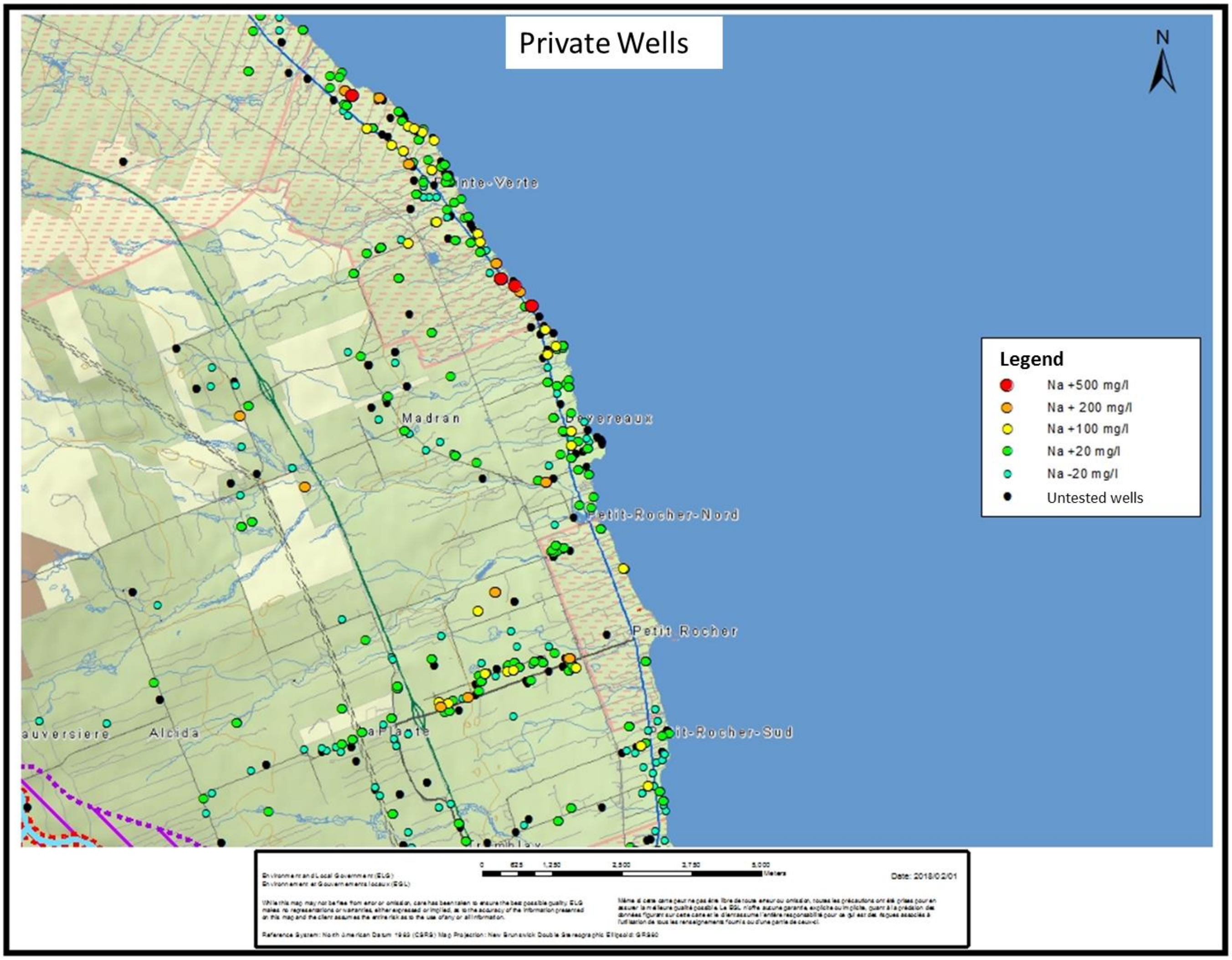

Figure 15: Location of wells dug after 1990 in the Pointe-Verte and Petit-Rocher areas, and indications of sodium (Na) concentrations (Source: DELG, provincial wells database).

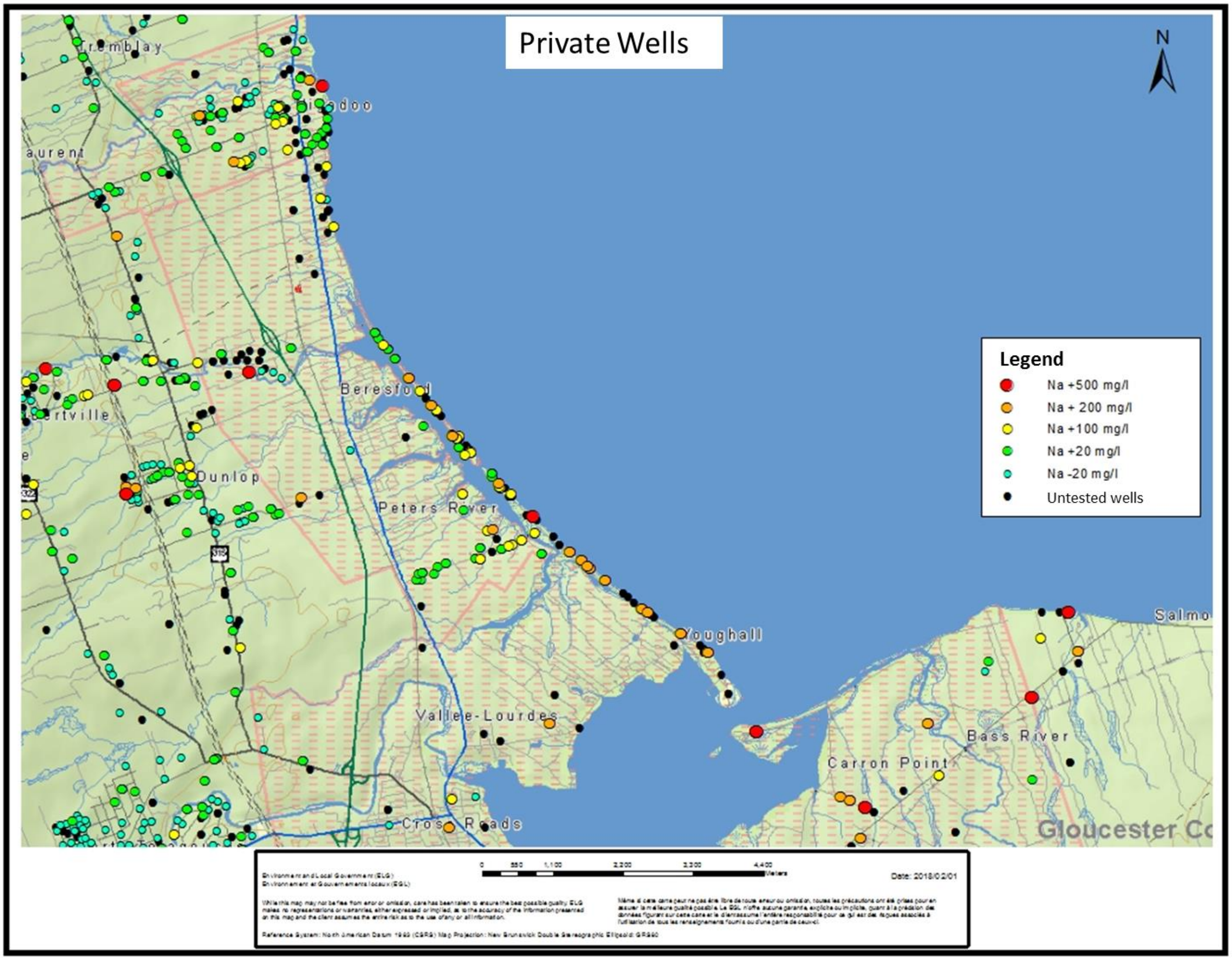

Figure 16: Location of wells dug after 1990 in the Beresford and Bathurst areas, and indications of sodium (Na) concentrations (Source: DELG, provincial wells database).

