STEP 1: GENERATING DIALOGUE
ADAPTATION TO SEA LEVEL RISE ON PRINCE EDWARD ISLAND

by

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ABSTRACT

Despite the uncertainties that exist within climate change projection models, the only way to reduce our vulnerability to future changes in sea level is to implement adaptation strategies. No-regrets adaptation strategies are those strategies that will benefit us regardless of how high sea level rises or how soon. The primary goal should not be to determine a worst-case scenario, but instead to identify the most vulnerable areas first, and to gradually introduce phased adaptation strategies into relatively lower risk areas. The present study specifically looks at how we assess the potential impacts of sea level rise and how we can make use of these assessments in planning and design practice. As a case study for impact and vulnerability assessments, the flood risk areas on the coast of Prince Edward Island are mapped and a method for conducting a vulnerability assessment for individual properties is proposed. Finally, design strategies that were generated through the assessment process are presented as examples of no-regrets adaptation strategies.

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PREFACE

INTENT. The progress of this practicum has spanned almost two years, of which the journey itself has altered the direction of the work significantly. In the preliminary design stage of selecting a site for a waterfront design project, I came to realize that many of the coastal landscapes of my childhood memories no longer existed. Coastal processes such as erosion were not exactly foreign concepts to me, but I had not previously considered the relatively short life that these naturally dynamic landscapes can have. It quickly became clear to me that part of what draws people towards waterfront designs is the ongoing dialogue between built forms and environmental forces - especially those of recent accelerated climate change trends. What had begun as a waterfront landscape design, was quickly cut short and my journey was redirected into a field of research that is relatively new in the practice of Landscape Architecture, that of climate change adaptation.

THE JOURNEY. Landscapes by their very nature change, but the rate of this change can vary dramatically from one landform to the next. In order to design a landscape that is continuously under the influence of change requires a thorough understanding of the forces at work, the cultural tendencies to respond and adapt to those forces, flexibility, and a long term perspective on how the landscape will be used by future generations.

As I proceeded to conduct a site analysis for the waterfront design exploration I started by collecting information on the environmental processes relating to Prince Edward Island's coast. It was then that I realized that the critical information about projected impacts of climate change, and more specifically sea level rise, has not yet been made readily available to be used in the application of design, as one might believe it to be in this day and age.

Scientists have been reporting on climate change and global warming for over thirty years, but the application of that information into site specific impact assessments is a relatively new science. Within the design community there is a fundamental lack of communication on what the projected impacts are for the landscapes in which we are currently working. While coastal development continues with little to no acknowledgement that the coastline is expected to change dramatically over the next century, one must ask, are the designers *unaware*, *unconcerned* or just *unable* to convince their clients otherwise?

MY RESPONSE. As I found myself challenged by the task of proposing a landscape design for a waterfront which may potentially be under many feet of water within my own lifetime, the intent of the project shifted. Instead, I focused on establishing a resource for planners and designers to use in addition to their more traditional site analysis tools. When a designer now asks what a site currently *is*? I wanted to encourage them to also ask what that site *may be* in the near future.

As I ventured into the realm of climate change research, I was soon challenged by some of the more common questions that professionals tend to ask: What exactly does *projected risk* mean? How high will sea level be? And, when exactly is this going to occur? What I had found was that the delay in finding the exact answers to these critical questions appears to be the reason why most people have been unable to make any decisions related to them. Instead of attempting to answer these questions which leading scientists remain unable to do, I choose to focus on the observed trends of climate change and the potential for future change, neither of which can be ignored any longer. Whether we are designing for today, tomorrow or for 100 years from now, what is obvious is that adaptation is necessary now.

In addition to describing the potential impacts of sea level rise on PEI, I sought to develop a method for identifying appropriate adaptation strategies for particular land use challenges, and a systematic way in which communities can prioritize such initiatives. My goal was to make the localized assessments available to the community, for the purpose of engaging community residents, and encouraging no-regrets coastal development from all perspectives including designers, planners, policy makers and individual property owners.

Research, field studies, interviews, meetings, number crunching, panel discussions, presentations, proposals, drawing, mapping, written correspondence and personal reflections have all contributed to the experience, the process and inevitably the format of the final product of this project. But most importantly it has been through dialogue with a variety of individuals with different backgrounds and expertise that I have found my way along this path. Having received support, encouragement and bids of congratulations from one side, and skepticism, anger and disbelief from another; the common perspective has been in realizing that many professionals have not previously been made aware of the current trends and projected risks of climate change, despite the fact that these risks have actually been known within the scientific community for quite some time.

Climate change itself is not a new issue within Landscape Architecture, but sustainable, green, environmentally friendly, eco-centric, organic, buy-local, "*you-get-the-point*" initiatives are continued attempts at climate change *mitigation*. The importance of these initiatives should not be underestimated, but unfortunately despite our best efforts observed trends have not yet deviated from their trajectories. Climate change is inevitable. We can not rely on a quick-fix solution to the changes that are coming; we must also learn to adapt.

In coming to a close on this practicum, I am looking forward to finding further opportunities to continue my research and to engage colleagues as well as the general public. Adaptation is a complicated process and with this project I am hopeful that I have contributed, at the very least, to what should be *Step One, the generation of dialogue* amongst planning and design professions about the importance of climate change adaptation.

STEP 1: GENERATING DIALOGUE

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"It is not the strongest of the species that survives,

nor the most intelligent,

but the one most responsive to change"

Charles Darwin

CHAPTER ONE. A CRASH COURSE IN CLIMATE CHANGE

INTRODUCTION

In order to assess the potential impacts of climate change we need to understand the nature of climatic systems. We also need to understand how our world currently relies on a consistency of those systems despite the fact that those systems are currently changing. Natural systems only cause problems when we fail to plan adequately for natural deviations, and the global community has chosen to continue to ignore the warnings that deviations from yesterday's norms are likely to become much more common. If we are going to continue to be skeptical of climate change projection models, perhaps we can look to the observed trends of recent years as reason enough to take action through the implementation of adaptation strategies.

WHAT IS CLIMATE CHANGE

The International Panel on Climate Change (IPCC) defines climate change as "any change in climate over time, whether it is the result of natural variability, human-activity or both" (IPCC, 2007a). Although this definition specifically refers to climate, the issues related to climate change expand well beyond that of climatology and continue to expand as the consequences of such change are further understood.

References to climate change and global warming are often used synonymously with one another. Global warming, however specifically refers to an increase in the mean global temperature which results from a process called the greenhouse effect (IPCC, 2007a). The consequences of the greenhouse effect have been studied for many years however implementing measures to address the broader range of impacts of climate change have often been impeded by the assumption that by *simply* reducing greenhouse gas emissions all climate change will be mitigated. Unfortunately, it is now understood that even if the most significant mitigation strategies to reduce emissions were to be implemented today, some degree of climate change is inevitable (Lemmen & Warren, 2004); the impacts of which will be experienced worldwide.

As a result of increased global temperatures, environmental systems have and will continue to be altered. These include precipitation patterns and extreme storm events, shifts in animal and plant species distribution, and changes in global mean sea level, to name a few. These natural systems have been evolving over geologic time and will continue to change with or without further human interference. Whether or not we believe that our interference has been the direct cause of the observed climate change trends, research indicates that the rate of change has been greatly accelerated in recent years (Lemmen et al, 2008).

There has been much debate over the level of uncertainty that exists within climate change models, and scientists agree that there is an imperfect understanding of exactly how environmental and human-systems will respond to such accelerated processes (IPCC, 2007a). Unfortunately, while these debates have continued, the impacts of climate change have already been experienced in many parts of the world (Lemmen & Warren, 2004). In fact, in many cases, the observed impacts have already exceeded the expectations of worst-case-scenario climate change models.

GLOBAL TRENDS OBSERVED

In 2007, the IPCC reported that the Earth had experienced eleven of the warmest years on record in the twelve year period between 1995 and 2006 (IPCC, 2007b). Also during this time period, many regions observed an increased frequency and intensity of extreme climatic events, such as heat waves, ice storms and tropical cyclones. The frequency of extreme high sea levels, which are related to the extreme weather systems, has also increased worldwide. These record breaking observations are non-disputable accounts of how global climate systems have already changed, and are consistent with the forecasts from projection models. Climate change is no longer an issue referring to future trends, and we need to recognize that the environmental systems today are already different from that of yesterday.

Although to date, many regions have had relatively minor fluctuations in their climatic conditions, other regions have been greatly impacted by increased drought or flooding; and, have already experienced the consequential socio-economic devastation that can result from changes in natural resource availability. Precipitation rates have increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia; in contrast, regions of the Sahel, Mediterranean, southern Africa and parts of southern Asia have experienced significant decreases (IPCC, 2007b). In high altitudes and high latitudes, temperatures have increased by almost twice that of the global average, resulting in a dramatic decrease in the amount of seasonally frozen ground, creating instability in the permafrost and causing increased rock avalanches in the mountains (IPCC, 2007b).

As the climatic zones of the globe have shifted, so have their relative ecosystems. Both plant and animal species have experienced poleward and upward shifts in the upper limits of their biomes. The timing of spring events such as leaf-unfolding, bird migration and egg-laying have also been recorded much earlier than in past records. Such natural migrations have had varying impacts on human systems, with some regions experiencing the benefits of longer growing seasons and many others dealing with the spread of new pests. (IPCC, 2007b)

With increased precipitation, there has also been increased runoff and an earlier spring peak discharge for many glacier and snow-fed rivers. Glacial lakes have increased in both size and number, and as the temperature of inland waters have increased, changes have been observed in both water quality and ecologic structure. Changes in the duration and thickness of seasonal ice coverage have led to changes in shoreline exposure and have resulted in increased susceptibility to erosion (Lemmen & Warren, 2004).

As the temperature of the ocean water catches up with the rising global air temperature, thermal expansion causes the global mean sea level to rise. Over geologic time and under natural fluctuations in global temperatures, the global mean sea level has changed dramatically around the world. Areas that are now islands had once been connected to the mainland by land bridges, and vice versa. In the early 1960s, the global mean sea level had been rising at an average rate of 1.8mm per year, however due to the accelerated process of global warming this average had increased to 3.1mm per year by 1993 (Bindoff et al, 2007). Thermal expansion of ocean waters accounts for over half of this change; the remaining increase is the result of melting glaciers, ice caps and polar sheet ice (IPCC, 2007b). But once again, these changes in global mean sea level have been observed differently in different areas, as local conditions such as regional plate tectonics, changes in local wave patterns and storm surge events also play a significant role in influencing local sea levels.

CLIMATE CHANGE MODELS

Many regions have been caught off guard and unprepared for the impacts of extreme climatic events that have occurred in recent years. By establishing and improving measures to provide advanced warnings to communities is just one example of how we have already responded to observed impacts, but unfortunately there remains much resistance to take proactive initiatives based on climate change projection models. Scientists agree that these models are simplified descriptions of how the future *may* develop; they are not intended to be predictions of what will happen (IPCC, 2000). Climate models represent the difference between a plausible climate scenario and the current conditions and they give us a general indication of the degree of impact that we will experience under a given set of variables (Lemmen & Warren, 2004).

Projecting global greenhouse gas emissions involves very complex calculations based on future relationships between global demographics, socio-economic and technological changes (IPCC, 2000). Different climate models are required to fully represent the different scenarios of how these factors may change in the future. The resulting projections thus range between, a worst-case scenario, otherwise known as the *business as usual* approach, and the optimistic scenario which projects a more environmentally sustainable future (IPCC, 2000).

One of the primary challenges in working with global climate change data is the degree of uncertainty that exists within these projection models. For example, the IPCC stated in its 2007 summary report that by the mid-2090s global sea level will likely reach between 22 and 44 cm above 1990 levels (IPCC, 2007b). Impact assessments have since used the mean value within this range at around 33cm for assessing potential flood risk in coastal zones (McCulloch et al., 2002); the assumption being, that the mean value is a relatively *safe* estimate.

Unfortunately, such impact assessments are an overly simplified representation of global projections. The results are often used without further regard for the scenario on which the projection was based. In this case, the original projection model that was included in the IPCC summary report was based on an optimistic scenario of the future, one in which the world experiences very rapid economic growth a population that peaks in mid-century and that has a rapid introduction of new and more efficient technologies (IPCC, 2000). The recent global recession would indicate that this particular model is at least partially outdated. In contrast, a less optimistic scenario projects the range to be between 26 and 59 cm for global mean sea level (IPCC, 2007b), with a mean value at 42cm. In this case, in terms of future coastal development and calculating necessary protection measures, the higher value may actually be the *safer* of the two estimates. This reductionist approach to impact assessment also does not account for addition factors such as local geography and storm surge tendencies which will ultimately result in significant differences between coastal regions.

GLOBAL SEA LEVEL RISE

With all scenarios included in the IPCC 2007 report considered, the projected values for global mean sea level rise vary from 8 to 88 cm by 2100, with continued rise and possibly accelerated rising in the following century (Lemmen & Warren, 2004). With such a wide range currently being published there is no wonder why there are debates over the accuracy of the models. But while such debates continue we can look to the observed trends for guidance on decision making today. In recent years the global mean sea level has been following, if not exceeding, the more pessimistic, worst-case scenario projection range (IPCC, 2007b). To date, global mitigation efforts have had no influence on altering this current trend and with no significant changes in our way-of-life coming in the immediate future, the trend is likely to continue on its current path (Lemmen, 2004).

It is also important to remember that other factors have knowingly been excluded from the published projections for global mean sea level rise, mainly the impacts of melting glacial ice sheets (IPCC, 2007b). These processes are complex and are a relatively new field of research, but model simulations and recent observations indicate that warming in high latitudes is accelerating the melting of the Greenland Ice Sheet. Despite the uncertainties in the projection data, observed trends have already exceeded global climate change projections (American Meteorological Society, 2007). Best estimates suggest that the total melting of this ice sheet would raise global sea level by about 7 meters, and the West Antarctic Ice Sheet would add another 5 or 6 meters to that total (IPCC, 2007b). With recent observations indicating how rapid these reactions can occur, such events can not be entirely ruled out from serious consideration. Whether such extremes are experienced within the next 100 years or 500 years, the current trends are headed in this direction.

To complicate things further the process of sea level rise does not occur uniformly around the world. Some regions will experience rates several times that of the global average and other regions will actually experience a drop in sea level. In 1998, the Geological Survey of Canada commissioned a study that assessed Canada's coastlines with respect to natural sensitivity to sea level rise, and examined variables such as relief, rock type, landform, sea-level tendency, shoreline displacement rate, tidal range and the maximum significant wave height (Shaw et al., 1998). With all factors combined more than 7000 km of coastlines in Canada were identified as being highly sensitive to future sea level rise, including much of the provinces of Nova Scotia, New Brunswick and Prince Edward Island (Shaw et al., 1998). Sea level rise in this region will result in permanent submergence of parts of the coast, accelerated erosion of beaches and coastal dunes, degradation of coastal wetlands such as salt marshes, saltwater intrusion into coastal aquifers, and significant economic impacts on urban infrastructure and developed properties (Lemmen & Warren, 2004).

CHAPTER TWO. SEA LEVEL RISE AND AN ISLAND

INTRODUCTION

In 1999, the Geological Survey of Canada began an in depth investigation into the impacts of sea-level rise due to climate change and land subsidence on Prince Edward Island, specifically for the City of Charlottetown and a small portion of the North Shore (McCulloch, et al. 2002). This project was a very important first step in establishing a precedent for sea level rise impact assessments, leading the way for more in depth studies on coastlines in other provinces across the country. Other less populated areas of Prince Edward Island however, have not been equally assessed, nor have the results of the initial study led to the implementation of any policies regarding future development within the identified flood risk zones.

The present study intends to address the knowledge gap between the scientists and the community, by applying the general impact assessment data from the initial study to the rest of the Island and communicating the results in a form that can be utilized for application in planning and design practices. At the provincial scale, a regional impact assessment is used to identify areas at risk, to guide future research and to aid in the establishment of province-wide adaptation strategies.

Using an island as a case study for research on coastal impacts and adaptation provides an opportunity that is unique from studying in other regions. The geography of an island provides somewhat of a *closed system* for coastal analysis where otherwise political boundaries tend to dictate research limits. Prince Edward Island's geography also has a range in natural environments, from sandy beaches, sandstone cliffs and salt marshes, to the many communities and cities that owe their origins to their coastal proximity. Current land use practices vary along the Island's coast, and as a result will have a range in socio-cultural implications to proposed adaptation strategies. The need for more detailed site specific assessments should not be underestimated, and this widespread regional analysis is intended to provide the foundational knowledge for generating dialogue with regards to such local initiatives.

THE ISLAND CONTEXT

Prince Edward Island (PEI) is the smallest province in Canada and is located on the East Coast in the southern part of the Gulf of St. Lawrence. It is separated from New Brunswick and Nova Scotia by the Northumberland Strait, which ranges between 15 and 50 km wide. Together these three provinces are commonly referred to as *the Maritimes*. The Island is a crescent shape that is approximately 230 km long, and ranges between 6.5 and 50 km wide. The topography is described as gently rolling hills, with the western and eastern parts of the Island being much lower and the elevation in the central portion rising to a height of 127 m above sea level (Van de Poll, 1983).

The Island has approximately 1000 km of saltwater shoreline (Natural Resource Canada [NRC], 2009) and owes its irregular shape to the many bays and estuaries that penetrate its coastline. These features represent former river valleys that were submerged when sea level rose and disconnected PEI from the other Maritime Provinces about 300 thousand years ago (Baldwin, 1998). On the North shore, the Island has a well-developed sand dune and beach system, and sandspit formations act to shelter many of the bays from the open water's of the Gulf. Famous for its rusted, iron-stained soil and red sandstone cliffs, the subsurface geology of the Island is continental in origin and consists of a conglomerate, sandstone and siltstone sequence of redbeds (Van de Poll, 1983).

The Island's current climate is characterized as southern to mid-boreal, and is strongly influenced by its proximity to the Atlantic Ocean and Gulf Stream Current. Recent records indicate that the mean temperature ranges between -8˚C and 18˚C in the winter and summer respectively, and the mean annual precipitation is approximately 1200mm, with about a quarter of that amount falling in the form of snow. Winds are predominantly from the west or southwest, however it is the northeasterly winds that tend to have the strongest force. (Environment Canada, 2004)

The Island falls within the Atlantic Maritime Ecozone, which is characterized by a mix of southern temperate vegetation and boreal forest (Vasseur and Catto, 2008). Despite the largely agricultural based economy on the Island, much of the land remains covered in forest. Three main forest types are a result of natural variations in the topography and influences of past land use practices. The upland hardwood forest is primarily found in the central and south-eastern hill-lands; the Black Spruce forest, or swamp-type woodland is found in areas of lower elevation, mainly in the east and west ends of the Island; and finally, the old field White Spruce and other conifer-dominated forest-types are found in the central and eastern parts of the island in the areas most impacted by past human disturbances. (Sobey & Glen, 2004)

After Europeans settled on the Island, widespread land clearing and unregulated hunting practices resulted in habitat loss and the elimination of large mammals such as the caribou, moose, lynx and black bear. In contrast, other species thrived in the young forests and farmland environments, such as red fox, ruffed grouse, snowshoe hare, and woodcock. More recently in the 1980s, the eastern coyote migrated to the Island across the winter ice on the Northumberland Strait and has since become a well established population at the top of the Island's natural food chain. (Gov. of PEI, Dept of Energy, Environment and Forestry, 2009)

Much of the evidence of the earliest people to inhabit the Island has been lost as settlements were most likely located on the shoreline, which is highly vulnerable to erosion. When the first Europeans arrived in the Maritimes in the late 1400s, the Island was being used by the Mi'kmaq Aboriginals in the summer months. Evidence of these early campsites has been uncovered on the east end of the Island between the current town of Souris and East Point, and on the North shore in the Malpeque and Rustico Bay areas (Baldwin, 1998).

There is a much more detailed record of the Island's modern history which is generally described as the time since Jacques Cartier arrived in 1534. Cartier designated the land as a colony for France and it was named the Isle de St. Jean. By the 1700s, Britain took interest in the colony and after a series of wars between the French and English it was eventually ceded to Great Britain. In 1767, the Island was surveyed and divided into 67 lots of approximately 20,000 acres each. Each parcel was distributed by a lottery to private proprietors who lived in Great Britain. Despite each proprietor's obligation to promote settlement within their townships, by 1774 the Island's population remained very small at 1,215 people and with only 19 of the 67 lots having any permanent residents. The absentee landlords charged significant amounts of rent to the settlers living on the land, which created much conflict between the Islanders and the Crown. Finally by 1873, the local Island government agreed to join Confederation in exchange for a promise that the remaining absentee holdings would be purchased and the land would be made available to Island residents for purchase. Despite gaining independence from the Crown at that time, the remnant boundaries of the 67 original parcels remains evident in settlement patterns and rural landscapes on the Island today. (Bolger, 1973)

In more recent years the distribution of Island residents has steadily shifted toward urban centers, and currently 45% of the 138,000 people on the Island reside in communities of more than 1000 people. The major community centers on the Island include two cities, Charlottetown (58,625) and Summerside (16,153), and seven towns; Alberton (1,081), Cornwall (4,677), Georgetown (634), Kensington (1,485), Montague (1,802), Souris (1,232) and Stratford (7,083). Despite the small population on the Island, its population density is the highest of all Canadian Provinces at 23.9 people/sq km, which contrasts the national average of only 3.2 people/sq km. (Statistics Canada, 2006)

CLIMATE CHANGE AND SEA LEVEL RISE IN THE MARITIMES

The impacts of global warming are expected to be felt around the globe in various ways due to local geographic variations. Researchers project that in the Maritimes there will be an increase in both the mean annual temperature and annual precipitation rates. By 2050, temperatures are likely to increase by 2 to 4˚C in the summer and between 1.5 and 6˚C in the winter (Vasseur & Catto, 2008). It is important to realize that such apparently minor shifts in average temperatures can have significant impacts on the length of the agricultural growing seasons. The changes in precipitation are expected to be seasonal and are likely to be experienced through more frequent extreme precipitation events, with summer months expected to be much drier (Vasseur & Catto, 2008).

Of particular concern for this region are the potential indirect impacts on the coastal zone, primarily as a result of global mean sea level rise. Locally, the impacts will be two-fold as much of the Maritimes is submerging due to tectonic rebound. Historic tidal data from Charlottetown indicates that there has already been a rise in sea level of over 30 cm over the past hundred years, this being under *pre*-climate change conditions (McCulloch et al., 2002). This trend is projected to continue and the affects of which will be cumulative with the rise in global sea level; as such, the Maritime region will experience a greater rise in relative sea level then in other coastal areas in Canada (Vasseur & Catto, 2008).

As the water rises, low lying areas will be permanently flooded by sea water, reshaping the coastline of the region. Periodic coastal flooding which already occurs as a result of storm surge events will continue to occur but will impact relatively higher elevations. Recent records indicate that a storm surge of about 3.6m occurs approximately once every 40 years in the southern Gulf of St. Lawrence and to date the highest storm surge level on record for the City of Charlottetown occurred on January 21, 2000 with a maximum height of 4.23 m above chart datum (Vasseur & Catto, 2008). Climate change models indicate that there will be an increase in the frequency and intensity of such storms and what was once a 1 in 40 year storm event, will likely be experienced annually by as early as 2100 (Webster et al, 2005).

Dealing with property and infrastructure damage as a result of storm surge events has become a regular occurrence in recent years. Hurricanes which normally become weaker over the colder waters of Atlantic Canada, have been hitting the coastline with more strength and on average, three to four tropical storms or hurricanes pose a threat to this region each year (Environment Canada, 2002). On September 28, 2003, with the North Atlantic 3-4 degrees warmer than normal, Hurricane Juan was strengthened to a category 2 hurricane as it reached Canadian waters and winds reached 186 km/hr in some areas of the Maritimes. Storm surge waters were almost 3m high in the Halifax Harbour, and maximum waves reached 19.9 m in height. Damage estimates for Nova Scotia and Prince Edward Island combined were approximately $300 million dollars. Less than five months later on February 19, 2004, a classic *nor-easter* winter blizzard, since given the nick-name of White Juan, hit the same region. In some areas almost 1 m (95.5cm) of snow fell in less than 24 hours, over 20 cm more than had previously been recorded for both Halifax and Charlottetown. Wind gusts reached 124km/h in Halifax and 104 km/h in Charlottetown, with tides 1.5m higher than normal. Once again, estimates on property damage due to coastal flooding during this storm exceeded all previous records. (McIntosh, 2004)

REGIONAL ASSESSMENT THROUGH FLOOD RISK MAPPING

Scientists have previously attempted to communicate to Island residents through reports, presentations and media releases, however little to no action has resulted from these discussions on the implications of projected sea level rise. The consensus appears to be that further research is still required to thoroughly assess such potential impacts, with different communities requiring unique forms of assessments to address their equally unique coastal conditions. However, natural forces do not recognize municipal boundaries and adaptation strategies implemented in one area are likely to have compounded effects down shore. If neighbouring communities do not work together, their efforts could negatively impact one another. Thus the intent of the regional analysis undertaken in this study was to document the entirety of the Island's coastline in a series of flood risk maps, illustrating the extent of potentially submerged land and areas at risk of future inundation by storm surge water levels, and from which further research can be conducted.

Flood risk mapping is a relatively simple concept that can become incredibly complex as additional variables are included in the calculations for the model. Water levels are not a static measurement and the maximum elevation of a potential flood is influenced by many variables including high tide, regional storm surge levels and local wave run up influences, such as wind speed, direction, offshore water depth and the shape of the shoreline (BirchHill GeoSolutions, 2007).

When the Geological Survey of Canada conducted their research on the impacts of sea level rise on the City of Charlottetown, the scientists had used a mean value of the IPCC's projection of global sea-level rise, in combination with other regional influences such as land subsidence, local storm surge, wind, waves, and ice cover. Their conclusions indicated that the upper limit of the area at risk of future flooding was somewhere between the elevations of 4.23m and 4.93m above chart datum. The low end of this range is equivalent to the flood that had been experienced in the record breaking storm of January 2000, and thus can not be considered as a future flood projection but instead as a baseline for the present flood risk zone based for the highest storm surge on record. The ‘worst case scenario’ projection (4.93m above chart datum) was calculated based on the same storm occurring after a rise in sea level of 0.7m, where 0.5m was taken from the mean value for projected global sea level rise, and 0.2m accounted for continued land subsidence within the region. (McCulloch et al., 2002)

In addition to water fluctuations, flood risk maps also require data on the land being flooded, most importantly a representation of the local topography. In the 2002 study, high-resolution topographic data called LIDAR (Light Detection and Ranging) was used to map the topographic elevations in great detail. During the spring of 2008, the Provincial government flew PEI in its entirety to collect similar topographic data however, by the following winter due to financial constraints, the collected data has not yet been processed and climate change researchers on the Island remain uncertain on when this data will be made available for their use. In the mean time, for smaller municipalities or for conducting larger regional analyses, a more cost-effective and timely technique is to simply identify the low lying areas below available topographic contour elevations along the coast without further delay of the pending LIDAR data availability (BirchHill GeoSolutions, 2007).