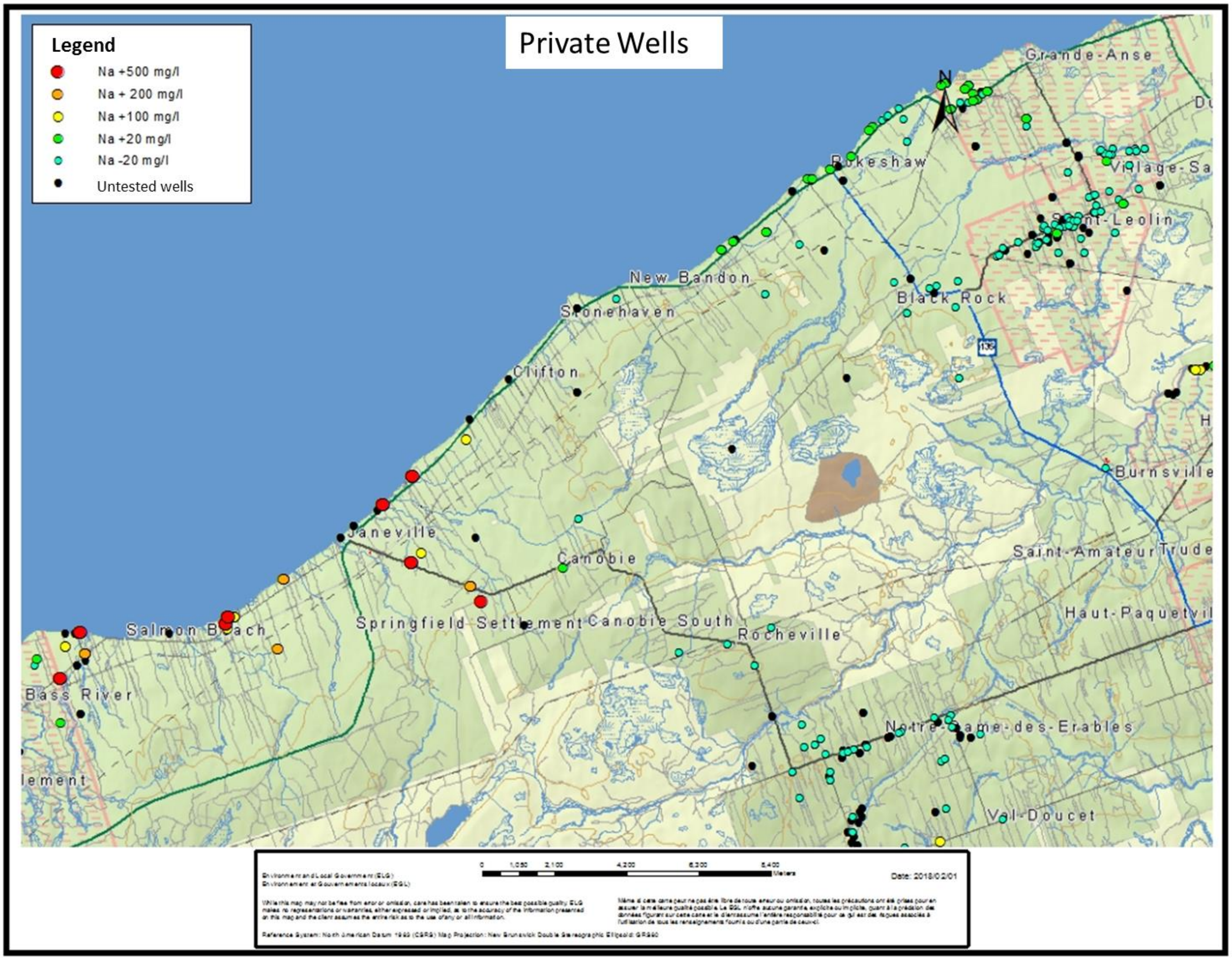

Figure 17: Location of wells dug after 1990 in the Salmon Beach and New Bandon areas, and indications of sodium (Na) concentrations (Source: DELG, provincial wells database).

3.1.1.7 Forest fires

More frequent heat waves and drought could increase the risks of forest fires across the country. Since the territory of the Chaleur RSC consists mainly of wooded areas, consideration must be given to the greater risk posed by forest fires. However, only general indications are available on the changes we can anticipate for the Chaleur region, i.e., national projections from Natural Resources Canada and projections in Eastern Canada (Ontario, Quebec and New Brunswick) from an article by Boulanger *et al.* 2013. According to these sources, it seems that New Brunswick is not one of the locations most at risk of forest fires in the future.

The extent of the annual area burned by large fires could increase in the Chaleur region and could be greater than that burned elsewhere in New Brunswick by 2071 to 2100 according to the RCP 8.5 scenario presented by Natural Resources Canada (Figure 18). However, modelling by Boulanger *et al.* (2013) (Figure 19) indicates that the extent of the annual area burned by large fires in the Chaleur region could remain essentially the same in 2071-2100 as in the past.

Some participants in the tabletop exercise on February 15 seemed preoccupied by forest fires and believed that the risk of fire could increase. The main concern was residences in rural areas close to dense forests. For example, Nepisiguit Falls has about 70 principal residences that could be isolated in the event of a forest fire, and in addition, the closest fire department is about a 45-minute drive away. It was also mentioned that residences surrounded by the land they sit on like in Allardville, St-Sauveur, Tétagouche-Nord, etc., are more at risk, because they are surrounded by trees.

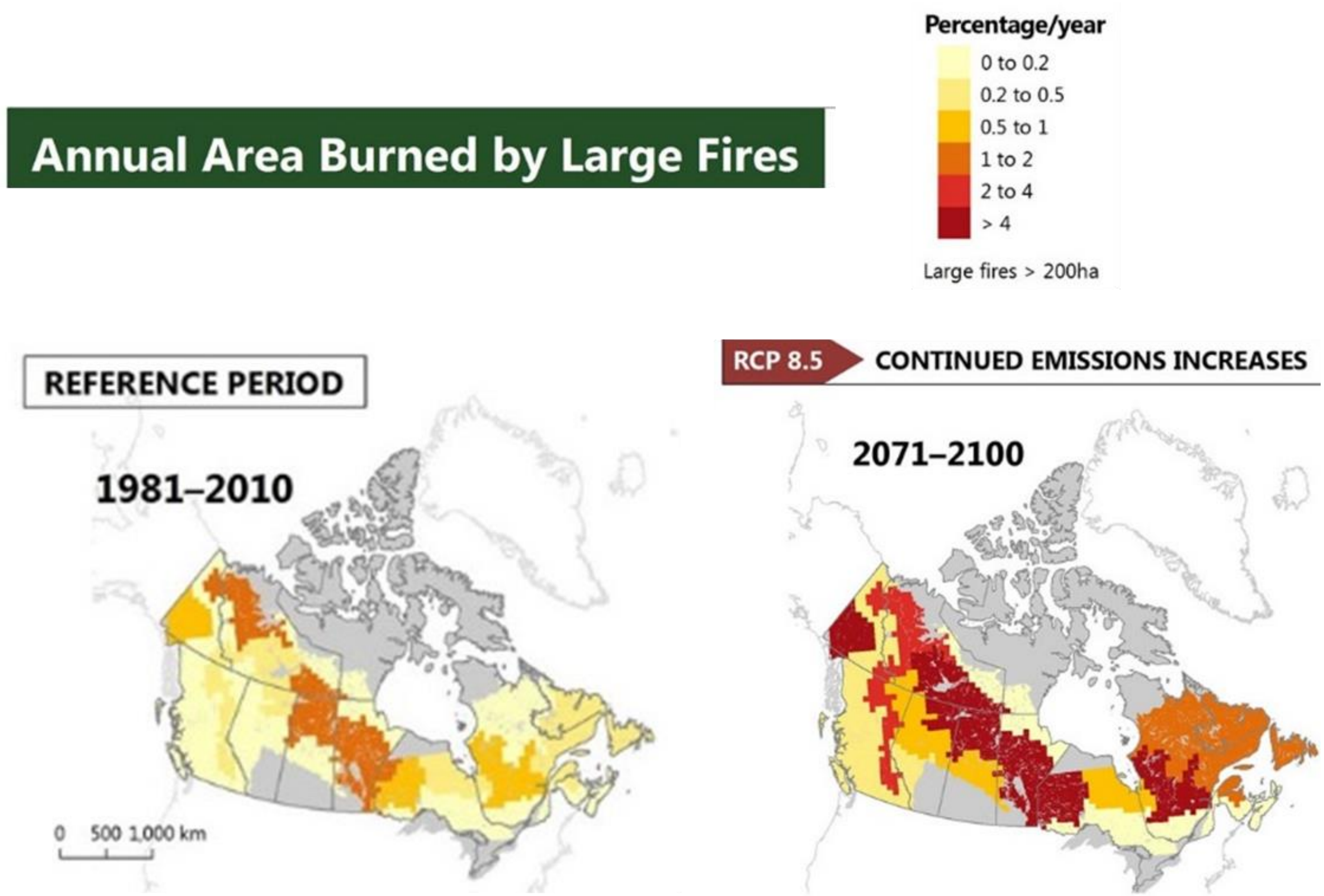

Figure 18: Annual area burned by large fires – a comparison of a reference period from 1981-2000 to a 2071-2100 projection according to the RPC 8.5 scenario (excerpted from a Figure from NRCan-CFS 2016).