For the present study, the flood risk categories were classified relative to the degree of accuracy of the 1:50,000 (2 meter) contour intervals. Given the uncertainty that still exists within climate change projection data, this level of resolution provides enough detail for general categorizations between present observed risks and future potential risks, and allows for comparisons based on the relative impacts between different areas. When the high resolution LIDAR data does become available in the future, the analysis can be conducted again to not only refine the limits of each range, but also to further sub-classify the levels of risk.

Using the 2m contours, all land areas below the 2m elevation was identified as being at *high risk*. This low lying land is already prone to flooding during storm surge events, with the Charlottetown area currently experiencing a surge of about 2.5m every 7 years (McCulloch et al., 2002). With projected increases in storm frequency and intensity these flood events will become more frequent and the ability for this low lying area to regenerate, or for infrastructure within this zone to be repaired between flood events will continually decrease over time. This high risk zone is also recognized as having the *most immediate risk* for permanent inundation.

Although chart datum elevations do not directly correspond with a constant topographic elevation around the Island, the 4.93m above chart datum level I is understood to be approximately the same as the 3.25m topographic elevation for the Charlottetown region (D. Poole, City of Charlottetown, personal communication, March 2008). As the available topographic data for the Island is limited to 2m intervals, the area between the

2m and 4m contours was considered on a general basis as that area which most closely corresponds with the flood risk limits as defined in the previous study.

As previously discussed, a margin of error exists when an impact assessment is based on a mean value of the projected global sea level rise range. As well, we are now aware that the data available in 2000 did not account for any additional sea level rise that is expected to occur due to continued ice sheet melting. Thus their *worst-case scenario* projection of 4.93 above chart datum can no longer be considered as an upper limit for potential flood risk areas. The elevation between the 4m and 6m contour intervals was included in this regional impact assessment, to account for these additional unknown variables of current projection models. The total elevation range, between the 2m and 6m contours, was classified as having a *moderate risk* to future flooding due to storm surge events. This flood risk zone accounts for a storm surge of the same intensity as experienced in January, 2000 occurring at high tide, continued land subsidence of at least 0.3 m/century, and a global sea level rise of approximately 1.4 m. The exact limits of an extreme scenario remain unknown and thus all interior land, above the 6m elevation, is considered to be at *low risk*, as it is above current projections for global sea level rise due to thermal expansion, and is out of range for projected storm surge flooding. However, pending future research on the long term consequences of the complete melting of the polar ice sheets, the potential for flooding beyond the 6m elevation can not be entirely disregarded. These sea level projection flood levels should not be mistaken as single flood events with a defined beginning or end, but instead as a continual process, the time frame and upper limit of which remains highly unknown.

In addition to the topographic data, land use and property data was used in the analysis of flood risk areas identified in the flood maps. This data was provided by the Province of Prince Edward Island in a Corporate Land-use Inventory 2000 (Department of Environment, Energy and Forestry, Government of PEI, July 2007). By including selected components of this dataset in the flood maps, specific implications could be further assessed, including impacts on various land-uses, land cover, roads, and ecologically sensitive areas such as National and Provincial Parks.

To contrast this strictly data analysis, a field-based visual assessment of the coastline provided additional information with regards to unique local coastline characteristics. Where one area may have been identified as being at a higher risk due to its relatively lower elevation, the more localized analyses may indicate otherwise due to other factors such as shoreline exposure, or erosion vulnerability. The photographic record of the coastline is used to further illustrate the natural variability and complexity of existing conditions on the water's edge around the Island. The photographs, documented over a two year period (2008-2009), also provide a basis for future comparisons as the coastline continues to change.

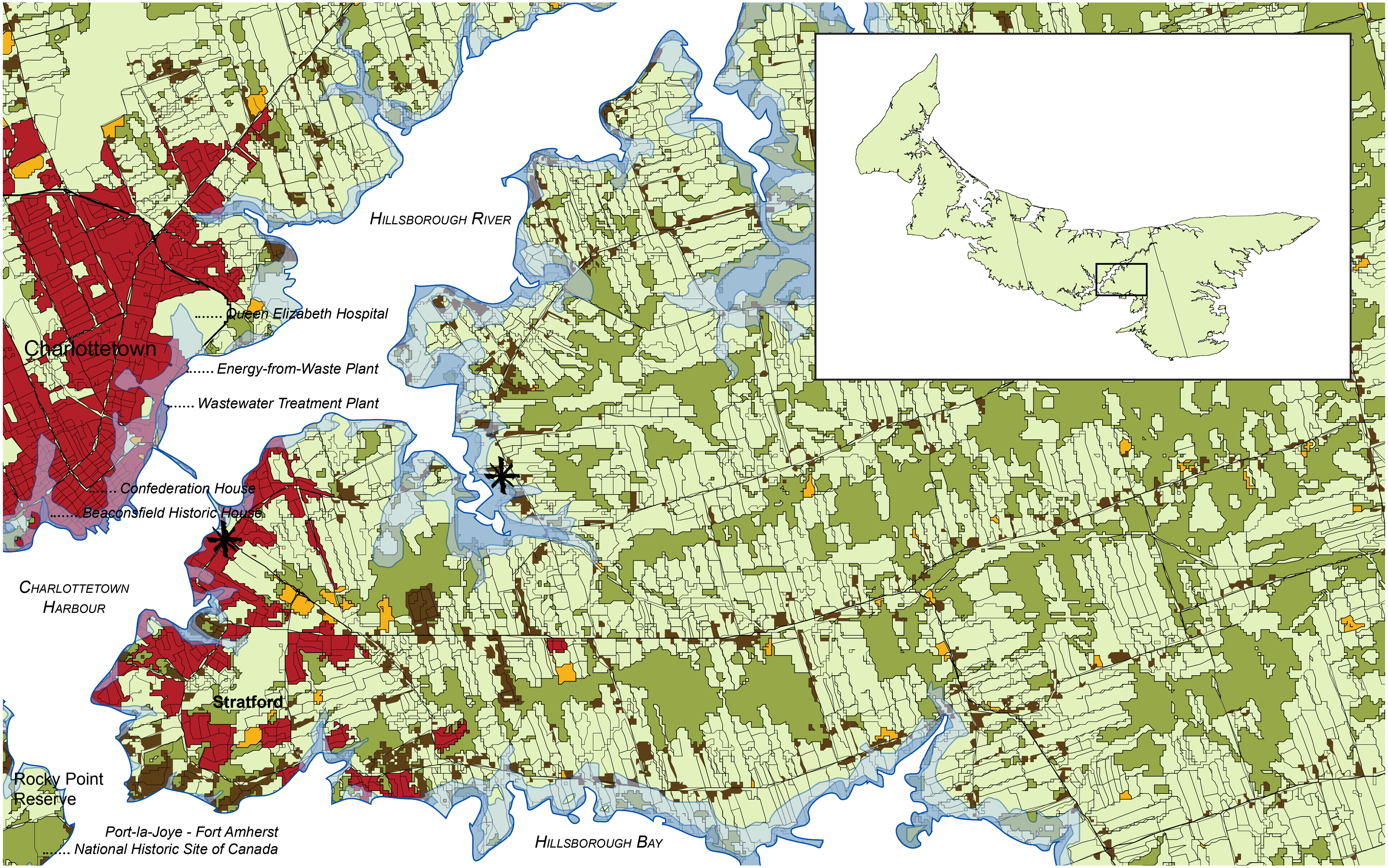
The final series of regional flood maps for the Island is attached in Appendix A.

FROM IMPACTS TO APPLICATION

Smart decision-making begins with having access to information and knowing what further research is still needed. Despite the necessary generalizations in the data, basic topographic flood risk maps are considered adequate to support preliminary discussions on planning for adaptation initiatives. These maps can be used primarily for identifying the high risk versus low risk areas, but also for delegating responsibilities to the smaller communities, by empowering municipalities, neighbourhoods and individuals with the ability to start making pro-active adaptation decisions rather than remaining dependant on government run initiatives which may face continued delays due to political controversy. The Provincial wide impact analysis provides equal coverage for both urban and rural areas, recognizing the importance of adapting coastlines of agricultural and forest covered land, as well as for city centers. In addition to identifying the areas that are directly within the flood risk zones, inland areas may also be impacted through relative association and the domino affects of such influences should also be considered. For example, if a coastal road is washed out, inland areas will need to be used to reroute transportation infrastructure, but consequently development trends are also likely to change accordingly, to follow these new routes.

Each flood map is worthy of generating a lengthy discussion on the identified flood risk zones, the potential ramifications, and for adaptation related action plans. The following summaries provide an example of three different coastal conditions, the urban, rural and small community; each is just a preliminary examination of the breadth of information that can be generated from the regional flood risk assessment maps.

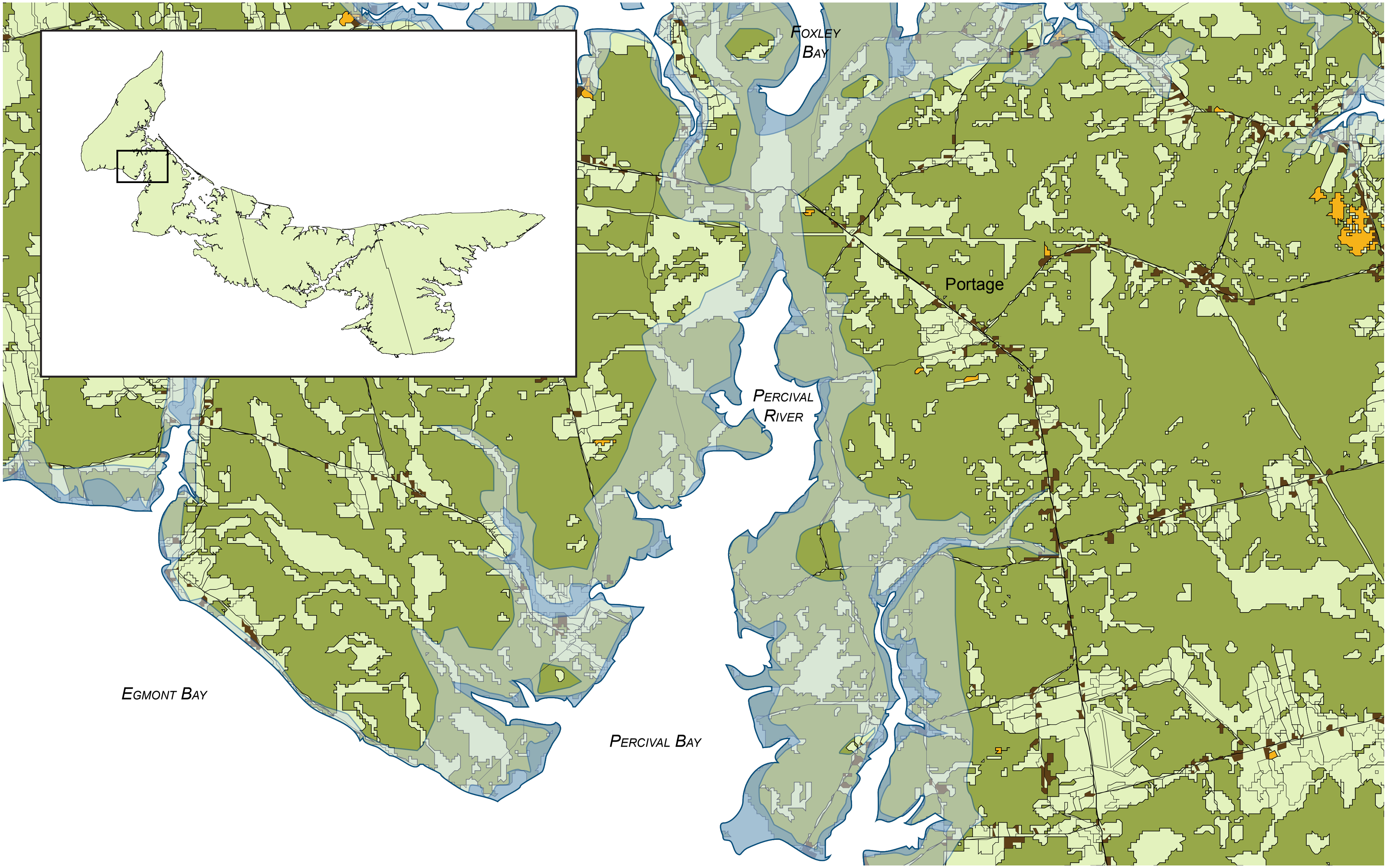
Map Q10 – Charlottetown and Stratford, shows the east side of the Charlottetown Harbour, the Hillsborough river area and the Town of Stratford. Of particular interest is the contrast between land uses within the flood zones in the City of Charlottetown versus those in the Town of Stratford. Stratford's town centre and the majority of the commercial and industrial properties are more centrally located, and the waterfront properties have been developed mainly as privately owned residential uses. Current proposals to build 3 – eight story condominium buildings on Stratford's waterfront indicate that the town is moving towards further coastal development and adaptation strategies should be implemented in a proactive manner. But despite future development, Stratford may actually find that one of its primary impacts is the potential for being cut off from the services that are heavily relied on in Charlottetown due to the significant low lying area on the north side of the Hillsborough Bridge. Charlottetown on the other hand, has a highly developed waterfront and will require adaptation measures for existing infrastructure which will likely be more challenging than the pro-active new development proposals. Cost-benefit analyses are required in assessing the degree to which protection measures should be taken and the historical significance of Charlottetown's waterfront will likely play a large part in dictating the direction of such adaptation measures.



Q10 Charlottetown & Stratford

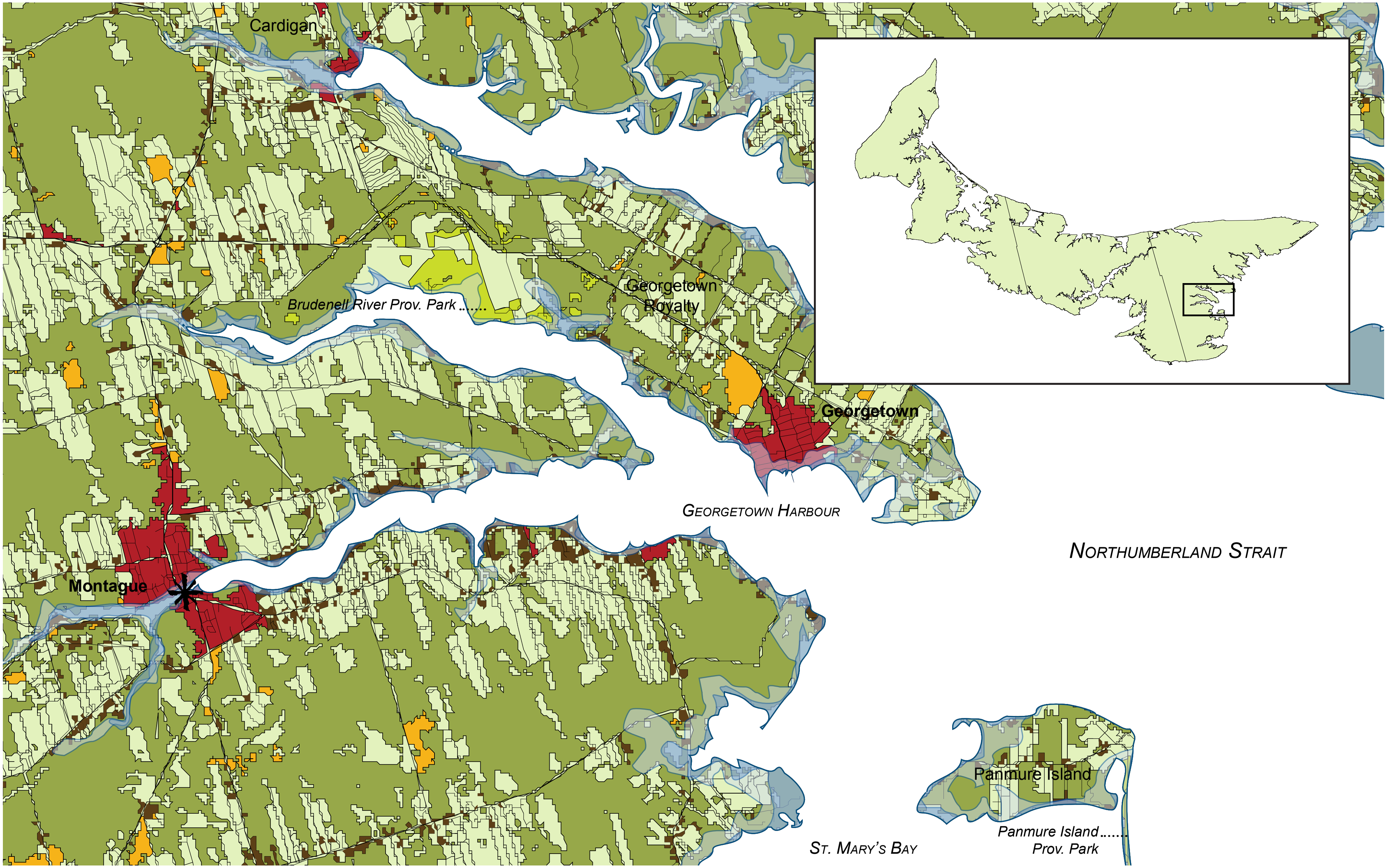
Rural areas on the Island are as equally vulnerable as the developed waterfronts within communities. *Map P16 – Percival Bay,* shows an area of low lying land that extends much farther inland, and at this location a storm surge, flooding to the 6m elevation could eventually connect through from the south to the north shore, essentially dividing the Island into two. Although there may not be existing development or infrastructure requiring immediate protection in this particular area, the general maintenance of RTE 2, the Western Road, is critical to the entire West End of the Island. Through continued monitoring, under early signs of stress the highway could be reconstructed into a causeway or bridge well before an unexpected storm-surge event occurs that would otherwise critically isolate this large portion of the Island.

Further research on this region's exposure and erosion potential, should be examined prior to future development or significant changes in land use. As a known flood risk area, special planning incentives should be used to preserve the natural resistance that the area currently has in tact. The existing forest cover on the south will reduce the low-lying area's vulnerability to erosion as storm surge levels increase. The importance of maintaining this cover, and ensuring that salt tolerant species are incorporated into the existing ecosystem should be considered a priority.



P9 Percival Bay

Map K13 – Montague, Georgetown and Panmure Island illustrates that even within close proximity, a wide range of impacts could occur between neighbouring communities. Georgetown, which is located on a low lying area at the tip of a peninsula, will be much more vulnerable when exposed to high storm surge levels in comparison to the Town of Montage which is located on relatively steep banks of the river. There is currently little development directly on the water's edge in Montague and inland flooding and salt water intrusion of the river are likely to have more impact than the direct impacts from surge events. The exposed east side of Panmure Island is relatively high which helps to protect the habited lower lying area to the west, however the only road access to the Island is across a very vulnerable, low lying dune system that has been made into a causeway. This access road has to date been well maintained as it is a designated Provincial Park but as storm intensities increase the chances of this Island becoming cut off from the mainland for periods of time due to wash out, or permanently due to sea level rise, will become more likely. Panmure Island residents should be made aware of these imminent risks so that they can be better prepared for such events, and for long term changes in the accessibility of their community.



K11 Montague, Georgetown & Panmure Island

RECOMMENDATIONS FOR FUTURE RESEARCH

On a regional scale, flood risk maps are a preliminary step for identifying the potential high risk zones. Once identified, localized studies into the additional factors that influence the degree of potential risk for a specific area can be assessed in further detail. These studies may include factors that influence storm surge likelihood, such as the local bathymetry, fetch and sea ice cover; as well as land based influences such as vegetative buffers and soils and geological factors relating to erosion rates.

In contrast, analyzing past trends and experiences may be just as valuable for identifying adaptation needs of an area. To date, there is no known database for tracking occurred impacts from storm surge events. With surge levels varying significantly along a coastline, the number of monitoring stations that would be required to measure these fluctuations would be impractical. However, the relative degree of impact experienced between one home and the next could be determined, and thus could also contribute to the projection model calculations. Such a database would require archival research, as well as establishing a method for collecting information upon future storm surge events. Documentation, such as insurance claims for example, could be collected and the “data” could be mapped to track the varying impacts of each surge occurrence. The past trends of high risk zones could then be identified and assessed comparatively with the projection models. Unfortunately the value of such a tool is limited by the amount of data that is collected and thus it would be necessary to implement such a process sooner rather than later.

In addition to such “data” based impact assessments, there is a wealth of knowledge currently stored within private collections in the form of photos, personal records and in memories. Stories told by past generations, of extreme storm events and the gradual processes of change within the landscape, indicate that coastal processes have been adapted to in the past and have been accepted in the past as inevitable change. This *soft data* may also be found to be a more useful tool for reminding long term residents of the changing coastlines, and for explaining how these past processes are likely to be accelerated by climate change processes in the future.

CHAPTER THREE. ASSESSING VULNERABILITY

INTRODUCTION

From the regional impact assessment it is recognized that varying landforms and land uses that currently exist along the Island's coastline require different methods of detailed risk assessment and equally unique strategies for adaptation. Despite the importance of assessing natural processes on a regional scale, adaptation measures are more likely to be implemented at a local scale, by municipal governments and community organizations as this is the scale in which local development is approved under the *Provincial Planning Act*. Unfortunately such detailed studies are rarely conducted for small communities or rural coastlines due to financial and temporal constraints. As such, the present study further proposes a method for conducting a relatively low-cost, data-based property vulnerability assessment for a small coastal city which is based on existing property information as the primary data source.

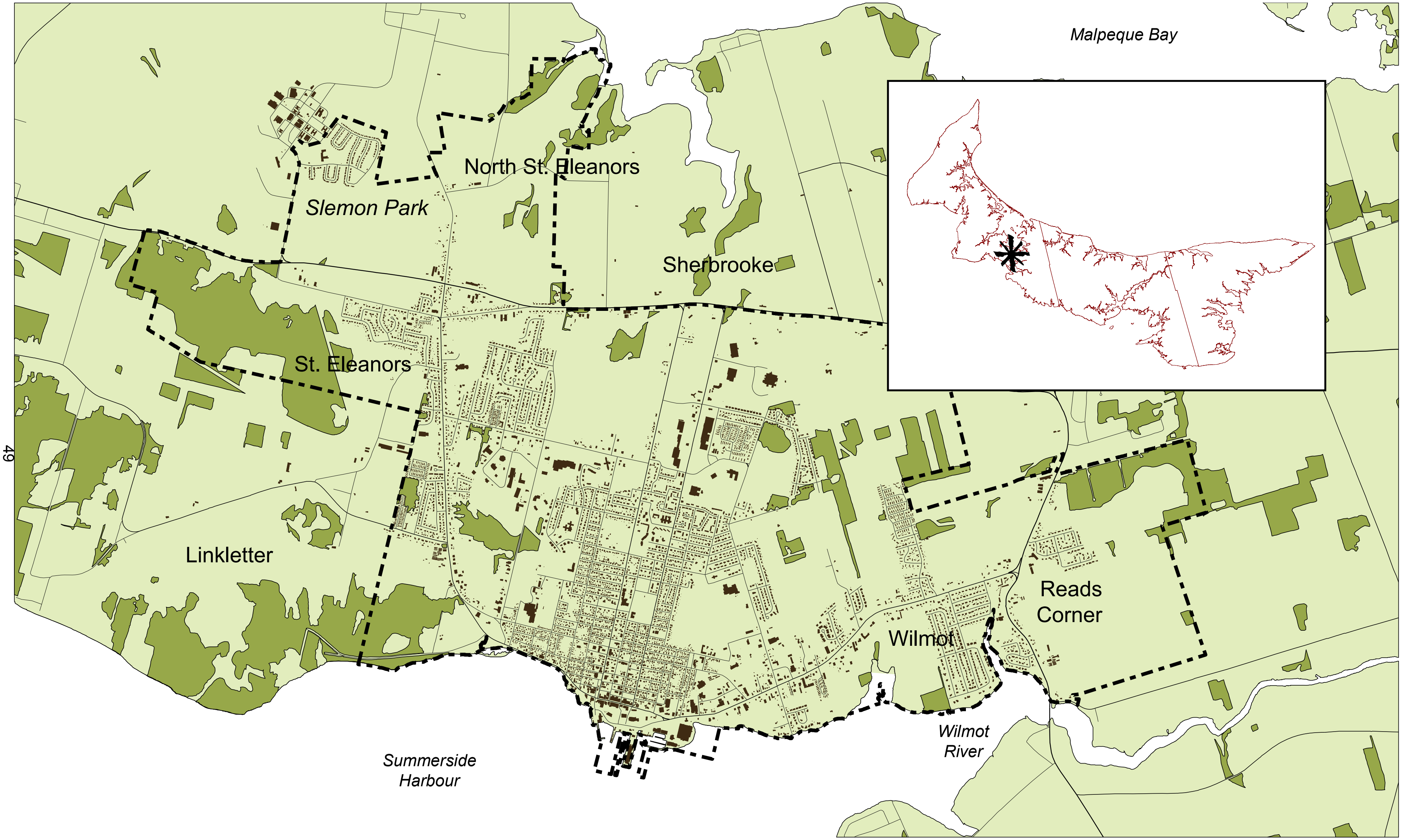
Vulnerability accounts for not only the potential flood risks of low lying land areas but also the socio-economic impacts that result from such risks and which varies significantly between different land uses. For example, different land uses are typically given different levels of priority when assessed for necessary funding in disaster relief scenarios, especially during reactive adaptation decision making processes, when immediate health and safety concerns are of the utmost importance. In the past, public funds have generally been allocated to those areas that will help the greater public good however we must remember that disaster relief resources are expected to decrease as extreme climatic events become more frequent worldwide (Holms, J. February 12 2008). The proposed vulnerability assessment, conducted here for the City of Summerside, attempts to distinguish between those land uses that are more vulnerable than others. The results can be used to guide the implementation of proactive adaptation strategies, which private land owners can equally benefit from, through smart planning and innovative design practices.