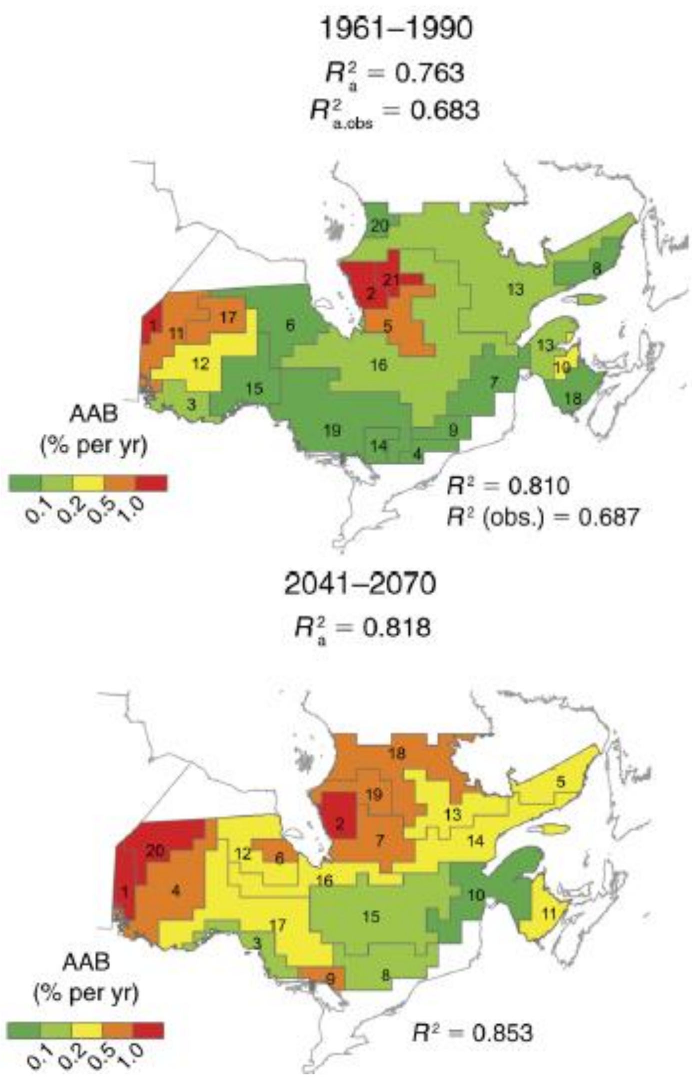

Figure 19: Annual area burned (AAB) in percentage for a reference period from 1961-1990 and future projections for 2011-2040, 2041-2070 and 2071-2100, for homogeneous fire regime zones (the zones are numbered) (excerpted from a Figure from Boulanger *et al.* 2013).

3.1.1.8 Impact of temperatures, precipitations and winds on infrastructures

The Chaleur region has road, rail, maritime and air infrastructures (Table 3). For example, the rail system carries passengers and goods within Canada, the Belledune port provides an international maritime transport service, and the Bathurst Regional Airport has flights to various locations around the world. Climate change could affect transportation by damaging and accelerating the deterioration of infrastructures, disrupting movements and creating unsafe travel conditions (Rapaport *et al.* 2017).

The Chaleur region is home to other major infrastructures. In addition to power, telephone, water and sewer infrastructures and systems, it has mining development sites, a sanitary landfill site and a hydroelectric dam. Freeze-thaw periods, major temperature fluctuations over short time spans, extreme heat or cold spells, strong winds, freezing rain and significant snow buildup can deform and damage these systems and infrastructures. For the time being, there is unfortunately little specific information on how vulnerable Chaleur RSC infrastructures are to these risks. We do know, however, that some persons responsible for managing these infrastructures, at least, are taking measures to adapt them to climate change. For example, NB Power has a strategy to manage the effects of climate change on its activities, which includes the definition of scenarios, an evaluation of vulnerabilities and the identification of adaptation measures (Samms, personal communication). Following the 2017 ice storm, NB Power conducted a study on the recurrence of a similar event and what were the most susceptible locations in New Brunswick. It also studied the breakdowns and failures of the transmission system during this event to identify potential changes to be made with respect to construction standards.

Another example that came up during the tabletop exercise with the representatives of public utilities is that of the Bathurst Regional Airport, which is affected by the increase of freeze-thaw episodes in the winter. These conditions alter the friction capability on the landing strip and require more responses from the maintenance team, which is looking for new de-icing products since salt cannot be used.

Table 3: Extent and types of transport systems and infrastructures in the Chaleur RSC relative to New Brunswick as a whole (data from the Chaleur RSC 2018 and Rapaport *et al.* 2017).

TYPE OF TRANSPORTATION	**CHALEUR RSC**	**NEW BRUNSWICK**
Paved road (km)	933	18 785
International commercial port	1	2
Railway	148	1159
Airport	1	7
Fishing port	4	N/A

3.1.1.9 Human health

Climate change can affect human health in numerous ways. For example, reduced air quality, increased risk of food and water contamination, shortages of drinking water and extreme heat that bring on heat stroke and dehydration are potential consequences of projected climate change. This is over and above the stress and accidents caused by more frequent extreme weather phenomena (Berry *et al.* 2014).

Furthermore, climate changes will cause a northern migration of numerous animal and plant species, some of which carry diseases, parasites or other harmful agents. Lyme disease is one example. Leighton *et al.* (2012) predicted that climate change will cause populations of ticks carrying Lyme disease to migrate north, especially in Eastern Canada. Consequently, the risks of contracting Lyme disease in New Brunswick could rise. The Chaleur region is reportedly transitioning from a very low risk zone to a moderate risk zone (Figure 20). Note that some species and diseases could harm cattle, agricultural or aquacultural production and fishing, thereby directly or indirectly affecting human health and the economy.

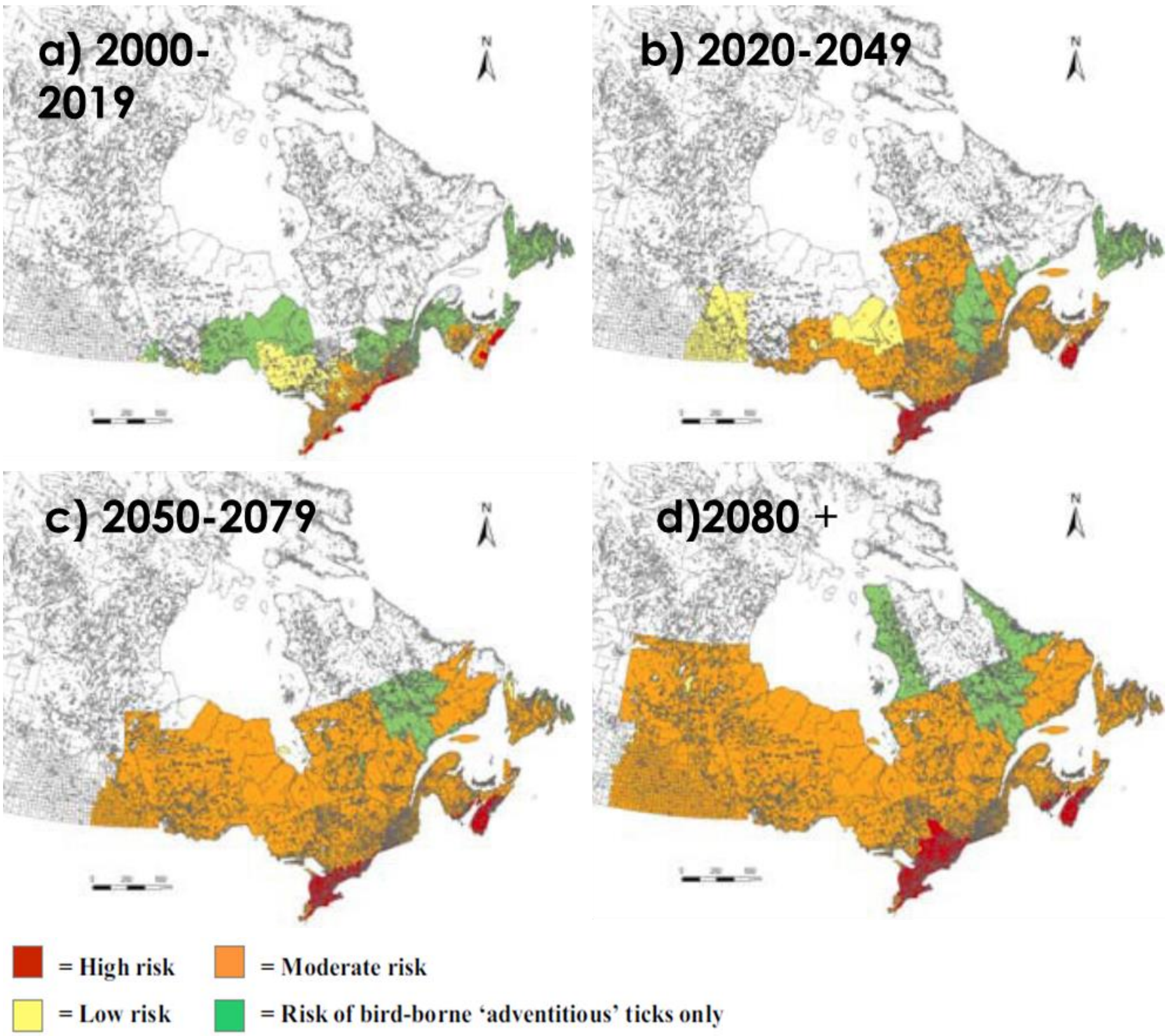

Figure 20: Projected expansion of the *I. scapularis* distribution area in Canada for 2000-2019, 2020-2049, 2050-2079 and 2080 and beyond (excerpted from a Figure from Ogden *et al.* 2008).

3.1.2 Quality and availability of information sources and tools

The quality and scale of information and projections available for risks deemed to be of low and medium priority in terms of the field of intervention (responsibility and ability to act) of municipalities and communities are sufficient (Table 4). For the time being, the regional descriptions of the risks of drinking water shortages and contamination are sufficient, but the situation shall be monitored. Note that follow-up would be more readily achieved if the Chaleur RSC were able to get a copy of the provincial wells database.[4] The information and tools may be insufficient in terms of gauging impacts on systems and infrastructures other than those due to flooding and erosion and are clearly insufficient with respect to coastal erosion and coastal and inland flooding (Table 4).

There is much information and data and many tools already available to help conduct risk and vulnerability assessments and climate change adaptation at the local scale. The Chaleur RSC has GIS data on infrastructures and land uses, (Appendix 3) (Figures 21, 22 and 23) coastal flooding polygons and an altimetric model based on LiDAR data for most of the territory (Figure 24). In addition, there are historical and recent aerial photos for most of the territory (Figure 25). However, the Chaleur RSC could obtain data on historical erosion rates and projections of the potential location of the coast line for various time horizons at a scale that would make it possible to gauge with more precision the risk posed to infrastructures. In the same vein, a risk assessment to infrastructures could be obtained, at the local scale, for various coastal flooding scenarios. In both cases, this would involve having consultants conduct research, as was done in the Acadian Peninsula and in Bathurst.

In order to evaluate the risks due to inland flooding, it would have to be determined whether new models representing the depth of underground water with respect to the surface (wet areas mapping) are available for the region and whether they are realistic enough. The model the Chaleur RSC has dates back to 2010 and is inadequate. Paul Arp of UNB (Arp, personal communication), who does this kind of modelling in New Brunswick, indicated that complete coverage of the province based on the most recent LiDAR surveys could be available within a few years. In the meantime, Paul Arp may possibly be able to provide other tools such as a layer illustrating the flood plains[5], which could be used as an indication.

[4] A request to this effect was submitted to the DELG in January 2018.
[5] Awaiting a response to this effect from Paul Arp.

Table 4: Evaluation of information and data needs to facilitate local planning with respect to hazards (refer to specific hazard sections for more details).

Hazard-consequence	Prioritization	Information-data quality	Needs	To be obtained
Temperatures	Low	Provincial scale projections	Sufficient	
Freeze-thaw	Medium	Provincial scale projections	Sufficient	
Precipitations	Medium	Provincial scale projections	Sufficient	
Forest fires	Low	National scale projections	Sufficient	
Transport and infrastructures	Medium	General descriptions	?	?
Human health	Low	General descriptions	Sufficient	
Sea level rise	High	Regional projections	Sufficient	
Sea ice cover	Medium	St. Lawrence Gulf scale projections	Sufficient	
Coastal erosion	High	Regional descriptions	Insufficient	Local scale projections and risk analysis
Inland flooding	High	Provincial scale descriptions	Insufficient	Flood plain model and depth to water table
Coastal flooding	High	Local scale infrastructure data and projections	Insufficient	Local scale risk analysis
Drinking water	Low	Regional descriptions	Sufficient	

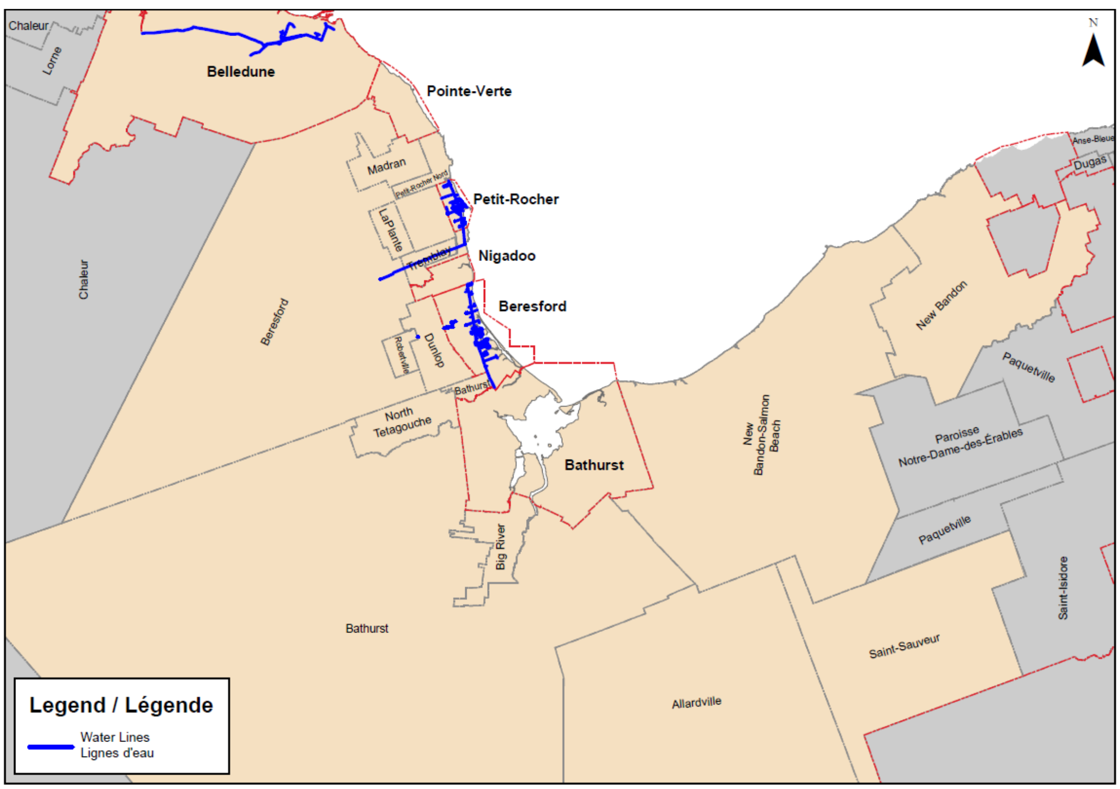

Figure 21: GIS coverage available on drinking water supply systems.

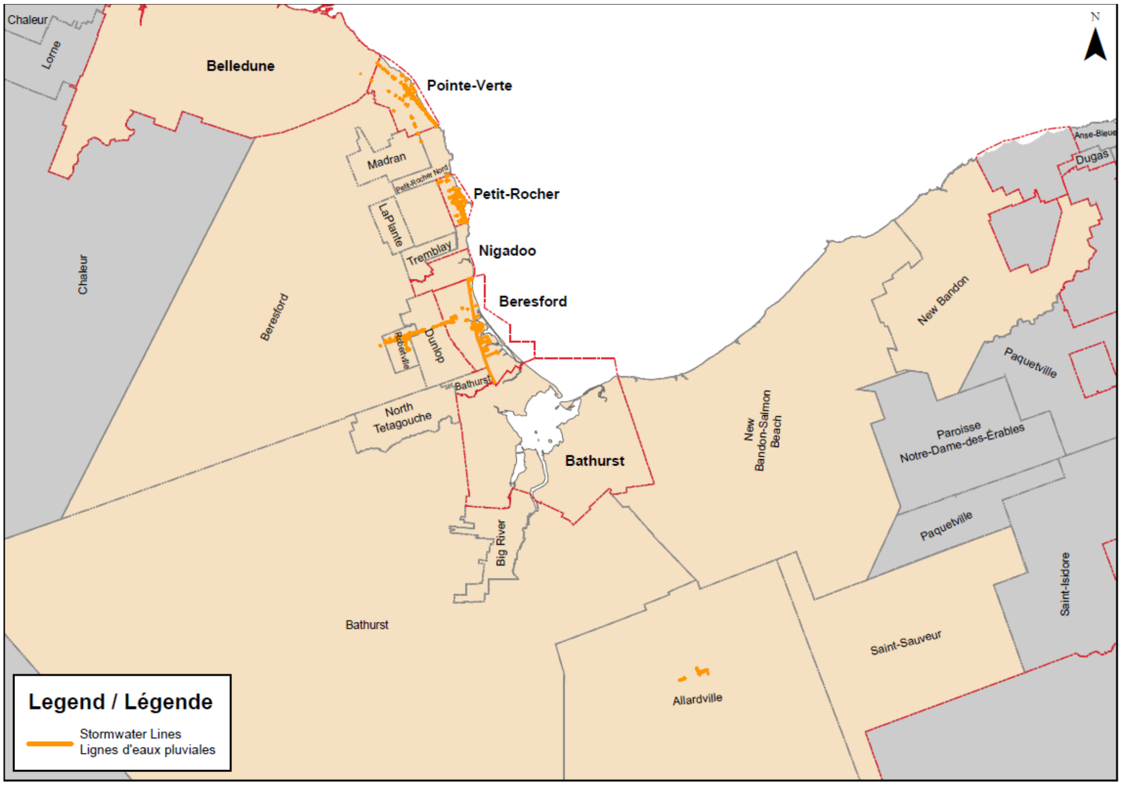

Figure 22: GIS coverage available on storm water drainage systems.