CONTEXT: CITY OF SUMMERSIDE

The City of Summerside was officially formed on April 1, 1995 after amalgamating the former Town of Summerside, and the Communities of St. Eleanors and Wilmot, and part of the Community of Sherbrooke. It is located on one of the narrowest portions of the Island and the municipal boundaries extend between the Bedeque Bay to the south and the Malpeque Bay to the north, with a total land area of about 29 square kilometers. The topography is relatively low with the highest elevation at about 39 meters. (City of Summerside, 2006)

The history of the area's development was predominantly influenced by trade due to Summerside's superior harbour and its proximity to the railroad networks in New Brunswick and eventually on the Island itself. Summerside is well known for its role in the lucrative silver fox industry during the Depression years and by 1941, the Town's population had grown to well over 5,000 people. The physical growth of the community originally stretched outwards from the waterfront along the old Number 1 Highway, which included South Drive and Water Street East. In the 1960s, the new Number 2 Arterial Highway was built, and had been specifically designed to bypass downtown Summerside by extending between St. Eleanors and Sherbrooke to the north of the city center. Limited development has been allowed along this highway, but as a result of its location, the commercial growth in the City shifted northward and resulted in what is now a well developed *vehicle-oriented* commercial centre on North Granville Street. In the early 1970s the Summerside Regional Development Corporation (SRDC) responded to this shift by reclaiming a 27-acre parcel of land on the City's waterfront adjacent to the older downtown area, and over the next 20 year period SRDC comprehensively developed this waterfront with a shopping mall, offices, hotel, tourist outlets, and cultural and educational facilities. In the 1980s, the Summerside Harbour port was upgraded to accommodate vessels of up to 5,000 tons, many of which ship agricultural products throughout North and South America (SRDC, 2009). A 2003 survey of City residents indicated strong support for further commercial development and revitalization of the downtown core which contrasted views from the mid-1990s when preference was still given to the North Granville Street commercial centre (City of Summerside, 2006).

Currently, the portion of the City that extends north of the Number 2 Highway, is dominated by agricultural land with considerably less forest cover here than in other areas on the Island. A recent proposal to develop this area as a wind farm, as a source of renewable energy for the City has received considerable opposition from local residents. City Council has not yet approved this development but has rezoned the land accordingly, and the Province is currently conducting the necessary environmental impact assessment (The Guardian, 2008).



CITY OF SUMMERSIDE

FLOOD RISK MAPPING

The topography data and flood risk classifications that had been used in the regional provincial analysis were also used for the impact assessment at the local scale for the City of Summerside. Starting with a similar topographic flood mapping exercise, different levels of risk were identified for each topographic band along the City's waterfront, where: the 0-2m elevation range was classified as high-risk, the 2-4m elevation range was classified as moderate risk, and the 4-6m elevation was classified as a low risk potential flood zone. The areas located above 6m elevation were not considered to be at a risk level that warranted any further detailed assessment at this time.

The flood risk map generated with these three contour intervals, provides a general overview of the low lying areas. Four locations on the south shore and two on the North shore reflect the freshwater inlets that either exist or did exist at one time along these coastlines. The downtown core which includes the reclaimed land on the waterfront adjacent to the piers is clearly showing as the largest land area beneath the projected flood risk elevations.

City of Summerside

Flood Risk Analysis

Topographic contours highlighting areas beneath the 2m (high risk), 4m (moderate risk) and 6m (low risk) elevations for the purpose of general flood risk analysis.

FLOOD RISK MAPPING FOR PROPERTIES

Although this topographic based flood risk assessment was found to be useful at the regional scale, there are limitations to applying these general flood risk categories into practical use within the city. The flood risk zones can be used to identify potential impacts for general areas but not at a scale conducive to independent site development by property owners. In contrast by merging the topographic-based risk data with the boundaries of each property, a new type of flood risk map is produced. This map illustrates the same general trends as the topographic flood risk map, but communicates quite differently. In the new map, individual properties are identified by the flood risk zone in which they are located. The implications of such a categorization are capable of influencing not only future development trends, but also specific property assessments and insurance premiums. Over time, one might expect or hope that these other factors will encourage land-use choices in a more responsible direction; whether or not development policies or general attitudes towards climate change are adapted in the mean time.

City of Summerside

Flood Risk Analysis

Property flood risk analysis based on topographic elevations.

VULNERABILITY RISKS

Identifying the projected impacts is only the first step in making decisions towards implementing adaptation strategies, which can not be based on topographic analyses alone. Instead, areas and more specifically properties should be assessed by their vulnerability, which is defined as a function of both the degree of projected impact and the adaptive capacity, or the ability for adaptation measures to be implemented. For example, a vacant lot would not be considered as vulnerable as the city's sewage treatment plant, despite being situated on adjacent properties at similar elevations. Some properties will have more to lose than others in the event of a flood, and some will cost significantly more to protect; those properties will have a lower adaptive capacity and thus a higher vulnerability.

The method used to assess the vulnerability of properties was adapted from the methods used by Shaw (1998), in the Canada wide Coastal *Sensitivity* Study. In the previous study, Shaw (1998) *calculated* coastal sensitivity based on seven variables that were collected for different coastal regions, including relief, rock type, coastal landform, sea level tendency, shoreline displacement rate, mean tidal range, and mean annual maximum significant wave height. Each variable was assigned a value in the range of 1 to 5 relative to the degree sea-level rise would result in physical change of that variable on the coastline (Shaw et al. 1998). The Sensitivity Index (SI) was calculated by the following formula:

$$SI = \sqrt{(a1 \times a2 \times a3 \times a4 \times a5 \times a6 \times a7)/7}$$

Similarly, the proposed Vulnerability Index (VI) was based on a series of variables related to aspects of a property that would be impacted by such change, where *n* indicates the number of variables used in the assessment:

$$VI = \sqrt{((a1 \times a2 \times a3 \times a4 \ldots \times an)/n)}$$

As the proposed method is intended to be transferrable to other communities, the number and type of variables used in the assessment should be based on availability of data, and when applying this formula in other areas, the number and type of variables may change.

For the City of Summerside, four variables were chosen in the calculation of the Vulnerability Index (VI), where: a1 = potential flood risk; a2 = property assessment; a3 = property size relative to risk, and a4 = current land use zoning. For each property within the City that is at least partially beneath the 6m contour elevation, these property variables were assigned a value in the range of 1 to 5, where 1 indicates a low degree of influence, and 5 indicates significant influence by change.

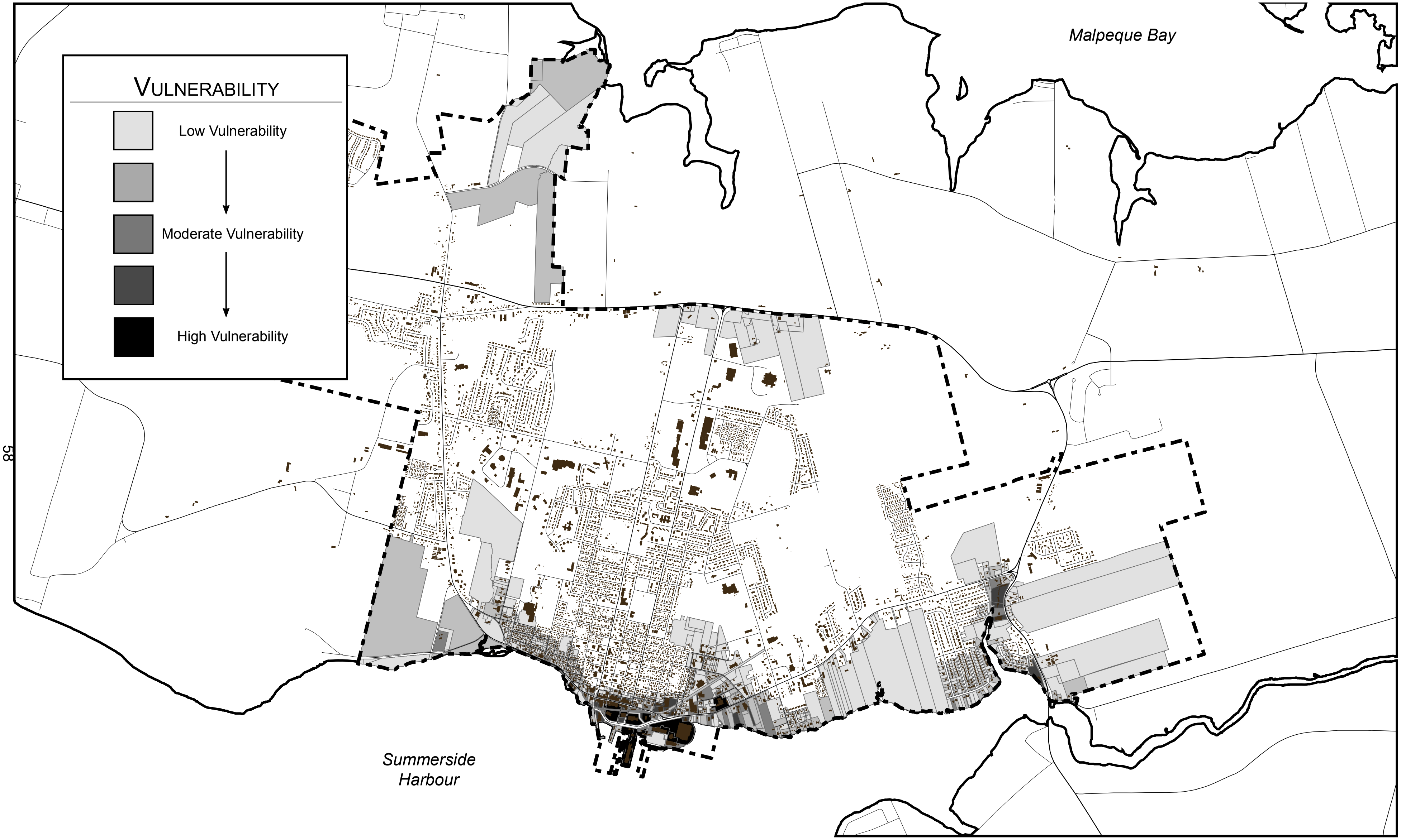
As previously described in detail, the a1 variable was used as the indicator of the relative level of flood risk based on the topographic analysis. All properties beneath the 2.0m elevation were considered high risk and were assigned a value of 5. All properties within the 2.0 to 4.0m elevation range were considered at moderate risk and assigned a value of 3, and all areas between the 4.0 and 6.0m were assigned a value of 1.

The property assessment variable (a2) was used as an indicator of the existing property and infrastructure value. One may dispute that a property with a higher assessed value is not necessarily more vulnerable, as a factor of the ability for that property to be adapted. However, the property assessment rates are directly related to insurance claims and to disaster relief disbursements by local governments, and thus the properties with a higher “value” will carry a greater burden on the community should they be impacted by sea level rise. By identifying the properties with a higher assessed value as being those that are more vulnerable, the intent is to reduce that vulnerability prior to an extreme storm event, so that when needed, available funds will be available for disbursement between more less-vulnerable (ie. less assessed value) properties.

The next variable (a3) was based on property size and the percentage of property within the identified impact zone. This variable was needed to offset the potentially skewed values for very large properties with high assessment values, and for those properties that have undeveloped portions of land in low elevations and developed portions located at relatively higher elevations. Open space, parkland, cemeteries and other designated green spaces within the city were valued equally as built infrastructure as not to diminish their importance to the City as a whole.

The final variable (a4) was an indicator of land use, based on current zoning classifications. Although land use zones are variable in themselves, the value assigned for each property was associated with the types of use permitted within the zone and the relative impact that a change to that use would have on the greater community, such as through the potential lose of public resources, infrastructure and employment opportunities. In this case residential properties were considered to have the lowest vulnerability, as private dwellings are generally not as location specific as other commercial or industrial properties which may rely on surrounding resources and transportation infrastructure. High density residential complexes, seniors housing and other special residential uses could have been identified as being more vulnerable than typical single family homes, however this information was not included in the present study.

Finally the Vulnerability Index values were calculated for each property and were grouped into high, moderate and low vulnerability categories to produce a final Vulnerability Index map for the city. The benefit of quantifying the varying degrees of vulnerability between individual properties is to provide a reference point for establishing priorities for implementing adaptation strategies. The map can be used to identify the areas with the highest vulnerability and to encourage a smart-direction of growth for future development. This map is also useful for identifying relative risks and associations between properties, where the implementation of adaptation strategies (or lack there of) for one property may have adverse or beneficial influences on another.



City of Summerside

Flood Risk Analysis

Property vulnerability index analysis based on combined factors relating to impact risk assessement and adaptive capacity.