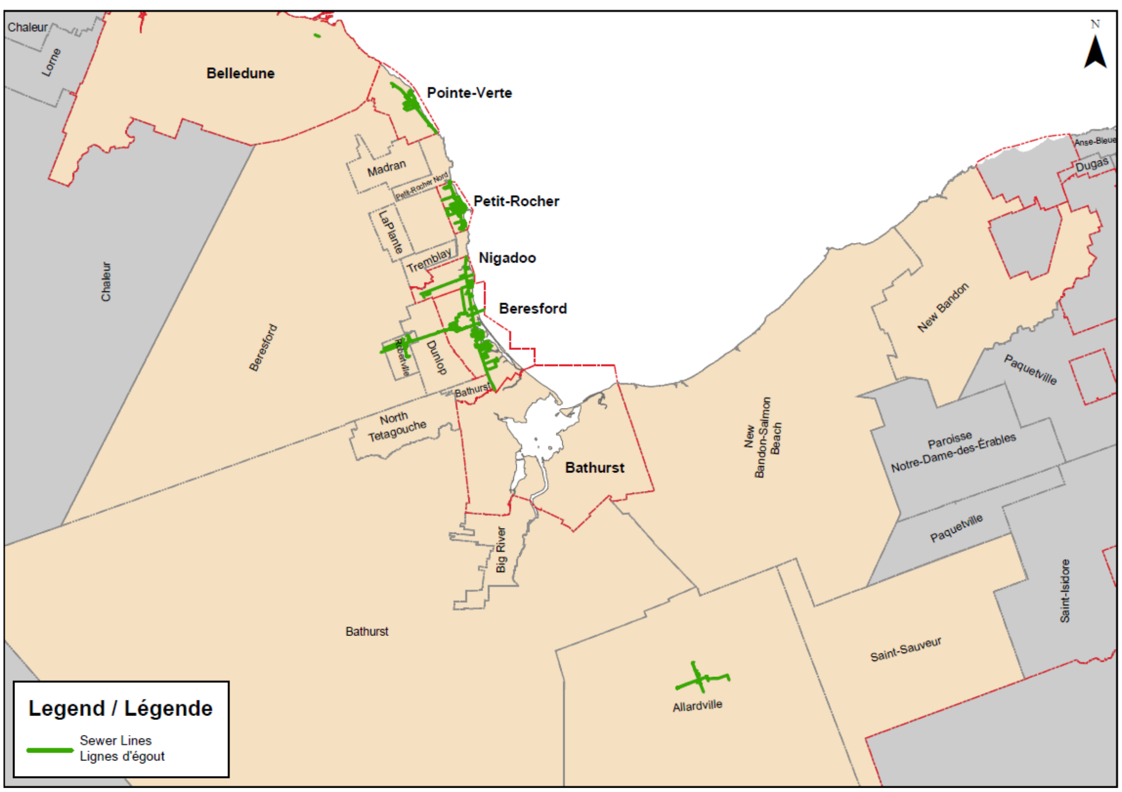

Figure 23: GIS coverage available on sewer systems.

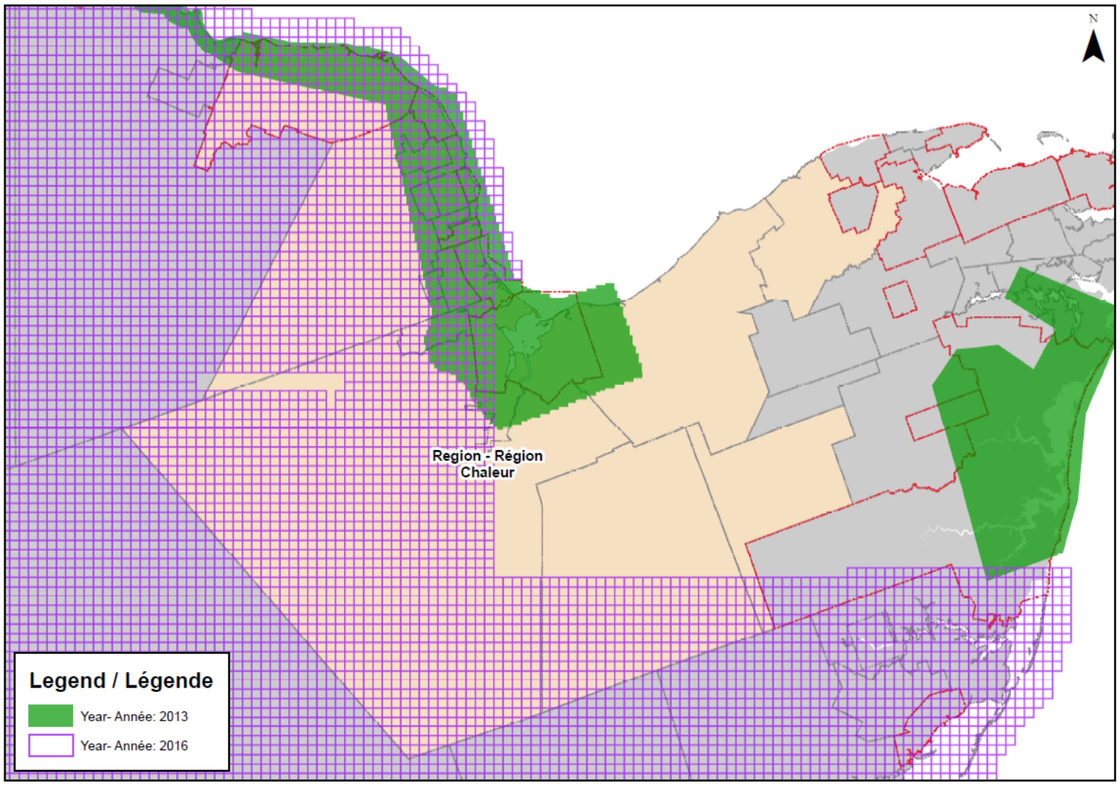

Figure 24: LiDAR coverage.

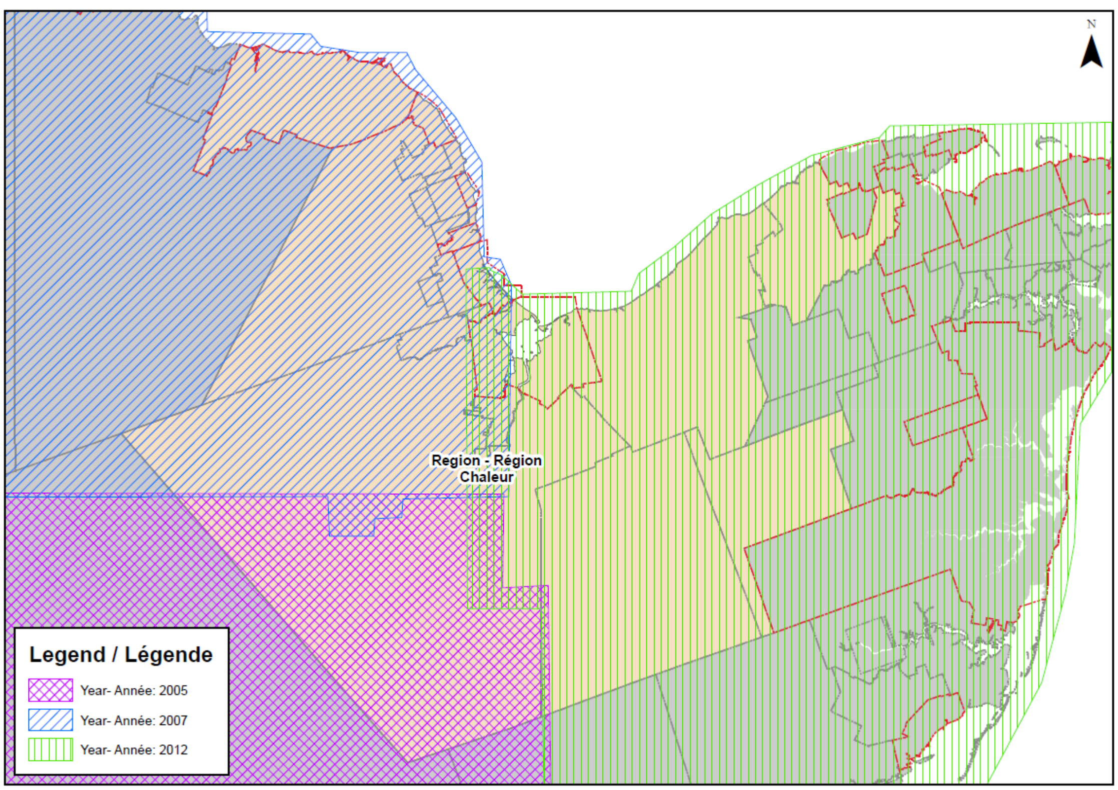

Figure 25: Most recent aerial photo coverage.