VULNERABILITY APPROACH

For comparison, a similar method called the 'vulnerability approach' is described in detail in the *Climate Change Impacts and Adaptation: A Canadian Perspective* report (2004); where the current vulnerability of a system is initially examined independent of future changes. The first step in the Vulnerability Approach involves the engagement of stakeholders, such as industry representatives, public planners, landowners and policy makers. By establishing a two-way exchange of information and ideas, the particular system or region of interest can be better understood by the researchers and the results of the study are more likely to be adopted by the stakeholders in their future decision-making processes. The second step in the process is to assess the current vulnerability of the system. In this case, vulnerability is defined as "the degree to which the system will be susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2007b). Therefore, it stands to reason that if appropriate adaptations measures are implemented, then a system which may be highly sensitive to climate change variability, will not necessarily be vulnerable when faced with such changes (Lemmen & Warren, 2004). Once the current vulnerabilities are determined, researchers applying this method use climate, environmental and socio-economic scenarios to evaluate future impacts. Adaptation measures are thus implemented based on factors that will reduce the existing vulnerability but not necessarily the level of risk. This approach provides a framework for establishing priorities through the involvement of stakeholders and encourages the implementation of no-regrets adaptation strategies, which can result in both immediate and long term benefits. (Lemmen & Warren, 2004)

The Vulnerability Approach has been identified as having both benefits and limitations (Lemmen & Warren, 2004), and the proposed method for mapping an index of vulnerability is not intended to replace this established approach, but instead to be used in conjunction with it. Small, rural communities and small cities that have limited resources for hiring consultants to conduct such lengthy studies can use this data-based vulnerability mapping technique to quickly identify high risk areas, to establish priorities for altering (if necessary) their land use management plans, and for communicating with local property owners, to encourage innovative design ideas to decrease their own vulnerability levels along the coast.

The definition for adaptive capacity is the "*ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*" (IPCC, 2007b). A property or region's adaptive capacity is a relative term which can only be measured in comparison to another more or less *able* system. In the present study, adaptive capacity is assessed as the likelihood that a property will be more or less negatively influenced by changes that will result from sea-level rise and increased storm surge frequency and intensity, and thus will require more or less effort (or expense) to mitigate or prevent such changes from occurring.

MISSING LINKS

The proposed method is intended to be a first step in assessing the impacts and vulnerabilities of properties, but disadvantages of using such a *data*-based assessment tool have been recognized. An obvious challenge is in the time-consuming review of the existing datasets to ensure that they are up to date and accurate, with the size of the dataset being directly related to the size of properties and the length and slope of the coastline being assessed. Other challenges are related to missing links such as property characteristics that can not easily be quantified, and the potential for conflicts of interest with the stakeholders that are involved in the process.

Properties that are indirectly impacted by projected coastal flooding and extreme storm surge events are also overlooked through this method. Transportation infrastructure that is located along the coast may be the only access route for a property located further inland. Water, sewer, electrical or communication services may also be impacted in the coastal area which may trigger outages of services, or sewer backups for properties outside of the identified impact limits. Impacts to community and emergency resources will ultimately impact an entire community and reducing the vulnerability of these properties should be identified early in the process.

The proposed *data*-based method also excludes the more qualitative characteristics of the City, including heritage assets, landscape and landmark features, and the community's sense of place which can exist at numerous scales but more frequently would be described as including numerous properties and overall streetscapes rather than an individual property. These significant *variables* can only be properly included into the assessment through public participation processes, which should involve more than just the immediate property owners but also members of the community as a whole. Such participatory programs should be proactive to get people involved prior to a disaster situation to avoid situations that would result in rash decision-making. Seminars on how private property owners can help to reduce their own vulnerability could help assist individuals when local government initiatives are planned for other properties with higher degrees of vulnerability.

When cost-benefit strategies are being used to assess the appropriateness of different adaptation strategies, there are bound to be individuals with opposing views. Whether discussing long term permanent inundation of coastal properties or temporary impacts due to extreme storm surge events, it is not expected that an individual property owner would likely surrender their own land, home and/or livelihood easily. By seeking pro-active adaptation strategies through public processes a community can hopefully avoid these potential conflicts of interest that would otherwise exist when projected impacts are sensed as an imminent threat.

Conflicts of interest may also arise when attempting to label properties within vulnerability categories, as there are both benefits and disadvantages to being identified as a highly vulnerable property. A property that is identified as highly vulnerable to flooding is likely to loose value over time, as well as to eventually have increased insurance rates, or worse, to be uninsurable at all. With a short term perspective on these consequences, this is likely to turn property owners quickly off from any public participation process; actions that remind us all that *ignorance is bliss*. However, if the same property owner is made aware that the Insurance Bureau of Canada is currently the leading sponsor of climate change adaptation research in the country (RAC, 2009) and that their insurance rates will be increasing regardless of whether or not their community identifies the risk in advance or not, then they may want to take a proactive approach to reducing their own vulnerability and thus potentially benefiting from services or funding that may be available to those people taking proactive measures. The highly vulnerable areas will also likely take priority in the public initiatives for implementing policies regarding future development and adaptation measures.

Where the data-based vulnerability assessment has its strength is in the nonpartisan and unbiased nature of the results. The maps are disconnected from the people and their emotional ties to the land. It thus provides a starting point for introducing the information to the community and for generating dialogue about ways in which the community can take responsibility for improving their own vulnerability to projected climate change impacts.

“While humans have access to massive amounts of information describing the state of the Earth, we seem incapable of acting upon it to influence the future.”

David Suzuki, *in* Aberley, 1994

CHAPTER FOUR: ADDRESSING ADAPTATION THROUGH DESIGN

INTRODUCTION

The importance of a phased approach in the implementation of adaptation strategies can not be underestimated. Climate change trends are occurring, but due to the very uncertain rate of this change, responses have been delayed and in many cases completely absent. Similarly, extreme adaptation protection measures are more likely to be ignored than taken seriously by any region not currently in a state of emergency.

Climate change researchers are now going further than strictly identifying the impacts and vulnerabilities of the coastline, and are exploring what is meant by adaptation and what are realistic approaches to adaptation for a particular area. As many small cities and rural communities are already challenged by the demanding constraints of day-to-day business, the hope of having an adaptation management study conducted in such an area is not as likely to happen as it is for a highly vulnerable, highly populated city. Municipal planners and policy makers within Atlantic Canada, in particular, have had little success at implementing such initiatives. As such, it is proposed that the most appropriate immediate response is through the education and direct dialogue with individual property owners, developers and designers. If these individuals can accept responsibility for their role with regards to incorporating phased adaptation into plans for new development, then it is more likely that after observing the benefits of these actions, that the community as a whole may adopt a policy with regards to regulated such practices.

ADAPTATION *AND* MITIGATION

In many parts of the world, the general public is already accustomed to *adapt*ing to imminent climate related threats. For example, when the National Hurricane Centre in the United States detects a tropical storm, the public is informed of the potential hazard and due to prior experience and education, action is immediately taken. People are advised to have an emergency plan in place, a disaster supply kit handy and they are generally prepared to secure their home when such warnings are made. In contrast, despite the serious long term threat of projected climate change impacts, communities in many parts of the world have remained unresponsive, and as a result relatively little action has been taken towards pro-active adaptation measures.

One of the primary reasons for the lack of adaptive responses to climate change is that the focus of public awareness and educational programs has been on promoting *mitigation* strategies. Mitigation refers to such actions that aim to reduce greenhouse gas sources and emissions in an attempt to decrease the rate and magnitude of climate change. Although the importance of mitigating strategies should not be underestimated, strong evidence indicates that mitigation strategies alone will not prevent climate change from occurring (Lemmen & Warren, 2004). More specifically, even if a stabilization of carbon dioxide levels could be achieved immediately, global mean temperatures will continue to rise due to past emissions, and the global processes such as sea level rise that are caused by such temperature change will also continue to be impacted (IPCC, 2001).

Our only option for a successful response to projected scenarios requires a combination of both *mitigation* and *adaptation* strategies. Adaptation is not a substitute for mitigation but a compliment to it. Adaptation strategies aim to reduce the negative impacts of climate change and take advantage of new opportunities by making adjustments to current activities and practices (Lemmen & Warren, 2004). Anticipatory or proactive adaptations are actions taken before impacts are observed and in preparation for the potential risks. In contrast, reactive responses occur after the impacts have already been felt and are often implemented under stressful conditions resulting in rash decisions. Anticipatory, planned strategies that are implemented through deliberate, enforced policies and that have been established through the collaboration of stakeholders are more effective and cost-efficient methods to respond to projected impacts (Lemmen & Warren, 2004).

Adaptation researchers are generally faced with three questions: They must ask, what is being adapted to? Who or what will adapt? And, how will adaptation occur? (Lemmen & Warren, 2004) Most adaptation studies use a climate change scenario as their starting point, and from which, the potential impacts on natural and human-systems are identified and a range of adaptation options are then assessed. As previously discussed, there are limitations to such an approach that is based on a projection range, due to the high degree of uncertainty that exists within climate models. As such, researchers have identified a need for strategic methods of assessing risk factors despite uncertainties associated with projected future climate change impacts. (Lemmen & Warren, 2004)

Challenges have been identified in the implementation of adaptation strategies at the municipal level which include financial constraints, attitudes of the public and council members, and the nature of the municipal political process (Lemmen & Warren, 2004). In these cases, active responses to projected impacted have been found to be restricted by the very processes that were established for ensuring that such proactive, planned strategies would be in place in the event of a an emergency situation. This challenge is one that needs to be addressed through improved communication between scientific researchers and the decision makers. The transfer of information also needs to be inclusive of other professionals, such as city planners, landscape architects, architects, engineers and developers; all of whom play an important role in shaping our communities.

DESIGN FOR ADAPTATION

Climate change mitigation strategies have received much attention within the design community in recent years. In Canada, the practice of sustainable design, such as that promoted by LEED - Leadership in Energy and Environmental Design, has been accepted as standard practice by many professionals, with cities such as Vancouver leading the way in promoting sustainable growth. The theory behind sustainable design practice is also integrated into the curriculum of most accredited design schools. However, sustainable design is essentially a design-based mitigation strategy, and just as the general public has been lagging behind in responding to the need for adaptation, so have many Canadian designers. The reason, as was stated by Orr (2004), is that "we do not know enough yet and that taking action will be very expensive; however, if we do not act now, it will either be too late or it will only get more expensive and less effective". Thus we can no longer delay the implementation of adaptation strategies, and responsibilities for such actions need to be allocated.

Within the broad scope of environmental design professions, different professional roles will have varying abilities to influence the implementation of the different types of adaptation measures. The first type is in the prevention of any further development that is constructed based on out-dated data, such as past tidal gauge measures, as well as those that are simply ignorant to projected sea level rise impacts. In short, we need first stop adding to the problem. Secondly, we need to incorporate adaptation strategies into the general maintenance and upkeep of our existing landscapes and infrastructure rather than rebuilding and maintaining structures to what are now obsolete requirements. And finally, the third and potentially most challenging issue is to find solutions for long term methods of adapting existing landscapes and building infrastructure. In this case not all existing conditions will be *worthy* of being maintain in their current form. Many difficult decisions will need to be made with regards to what is worthy of being preserved and protected as a community legacy to be left for future generations. Investments into the adaptation of structures as immediate but temporary solutions should be avoided, as to focus available resources on quality long term solutions.

There is an obvious trend in current literature on the topic of climate change adaptation that specifically identifies the responsibility of municipal planners and policy makers to develop adaptation management plans and to adopt relevant policies and regulations that will address the projected impacts. As such actions have failed to materialize, one might speculate that there is a missing link in the communication between the climate change scientists who specialize in natural systems, and the planners and policy makers who may be more specialized in socio-economic related issues. City planners or land use planners are described as those individuals who are "concerned with the scientific, aesthetic and orderly disposition of land and resources and the location of facilities, buildings and services over a given territory" (Canadian Institute of Planners, 2009). Although risks associated with development within coastal areas should now be understood, it has not been reflected in present land use location choices (Parks, 2006). Planners have access to specific tools which may be utilized for adaptations related to sea level rise, including better land use practices which can be enforced through policies and by-laws, and structural adaptations enforced through new building and engineering codes. As such, the primary role of planners will be in adapting the policies and regulations related to new land uses and new developments.

In contrast, Landscape Architects may be considered to be uniquely qualified to address both of these inter-related systems. The Canadian Society of Landscape Architects (CSLA) describes their members as working in “the creation of meaningful and vital outdoor places, through a commitment to the sustainable management of our environment” (CSLA, 2008). The CSLA further asserts that the professional practice manages and creates these environments as attractive, innovative, functional, and appropriate solutions (CSLA, 2008). By the mere nature of the profession, landscape architects work with the juxtaposition of the natural and built environments, and thus one might assume that in order to achieve *functional* and *appropriate* solutions, landscape architects must consider the issues related to climate change and the potential impacts of such change on the future of their site specific design projects.

Landscape Planning, a specialty within the landscape architecture field, involves both cultural and environmental assessments at the regional scale (Taylor, 2006). As similarly described by Landscape Architects from the University of British Columbia, “landscape architects are in a privileged position: we can move beyond the constraints of scientific objectivity and individual disciplines and into the realms of behaviour change and whole landscape solutions.” (Flanders et al, 2009). But in order for landscape architects to incorporate adaptation strategies into design practice, they first need to become more involved with impact assessments and other related public participatory processes which are so badly needed in coastal communities across the country.