3.2 Needs, challenges and contemplated actions

In order to help communities in the Chaleur region adapt to climate change, it is necessary to know their needs and challenges. The brainstorming session with members of the CRACCCA yielded several:

- The governance structure can pose challenges in that there is no government at the local scale in non-municipal communities (LSDs) that occupy most of the territory.
- The propensity by citizens or levels of government to slough off responsibility for risk management and adaptation to a higher authority also poses a challenge. The example raised was the level of responsibility that citizens take on themselves and how to go about ensuring they take on a greater share of the responsibility.
- Whether in the LSDs or the municipalities, financial and human resources are limited, and the communities need financial support and external expertise in several fields, including engineering.
- Communities also need support in terms of asset management and capacity building, in order to develop the means and competencies needed for adaptation.
- Communities also need local scale information on risks to be able, for instance, to map the flood zones or other zones at risk, identify the infrastructures and populations at risk and find out the conditions for which the infrastructures and the emergency plans (such as water levels and flows, etc.) need to be adapted.
- Guidelines and standards that can be applied at the local scale, in a uniform manor throughout the region, are necessary.
- The public needs to be informed and made aware of the risks and potential adaptation measures.

The following ideas of potential actions that could be undertaken by the Chaleur RSC to meet these needs and help the communities adapt to climate change were proposed:

- Provide the Chaleur region with a vision and development objectives for the territory in the context of a changing climate, particularly to ensure the preservation of the natural habitats of coastal areas (beaches, dunes, marshes).
- Serve as an intermediary to ensure a closer fit between provincial policies, decisions or actions and adaptation and development objectives at the community level.
- Ensure the participation of elected officials (2 levels of government), administrators and the public in the climate change adaptation planning process.
- Develop zoning by-law models for municipalities and LSDs to oversee land use in order to minimize risks
- Develop guidelines on building construction and the construction and use of protective structures.
- Facilitate the updating of emergency plans (regional and local) in relation to climate change impacts.

- Develop erosion and flood scenarios and projections to arrive at a more accurate delineation of risk zones (for regulation and other purposes).
- Accompany communities (according to an established order of priority) in their climate change adaptation plan development process.
- Develop, in cooperation with the provincial government and communities, incentives or assistance programs for owners of high-risk properties (the program type has yet to be defined, but could be along the lines of a buyout program).
- Find and gather examples of best practices (what is being done elsewhere and could be applicable) in the field of climate change adaptation.
- Monitor climate events and changes occurring in the region.
- Monitor local adaptation efforts and how successful they have been.
- Act as a resource centre to citizens and communities.
- Develop communication tools (e.g., interactive cartographic tool) to disclose reliable information on risks and adaptation strategies to the public.

These ideas will be considered during phase 2 of the project.

4. Conclusion

The objectives of phase 1 have been achieved. The Chaleur RSC established an advisory committee to accompany it in the development of an action plan regarding climate change adaptation. It specified the scope and type of plan that will be developed by 2019. With the support of the CZRI, the Chaleur RSC performed a preliminary evaluation of the risks and vulnerabilities at the regional scale through documentary research, a GIS analysis and consultation with key stakeholders. It also identified gaps with respect to the available information and tools needed to evaluate risks and vulnerabilities along with avenues that could be explored to acquire some of the missing information and tools. It has also identified, with support from CRACCCA, community needs that could be addressed and potential actions that could appear in the plan.

The participation of CRACCCA members in this process was excellent. Likewise, close to twenty persons took part in each of the tabletop exercises. Thus, there seems to be genuine regional interest in the initiative, which is promising for what lies ahead. The Chaleur RSC submitted two funding applications in order to continue on with the process: one to complete phase 2 of the action plan development and one to begin the preparation of erosion scenarios and detailed assessments of the risk of coastal flooding and erosion on infrastructures (buildings and roads).

During phase 2, it is anticipated that actions to be integrated into the plan will be defined and chosen following information and consultation sessions with the public, elected officials and key stakeholders concerning the proposed actions along with the risks and vulnerabilities. Moreover, implementation plans will be developed for the actions chosen.

References

Acadie Nouvelle. 2017. Consulted on February 6, 2018. https://www.acadienouvelle.com/actualites/2017/04/17/inondation-residants-de-rue-mathilda-lont-echappe-belle-a-bathurst/

Arp, P. 2018. Personal Communication. Coordinator of the Forest Watershed Research Center. University of New Brunswick.

Berry, P., Clarke, K., Fleury, M.D. and Parker, S. 2014. Human Health; in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, (ed.) F.J. Warren and D.S. Lemmen; Government of Canada, Ottawa, ON, p. 191-232.

Boulanger, Y., Gauthier S., Gray, D.R., Le Goff, H., Lefort, P. and Morissette, J. 2013. Fire regime zonation under current and future climate over eastern Canada. Ecological Applications, 23(4): 904-923.

Chelbi, M., Clement, V., Jolicoeur S., O'Carroll, S., St-Pierre, M. and Bérubé, D. 2015. Évaluation de la vulnérabilité aux changements climatiques pour la ville de Bathurst. Contribution au rapport final du projet, volet Érosion côtière. Université de Moncton. 39p.

Daigle, R. 2014. Updated sea-level rise and flood estimates for New Brunswick coastal sections. Based on IPCC 5th assessment report, R. J. D. Enviro, 48p.

Dietz, S. 2017. Plan d'adaptation aux changements climatiques : Érosion côtière, inondations côtières et inondations fluviales. Ville de Bathurst. Groupe Aster-co-opérative de services environnementaux, 49p.

Environment Canada. 2018. Historical Total Accumulated Ice coverage for the weeks 1112-0129, seasons: 1980/81 – 2017/18. Consulted on February 6, 2018, http://iceweb1.cis.ec.gc.ca/Prod/page2.xhtml?lang=en

Environment Canada. 2017. Engineering Climate Datasets. Consulted on January 8, 2018, http://climat.meteo.gc.ca/prods_servs/engineering_e.html

Frenette, Y. 2018. Personal communication. Development Officer, Chaleur Regional Service Commission.

GNB (Government of New Brunswick, Environment and Local Government). Fact Sheet – Salt in Private Drinking Water Wells.

GNB (Government of New Brunswick, Environment and Local Government). 2012. Flood History Database. Consulted on December 11, 2017. http://www.elgegl.gnb.ca/0001/en/Flood/Search

GNB (Government of New Brunswick, Environment and Local Government). 2017. Transitioning to a Low-Carbon Economy. New Brunswick's Climate Change Action Plan, 21p.

GNB (Government of New Brunswick, Environment and Local Government). 2018. Consulted on February 6, 2018. http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/climate_change/content/climate_change_indicators/indicators/water/coastal_erosion.html

GNB (Government of New Brunswick, Transportation and Infrastructure). Traffic Advisories - Floofing. Consulted on January 24, 2018. http://www.gnb.ca/0113/en/traffic_advisories/flooding-e.asp

Guitard, M.A. 2018. Personal Communication. Water Planning Officer, Department of Environment and Local Government of New Brunswick.

Hunter, G.T. (Airphoto Analysis Associates Consultants Limited) 1975. Beach Resources, Eastern New Brunswick. Department of Natural Resouces of New-Brunswick, Mineral Resources Direction, 215 p.

IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Leighton, P.A., Koffi J.K., Pelcat Y., Lindsay L.R. and Ogden N.H. 2012. Predicting the speed of tick invasion: an empirical model of range expansion for the Lyme disease vector *Ixodes scapularis* in Canada. Journal of Applied Ecology, 49(2): 457-464.

NRCan-CFS (Natural Resources Canada – Canadian Forest Service). 2016. http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/forest/area-burned-projection-canada-map_b_1500.jpg

Neumeier, U., Ruest, B., Lambert, A., Bismuth, E., Dumont, D., Jacob, D., Savard, J.P. and Joly, S. 2013. Modélisation du régime des vagues du golfe et de l'estuaire du Saint-Laurent pour l'adaptation des infrastructures côtières aux changements climatiques. Rapport final présenté au ministère des Transports du Québec. Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, 253p.

Ogden, N.H., St-Onge, L. Barker, I.K., Brazeau, S. Bigras-Poulin, M. Charron, D.F., Francis, C.M., Heagy, A., Lindsay, L.R., Maarouf, A., Michel, P., Milford, F., O'Callaghan, C.J., Trudel, L. and Thompson, R.A. 2008. Risk maps for range expansion of the Lyme disease vector, *Ixodes Scapularis*, in Canada now and with climate change. International Journal of Health Geographics, 7(24): 15p.

Radio Canada. 2017. Consulted on February 6, 2018.

http://ici.radio-canada.ca/nouvelle/1028393/inondation-rue-fermee-bathurst-riviere-middle-nouveau-brunswick

Rapaport, E., Starkman, S. and Towns, W. 2017. Atlantic Canada. In K. Palko et D.S. Lemmen (Eds.). (2017). Climate risks and adaptation pratices for the Canadian transportation sector 2016 (pp. 218-262), Ottawa, ON: Government of Canada.

Roy, P. and Huard, D. 2016. Future Climate Scenarios – Province of New-Brunswick. Montreal: Ouranos. 46 p. + Appendixes

Samms, J. 2018. Personal communication. Senior technical specialist. NB Power.

Savard, 2014. Étude de la sensibilité des côtes et de la vulnérabilité des communautés du golfe du Saint-Laurent aux impacts des changements climatiques. Synthèse des résultats. Ouranos, Montréal, Québec, 48p.