Unfortunately, if publications on the topic reflect current Landscape Architectural practices within Canada, then there appears to be a significant lag in such consideration within the profession, in comparison to that of the greater design community and specifically that of the planning discipline. Of the 130 people that attended the 2008 Climate Change Adaptation Workshop for Atlantic Canada in St. John last year, the majority were municipal planners, engineers, representatives from Provincial Departments of Environment, and Federal representatives from Natural Resources Canada; and workshop discussions focused on the need for the generation of *policies* as the solution for implementing adaptation strategies, and where *appropriate designs* were assumed to be an automatic result of such new regulations. And no one appeared to be bothered by the fact that after more than a decade of research, reports, conferences and media releases, such policies still remain absent in municipal bylaws on Prince Edward Island (Poole, D. *pers comm.* 2008; Pinchuk, M. *pers comm.* 2008). As planners continue to struggle to adopt such policies, practices of maladaptation continue to occur by designers across the region. The solution can no longer be left up to these policy and decision makers, and designers must take a more active role in adapting their designs according to projected vulnerabilities, regardless of the minimum requirements to do so.

“No-regrets adaptation strategies” are those strategies that will benefit us regardless of how high sea level rises or how soon. They can be based on the information we have access to now and most importantly they can evolve over time as new information becomes available or when new policies and regulations are implemented. No regrets strategies address the uncertainty of climate change, by implementing cost effective adaptations that help, rather than hinder design solutions. These strategies err on the side of the environment by implementing solutions to problems that need to be solved anyways, in a pro-active, cost-effective way. (Parks, 2006)

There are three common types of adaption strategies that are specifically related to design, and the most effective solutions often involve a combination of each of these, which include protection, accommodation, and retreat (Lemmen & Warren, 2004). Protection is an instinctually response to the threat of flooding and can occur at a wide range of scales. In general, protection is costly and may have limited long-term effectiveness. Examples of such measures range from sandbagging on an as-needed basis to large-scale engineered structures like seawalls, dykes and levees. While softer methods of protection may be relatively lower in cost and may be perceived as have higher risks associated with them, the high tech, more expensive protection strategies remain limited by the projected impact in which they are built to withstand. The levees in New Orleans that were breached during Hurricane Katrina are an example of such protection measures that were not adequately designed for the intensity of the forces that they were subjected to.

Accommodation strategies refer to flexibility in long term visions, with the acceptance of gradual adjustments to land use activities and infrastructure to accommodate future changes in sea level. Examples of accommodating practices include communities of houseboats that have been built on what is currently still dry land and can now be found throughout Holland, or on a smaller scale the construction of a new building elevated on piles. Accommodating land use practices include changing an agricultural crop to a more salt-tolerant species, or further still to livestock, after land has been subjected to storm surge impacts (Lemmen & Warren, 2004).

The final type of strategy, referred to as retreat, is a deliberate attempt not to protect the land from the sea and to abandon land when conditions become intolerable (Lemmen & Warren, 2004). Although not directly related to design practices, designers should have an ethical responsibility to recommend retreat when all other options have been found to be inappropriate. There are a number of communities within the Maritimes that have already accepted retreat as the more practical option to their adaptation needs. Along Pigot's Point on the north shore of PEI for example, seasonal homes have been abandoned or relocated further inland due to the accelerated rates of erosion on the beach, which jumped from about 1.4 meters/year to 3.2 meters/year in the 1990s, and continued to accelerate through the past decade (Vasseur & Catto, 2008). For seasonal residential uses, the adaptation strategy for retreat may have been an obvious choice due to a simple cost-benefit analysis, but for larger communities and for small cities on the Island, the potential lose caused by such inundation will be substantially higher as sea level continues to rise.

LAND PLANNING FOR SEA LEVEL RISE IN THE CITY OF SUMMERSIDE

Long term, phased adaptation strategies are quite similar to landscape architectural services in land or master planning which involves large sites that will require long term development and where broad guidelines apply (Taylor, 2006). Three examples of how proactive land planning for adaptation can be incorporated into the long term vision for a variety of land uses are explored here. These case studies use different sites within the City of Summerside, and collectively illustrate how unique solutions may be required within relatively close proximities within a single community. Where policies are not yet in effect to regulate or to guide designers in their practice, the following recommendations are intended as no-regrets adaptation strategies that will address current issues and development trends within the City, while reducing the vulnerability of the coastal properties.

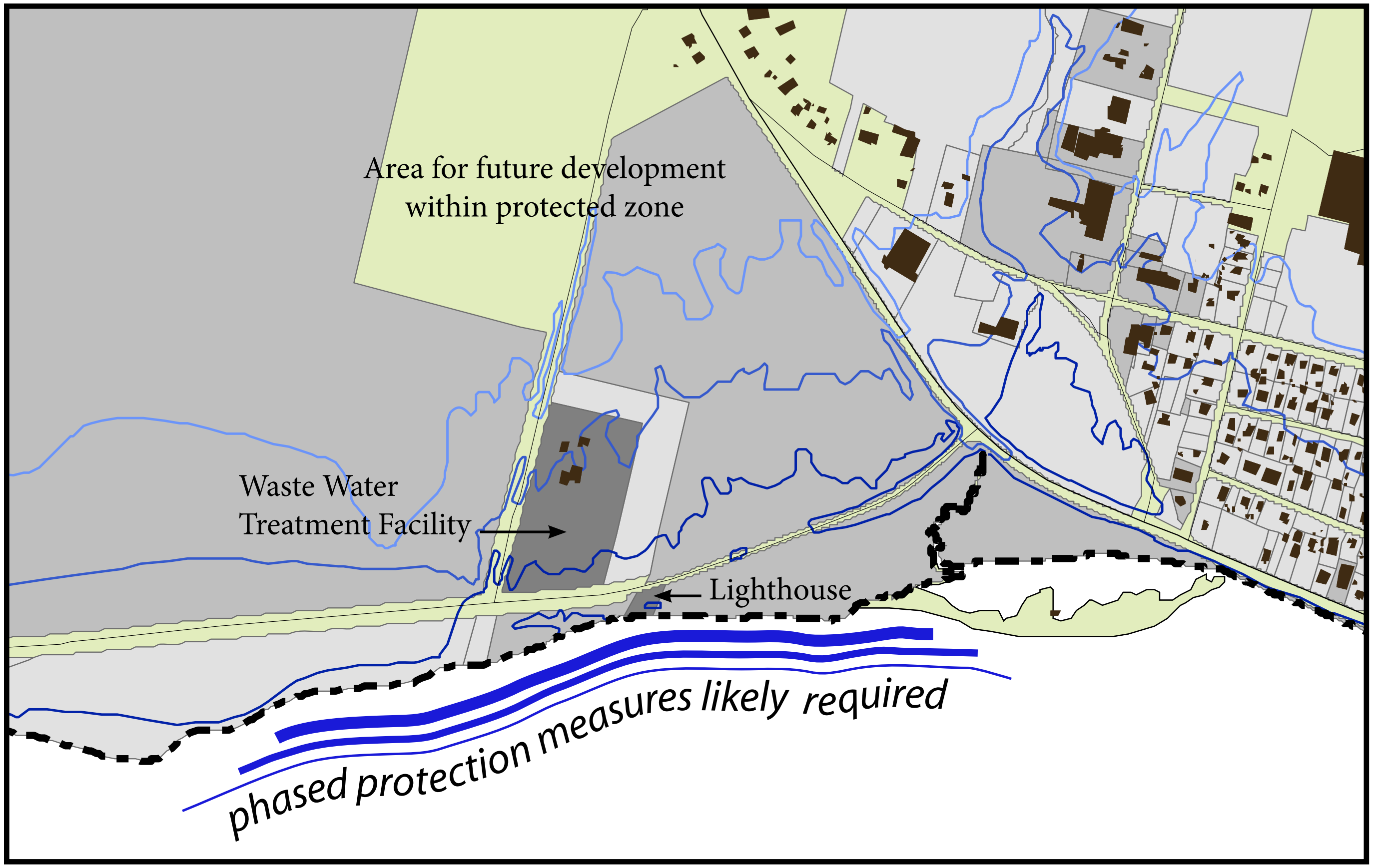
CASE STUDY #1: PROTECTION OF VALUABLE INFRASTRUCTURE

The waste water treatment facility in Summerside is located on the west side of the City's waterfront, and the property had been identified as moderately vulnerable through the Vulnerability Index assessment. As previously mentioned, one of the limitations of that method of assessment was the exclusion of impacts that one vulnerable property might have on another. This is especially true for this location where the compounded impacts that flooding of this facility would have on the entire City's sewage utility. Pending an in depth cost-benefit analysis of the recently upgraded infrastructure, it is likely to be found that protection of this property is of a very high priority.

The property location is on a particularly low lying area on the exposed end of the harbour and adaptation measures to prevent erosion are already in place with rip rap extending along much of this portion of the coast. As storm surge impacts increase in the future, further protection measures are likely to be found necessary. As a preliminary step in a phased strategy for protection, infill could be used on the seaward side of MacKenzie Drive to offset what is lost due to increased rates of erosion. This would also provide a much needed surface area on which an earthen berm could later be constructed to prevent storm surge and wave wash up from crossing the road and flooding the waste water treatment facility. As the risk of permanent inundation from sea level further increases, hard infrastructure such as an elevated seawall could be constructed as a last resort for holding back the water. As the time frame in which this action would be required is still very much unknown, the softer protection measures would be considered more appropriate (and more economical) solutions for the immediate future.

If a long term adaptation strategy plan could be developed in advance for this site, bench mark storm surge levels would be predetermined. Once reached, further investment into the implementation of the next phase in the land plan would be required, regardless of when that might occur. By establishing these benchmarks in advance, the City's elected officials would be held accountable to taking action at those designated times.

From a planning perspective, once a long term adaptation land plan is adopted to protect this particular location, trends for new development would likely shift towards the adjacent properties, prior to the construction of any specific protection measures. Such future development which would occur regardless of coastal flood conditions could continue at no additional expense to the developer or city in this to-be-protected zone, rather than in an area that would otherwise require future adaptation measures of its own. Through proper design, protection measures taken for this one site could thus provide a double service, by reducing the vulnerability of the existing infrastructure, as well as providing a no-regrets direction for growth and new development within the City.



Plan for Adaptation:

Step 1. Maintain soft protection efforts through erosion control measures including riprap and revegetation of coast.

Step 2. Escalated levels of soft protection efforts through landfill reconstruction on the seaward side of MacKenzie Drive, where an elevated berm can be built as needed to address surge impacts.

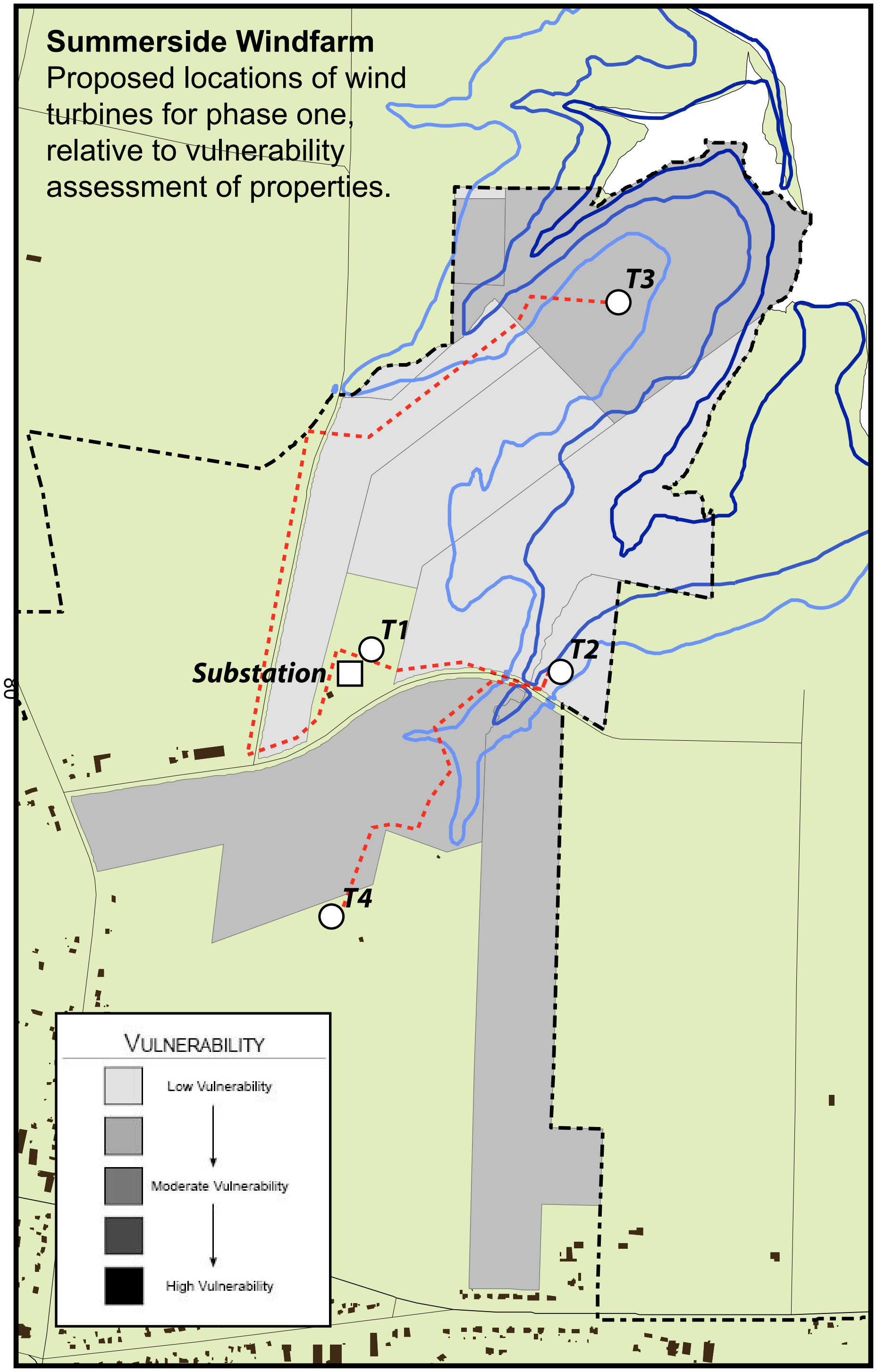
Step 3. When flood risk is of permanent inundation, hard protection measures will be required through the construction of permanent infrastructure such as an elevated seawall.