Senneville, S., St-Onge Drouin, S., Dumont, D., Bihan-Poudec, A.-C., Belemaalem, Z., Corriveau, M., Bernatchez, P., Bélanger, S., Tolszczuk, S. and Villeneuve, R. 2014. Rapport final: modélisation des glaces dans l'estuaire et le golfe du Saint-Laurent dans la perspective des changements climatiques. ISMER-UQAR, Rapport final présenté au ministère des Transports du Québec, 384p.

Simard, I., Robichaud, A. et Savoie-Ferron, F. 2015. Infrastructures à risque face aux inondations et à l'érosion côtières pour la municipalité de Bathurst, Nouveau-Brunswick. 36p.

Appendix 1: List of the Chaleur Regional Advisory Committee on Climate Change Adaptation (CRACCCA) members

Last Name	Name	Title	Entreprise/Organism
Arseneau	Ronnie	Citizen	Village of Pointe-Verte
Bérubé	Dominique	Coastal Geomorphologist	Department of Energy and Resource Development
Boudreau	Christian	Environmental Technician	Village of Petit-Rocher
Bouffard	Marc	Planning Director	Chaleur RSC
Bryar	Raymond	Citizen	LSD
Bujold	Denis	Local Services Manager	Department of Environment and Local Government
Capozi	Robert	Adaptation Specialist	Department of Environment and Local Government
Couturier	Brigitte	Councillor	Town of Beresford
Dion	Frédérick	Citizen	Village of Petit-Rocher
Fournier	Paul	Executive Director	Department of Environment and Local Government
Gauvin	Donald	CRACCCA President and Citizen	LSD of Tremblay
Godin	Marc-André	Executive Director	Town of Beresford
Guitard	Alain	Councillor	Village of Nigadoo
Hachey	Jocelyne	Executive Director	Chaleur RSC
Hachey-Boudreau	Mariette	GIS and Planning Technician	Chaleur RSC
Kana	Happyness	Project Coordinator	Chaleur Bay Watershed
Lavigne	Nadine	Environmental Technician	Chaleur Bay Watershed
Lee	Landon	Executive Director	Village of Belledune
McLaughlin	Donald	Planning Technician	City of Bathurst
O'Rourke	Jamie	Citizen	Village of Belledune
Poirier	Vincent	Executive Director	Village of Nigadoo and Pointe-Verte
Roy	Mike	Administrator	Village of Petit-Rocher

Appendix 2: Lists of participants at the working meetings and tabletop exercises

November 16, 2017 - Working meeting

Last Name	Name	Title	Entreprise/Organism
Arseneau	Ronnie	Citizen	Village of Pointe-Verte
Aubé	Mélanie	Project Manager and Researcher	Coastal Zone Research Institute
Bérubé	Dominique	Coastal Geomorphologist	Department of Energy and Resource Development
Boudreau	Christian	Environmental Technician	Village of Petit-Rocher
Bouffard	Marc	Planning Director	Chaleur RSC
Comier St-Cyr	Line	Administrative Secretary	Chaleur RSC
Gauvin	Donald	CRACCCA President and Citizen	LSD of Tremblay
Haché	Sébastien	Director- Innovation Marketing	Coastal Zone Research Institute
Hachey-Boudreau	Mariette	GIS and Planning Technician	Chaleur RSC
Kana	Happyness	Project Coordinator	Chaleur Bay Watershed
Lavigne	Nadine	Environmental Technician	Chaleur Bay Watershed
McLaughlin	Donald	Planning Technician	City of Bathurst
O'Rourke	Jamie	Citizen	Village of Belledune

February 6, 2018 – working meeting

Last Name	Name	Title	Entreprise/Organism
Aubé	Mélanie	Project Manager and Researcher	Coastal Zone Research Institute
Bérubé	Dominique	Coastal Geomorphologist	Department of Energy and Resource Development
Boudreau	Christian	Environmental Technician	Village of Petit-Rocher
Bouffard	Marc	Planning Director	Chaleur RSC
Comier St-Cyr	Line	Administrative Secretary	Chaleur RSC
Couturier	Brigitte	Councillor	Town of Beresford
Dion	Frédérick	Citizen	Village of Petit-Rocher
Gauvin	Donald	CRACCCA President and Citizen	LSD of Tremblay
Guitard	Alain	Councillor	Village of Nigadoo
Hachey-Boudreau	Mariette	GIS and Planning Technician	Chaleur RSC
Kana	Happyness	Project Coordinator	Chaleur Bay Watershed
Lavigne	Nadine	Environmental Technician	Chaleur Bay Watershed
McLaughlin	Donald	Planning Technician	City of Bathurst
O'Rourke	Jamie	Citizen	Village of Belledune
Sonier	Tina	Research Professional	Coastal Zone Research Institute

February 20, 2018 – working meeting

Last Name	Name	Title	Entreprise/Organism
Aubé	Mélanie	Project Manager and Researcher	Coastal Zone Research Institute
Bérubé	Dominique	Coastal Geomorphologist	Department of Energy and Resource Development
Boudreau	Christian	Environmental Technician	Village of Petit-Rocher
Bouffard	Marc	Planning Director	Chaleur RSC
Comier St-Cyr	Line	Administrative Secretary	Chaleur RSC
Dion	Frédérick	Citizen	Village of Petit-Rocher
Fournier	Paul	Executive Director	Department of Environment and Local Government
Gauvin	Donald	CRACCCA President and Citizen	LSD of Tremblay
Hachey	Jocelyne	Executive Director	Chaleur RSC
Hachey-Boudreau	Mariette	GIS and Planning Technician	Chaleur RSC
Kana	Happyness	Project Coordinator	Chaleur Bay Watershed
Lavigne	Nadine	Environmental Technician	Chaleur Bay Watershed
O'Rourke	Jamie	Citizen	Village of Belledune
Sonier	Tina	Research Professional	Coastal Zone Research Institute

February 14, 2018 – tabletop exercise (Infrastructures)

Last Name	**Name**	**Title**	**Entreprise/Organism**
Abernethy	Matthew	City Engineer	City of Bathurst
Aubé	Mélanie	Project Manager and Researcher	Coastal Zone Research Institute
Bérubé	Dominique	Coastal Geomorphologist	Department of Energy and Resource Development
Boissonnault	André	Vice President	Boissonnault McGraw
Boudreau	Christian	Environmental Technician	Village of Petit-Rocher
Bouffard	Marc	Planning Director	Chaleur RSC
Capozi	Robert	Adaptation Specialist	Department of Environment and Local Government
Comeau	Bruce	Civil Engineer	Roy Consultants
Cormier	Sébastien	Public Works	Village of Pointe-Verte
Frenette	Francis	Municipal Department Manager and Project Manager	Roy Consultants
Frenette	Yvon	Development Officer	Chaleur RSC
Gallant	Terry	Project Manager	Boissonnault McGraw
Gauvin	Donald	CRACCCA President and Citizen	LSD of Tremblay
Gionet	Serge	Public Works Manager	Town of Beresford
Hachey-Boudreau	Mariette	GIS and Planning Technician	Chaleur RSC
Kana	Happyness	Project Coordinator	Chaleur Bay Watershed
Lavigne	Nadine	Environmental Technician	Chaleur Bay Watershed
LeBlanc	Daniel	Regional Engineer	Department of Transportation and Infrastructure
LeBlanc	Ronald	Acting Executive Director	Village of Petit-Rocher
MacLellan	Cameron	Public Works Manager	Village of Belledune
McLauglhin	Donald	Planning Technician	City of Bathurst
O'Rourke	Jamie	Citizen	Village of Belledune
Sonier	Tina	Research Professional	Coastal Zone Research Institute

February 15, 2018 – tabletop exercise (Public utilities)

Last Name	Name	Title	Entreprise/Organism
Aubé	Mélanie	Project Manager and Researcher	Coastal Zone Research Institute
Bérubé	Dominique	Coastal Geomorphologist	Department of Energy and Resource Development
Bouffard	Marc	Planning Director	Chaleur RSC
Capozi	Robert	Adaptation Specialist	Department of Environment and Local Government
Comeau	Charles	Police Chief	BNPP Regional Police
Comeau	Pierre		Bell Aliant
Doucet	Adèlbert	Firefighter	Allardville Fire Department
Doucet	Jean-Claude	Firefighter Chief	St. Anne Regional Fire Department
Frenette	Yvon	Development Officer	Chaleur RSC
Gauvin	Donald	CRACCCA President and Citizen	LSD of Tremblay
Godin	Marc-André	Executive Director	Town of Beresford
Hachey-Boudreau	Mariette	GIS and Planning Technician	Chaleur RSC
Kana	Happyness	Project Coordinator	Chaleur Bay Watershed
Lanteigne	Katherine	Coordinatrice du marketing et des communications	Bathurst Regional Airport
Lanteigne	Réginald	Firefighter	Allardville Fire Department
Lavigne	Nadine	Environmental Technician	Chaleur Bay Watershed
LeBlanc	Ronald	Acting Executive Director	Village of Petit-Rocher
O'Neill	Chris	Firefighter	St. Anne Regional Fire Department
O'Rourke	Jamie	Citizen	Village of Belledune
Roy	Carolle	Assistant Director	Chaleur RSC
Roy	Stéphane	Sergeant	Bathurst Police Force
Sonier	Tina	Research Professional	Coastal Zone Research Institute
Tremblay	Marc	Team Leader Northeast District	RCMP, Bathurst Detachment

Appendix 3: List of the GIS data layers for the Chaleur RSC territory

Name	Description
Annotation	
NBHN_Wc_ClipAnno	River names associated with NBHN(New Brunswick Hydro Network)
Noms_geographic	Locations names
Przoning	River names in Petit-Rocher only
BelledunePortAnno	Annotation for port of Belledune
Beresford_trail	Annotation for Beresford Trail
BeresfordTrail_3000	Larger scale Beresford trail annotation
DSL_Muni_brdtxt	DSL text of borders
NigadooRiver	Nigadoo zoning river annotation
NigadooStreet	Nigadoo zoning street annotation
PRStreets	Petit-Rocher streets annotation
River_anno_sm	River annotation Small
RuesAnno	All roads annotation
WaterbodyAnno	Water body annotation
Communauté	
École	Schools / École
Environment	
Parc_provincial	Provincially designated parks
PNA	Protected Ecological areas
	Atlantic Canada Conservation Data Center. Protected and endangered species
ZoneÉcologique	Environmentally significant areas
Deer Wintering Area(DWA)	Deer wintering areas
Ecological Sites	Ecological Land Classification
ESA	Environmental Sensitive area
Forest	Forest types and ages
Landfill	
Non-Forest	Forest types and ages
Old Forest(OSFH)	Old Spruce Fir Habitat
Hydrographic	
National Hydro Network	Canada wide network standard
Digital Topographic Database 1998	Digital Terrain Model (DTM) Data Base and the Enhanced Topographic Base (ETB)
Government of New Brunswick Wetlands	New Brunswick regulated wetlands
New Brunswick Hydrographic Network	New Brunswick water network following the National standard
Government of New Brunswick Protected Water Sources	Protected watershed, rivers and appropriate set backs
Department of Natural Resources (watercourse)	DNR data, Environment Canada uses this data
ChampsCaptage	Protected well field / Champs de Captage
wa_nb_wam_final2010	Wet area mapping

Transportation	
NB911 Chemin	Data received from NB911, for internal use
RUES_2012	In-house created data based on NB911, tax data, Dep. Of transportation data and orthophotos
Control Access	Control access highway
NRWN_NB_1_0_TRACK	National Railway Network
NRWN_NB_1_0_STATION	Rail Stations
AirportOriginal	Created internally by Marcel and converted from a CARIS format, based on 1984 Roys document
Airport	Created internally by Mariette, based on EIA Registration report from Aug. 2011 and Transport Canada TP 1247 document
Airport3D	Created internally, 3D features
Airport3D_2	Created internally, 3D features
Route Forestière	Subset from etb98 data of forest and resource roads
BlockedPassageEntity	New Brunswick Road Network
CrossingEntity	New Brunswick Road Network
JunctionEntity	New Brunswick Road Network
TollPointEntity	New Brunswick Road Network
FerrySegmentEntity	New Brunswick Road Network
RoadSegmentEntity	New Brunswick Road Network
NRN	National Road Network
StatCan Road Network	Statistics Canada Road Network
Plan	
Plan	Index to subdivision plans (4452 documents)
Topographie	
Contour_1M	1 meter interval contours
Contour_5M	5 meter interval contours
HauteurPnt	Point height positions (contours are created based on this data)
High Precision Control Network	High precision control network
Limites administratives	
Comtés	County boundaries, names added internally, merge performed internally
Couronne	Crownlands / Terres de la Courrone
DSL	Local service district boundaries
Municipalité	Municipal Boundaries
Paroisse	Parish boundaries
PremièresNations	First nations Boundaries
Région	Regional boundaries
Infrastructure	
Building	Footprints of buildings reproduced in 2D
Elec_Pole	Telephone Poles
Proposed_Tower	Towers that we have overseen through permitting
TAFL_Mob_Micr	Technical and Administrative Frequency List & Mobility & Microwave
FM_Tower	Broadcasting data
TV_ Tower	Broadcasting data
Power_Lines	Power lines
Utility_lines	Power lines

Transmission_Lines	Power lines
Sewer	
Storm	
Water	
Zonage	
Belledune	Belledune Zoning
Beresford	Beresford Zoning
BigRiver	Big River Zoning
Chemin_classification	All classified streets within zoning areas
Chemin_désigné	all designated streets within zoning areas
Dunlop	Dunlop zoning
Nigadoo	Nigadoo Zoning
Petit-Rocher	Petit-Rocher Zoning
PointVert	Pointe verte zoning
PV_50M_Coast	Pointe Verte 50 M costal buffer
PV_Conditions	Pointe-Verte zoning conditions
PV_Lagoon	Pointe verte lagoon buffer
PV_MX_Buffer	Pointe-Verte mixed zone buffer
Robertville	Robertville Zoning
Tetagouche	Tetagouche Zoning
Tables	
NBHN_0000_NAMES	NB hydro network named river features
P_Type	Parcel property type key
Tax_Auth	Taxing authority for parcel data
Géologie-Bedrock	
NR1_2008	Bedrock geologie of all New Brunswick
NR3_2006	Bedrock geologie of North Western New Brunswick
NR4_2006	Bedrock geologie of central western New Brunswick
NR6_2006	Bedrock geologie of south eastern new Brunswick
NR5_2005	Bedrock geologie of South western New Brunswick
NR10_2008	Bedrock geology of central eastern New Brunswick
	North American stratigraphic code
Mineral_Claims	
Claims	Polygon shapes of claim locations, must go to hyperlinked website to get owner names
Mining Agreements	Polygon shapes of mining agreements
ClaimUnits	Grid units for creating claim numbers
LegacyUnits	Older claim index
WithdrawnAreas	Claims that have been removed, or areas of exclusion
Drillhole	
Drillhole	Database of all drillholes in province, location and company name included
Mineral Occurrence	Database of mineral occurrence based on drill holes, use website for details search
Surficial_Geology	
nr8	Surficial geology of province

Petroleum	
Seismic_line	petroleum data
Line_Lable	petroleum data
Aggregate	
MP_79_61	Aggregate maps
MP_79_42	Aggregate maps
MP_79_39	Aggregate maps
MP_89_9	Aggregate maps
MP_86_7	Aggregate maps
MP_76_115	Aggregate maps
MP_78_23	Aggregate maps
MP_78_19	Aggregate maps
MP_78_24	Aggregate maps
MP_86_226	Aggregate maps
MP_86_225	Aggregate maps
MP_86_223	Aggregate maps
Aggregate	Merge of aggregate maps
Sol	
CLI_Agri	Canada land inventory- soil capabilities relating to agriculture
a021p	Canada land inventory- soil capabilities relating to agriculture
a021o	Canada land inventory- soil capabilities relating to agriculture
nb_12map	Soils of central and northern New Brunswick - soil survey report no.12
	Soils of New Brunswick the second approximation
Bedrock	
text	1:50000 maps of bedrcok geology. 2003-2007
symbol	1:50000 maps of bedrock geology. 2003-2008
faults	1:50000 maps of bedrock geology. 2003-2009
outcrop area	1:50000 maps of bedrock geology. 2003-2010
geology	1:50000 maps of bedrock geology. 2003-2011
	Charlo area pdf
2007-18_c.tiff	Lithologic map of New Brunswick
Bedrock_Geology_MapNR1-e1.tif	Bedrock geology of New Brunswick (older 200 map, the new NR are more current)
NR7_2002-e1.tif	Metallogenic map of New Brunswick
Mines	
Mines	Point data on locale mines
PARCEL	
Birchgrove	Lots of birchgrove trailer park
Parcel	Parcel lots
Population	
Comté	Population by county for 1996, 2001, 2006, 2011, 2016
CT_2001	Population by census tract 2001
CT_2006	Population by census tract 2006
Stat 2006	2006 Census Statistics
Stat2001	2001 Census Statistics

Recreation	
VTT_Chaleur	VTT trails provided by MARCEL
Beresfrod_Trail	Beresfrod walking trails
Mi'gmaq Trail	Pdf files of maped trail
ParcAtlas	Atlas park trails
ATV-Snowmobile	Shared atv and snowmobile trails northern NB
NB_snowmobile	Snowmobile trails all fo NB
NB_atv	ATV trails for all NB
LiDAR	
Bathurst_1m	Bathurst lidar
BathurstHS_1M	Bathurst lidar hillshade
bathurst area FloodPoly 1.3 to 5.0 meters	Processed from Lidar Data
Charlo Area Flood Poly 1.3 to 5.0 meters	Processed from Lidar Data
Canada Land Inventory	
Agriculture	Classification of land for use in agriculture
Angulates	Classification of land for use in angulates(large animals)
Forest	Classification of land for use in forest
Land Use	Classification of land for use in land use
Recreation	Classification of land for use in recreation
Waterfowl	Classification of land for use in waterfowl
Land Use	
UtilisationduSol2010	Land Use classification
UtilisationduSol	Land use classification