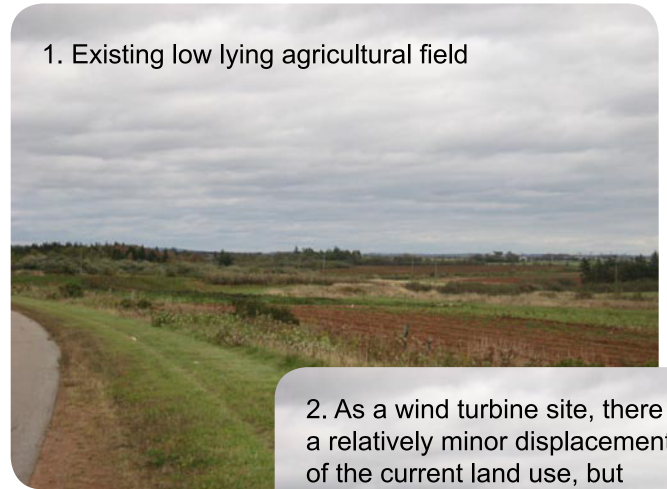
Case Study #1: **PROTECTION** OF VALUABLE INFRASTRUCTURE

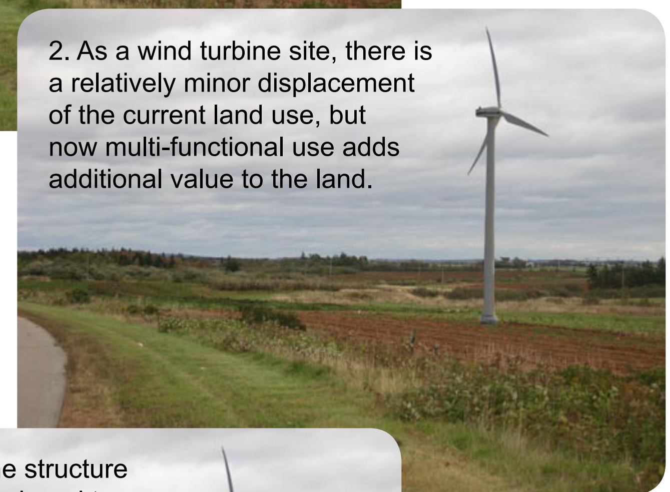
CASE STUDY #2: BUILD NOW TO ACCOMMODATE FLOODS LATER

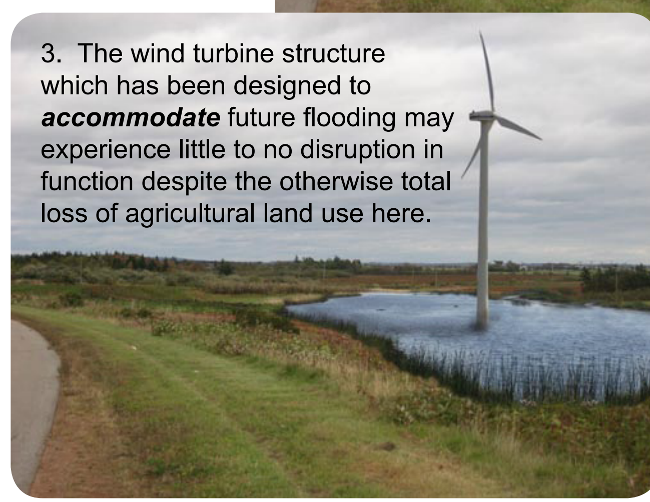
Accommodation is often thought of as the most “development friendly” form of adaptation. Instead of implementing strict no-build zones, developers could choose whether or not to meet specific performance based standards for development proposals within known flood risk areas.

On the north shore, the City of Summerside recently proposed the construction of a wind farm that will be a source of sustainable energy for the City in the future. The first phase includes four wind turbines, all of which are proposed for relatively high elevations within existing agricultural land, with only one being located below the 6m elevation contour. For the purposes of adapting such a development to the threat of sea level rise, while also addressing the concern of displaced property owners and farmers, this type of development provides a great opportunity for proactive, accommodating design initiatives. The location of the wind turbines could instead be constructed at very low elevations, where the current land uses which are mainly agricultural are highly vulnerable to seasonal inland flooding as well as projected sea level rise inundation and storm surge impacts. The wind turbines could be structurally adapted to withstand the potential for permanent or occasional flood conditions in the future. Wind farms that currently exist on land or at sea, are equally productive in their intent and if designed properly access and maintenance requirements could experience very little disruption despite the dramatic changes that might be occurring in the surrounding landscape.









Case Study #2: BUILD NOW TO **ACCOMMODATE** FLOODS LATER

CASE STUDY #3: RETREAT IN ONE AREA TO SAVE ANOTHER

The third form of adaptation is retreat. This is a cost/benefit strategy that weighs the efforts of protection, against the land and infrastructure value. Although these adaptation measures include avoidance or abandonment of vulnerable properties through decisions against further building, retreat methods also include the protection of existing features that are currently in place, when loosing those features to development would result in accelerated negative impacts.

Retreat is probably the most difficult form of strategy to implement. Affected property owners need to be involved in the process of determining what temporary protection measures can be taken that will be appropriate for the cost and the longevity of their effectiveness, and at what point retreat will eventually be required.

Residential properties in the Lefurgey Neighbourhood line the waterfront on the east side of the Summerside harbour, west of the Wilmot River estuary. Property owners here appear to be aware that they are at risk to flooding and erosion as many have already taken preliminary steps to protect themselves. Unfortunately there is a problem in the inconsistency of these efforts. Where one property has rip rap in place to protect the coastal edge, there will be accelerated rates of erosion on the adjacent unprotected properties. In addition, other property owners have permitted the water access across the coastline boundary through renaturalized salt marsh landscaping which acts to buffer the direct impacts of storm surge from the harbour. These particular measures also work against their neighbours by allowing water to encroach laterally into the lawns of the armored adjacent properties. Either attempt is a step in the right direction but their efforts are conflicting one another, and a consistent coastal management plan across all properties in this area would have a much higher success rate for reducing vulnerability to long term projection surge levels. Threats of permanent inundation of sea levels across these properties will also need to be addressed in the cost-benefit analysis of such a long term coastal management plan.

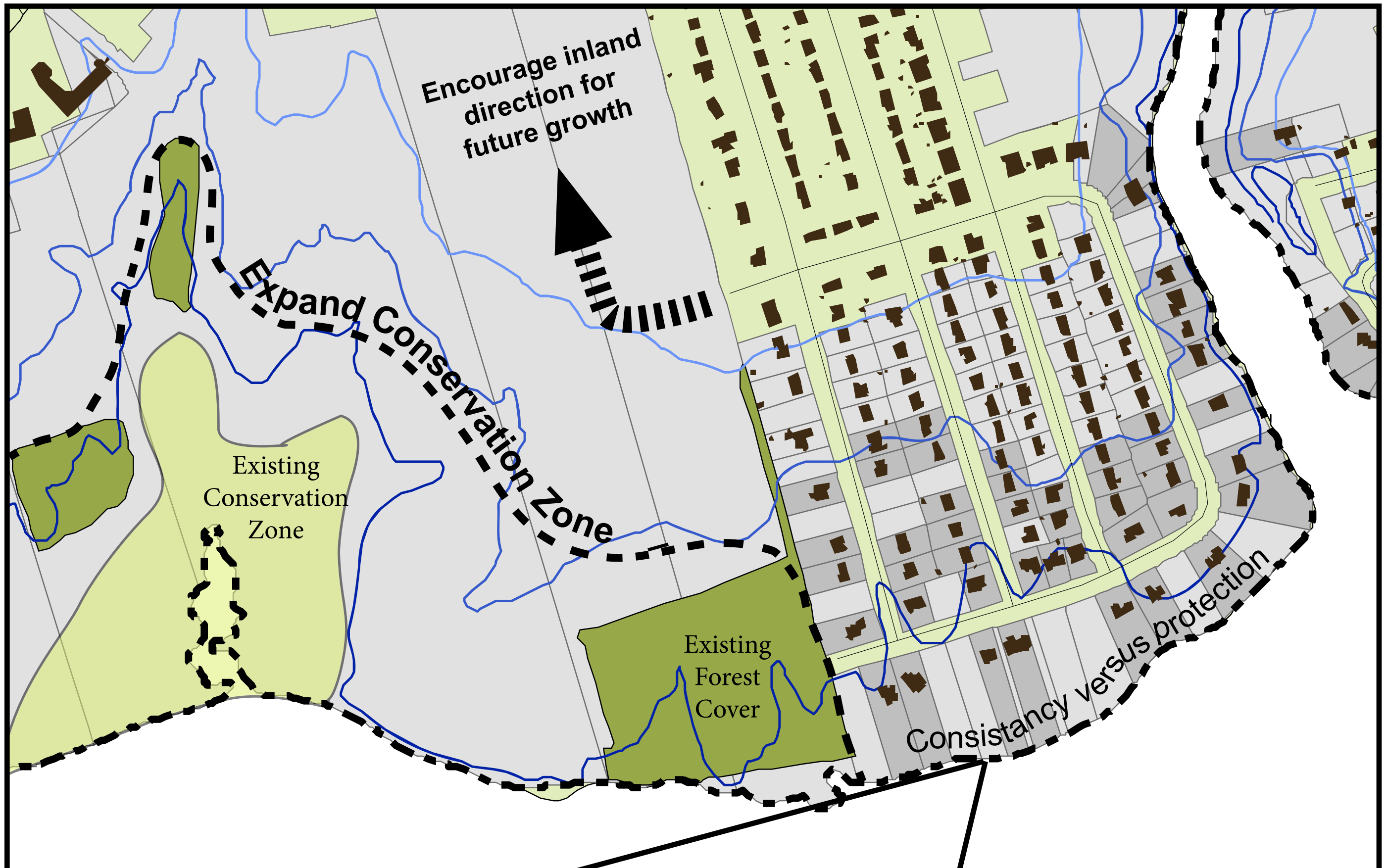
The adaptive capacity of this neighbourhood will also be influenced by the future development of the adjacent properties to the west, which area currently zoned residential. If the Lefurgey neighbourhood was to expand westward through the extension of the two existing dead-end roads, the removal of the existing forest cover along the southern portion of this large parcel could result in accelerated erosion along the shoreline, and increased flood risks to the existing waterfront properties to the east. By retreating from any further development plans on this property, and by expanding the conservation area that currently exists further to the west, the existing coastal forest cover could be protected. Future development could continue within the neighbourhood and be redirected inland on higher elevations.

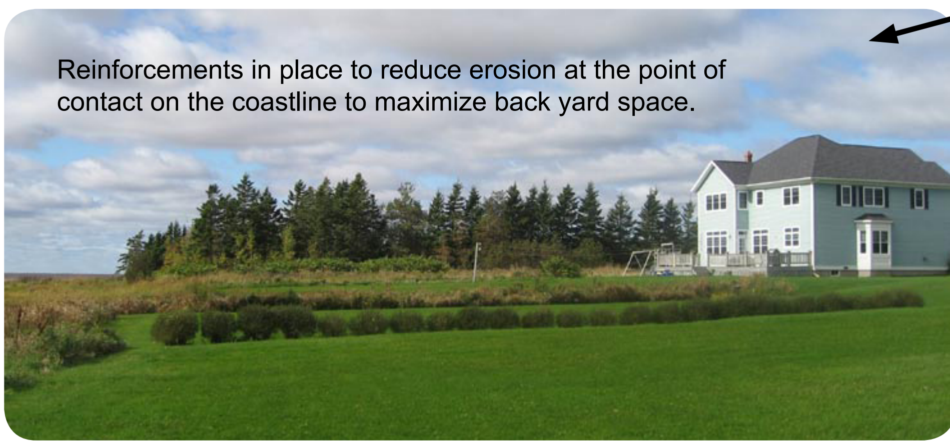
Coordinated Efforts

1. Education of existing property owners to encourage consistant efforts to buffer impacts from surge events that will not work against one another.

2. Where further growth is demanded within the community, encourage no-regrets development inland and away from the identified flood risk zones.

3. Retreat from development plans and expand the existing conservation zone to include the existing undeveloped forest cover area which strengthens the coast's ability to resist erosion.




Reinforcements in place to reduce erosion at the point of contact on the coastline to maximize back yard space.


Renaturalized edge condition with encroaching salt marsh provides soft buffer to surge impacts, with less lawn to maintain.

Case Study #3: **RETREAT** IN ONE AREA TO SAVE ANOTHER

*"Our human Landscape – our houses, roads, cites, farms and so on – represents an enormous investment of money, time and emotions. People will not change that landscape unless they are under very heavy pressure to do so" (*Lewis, 1979).

GENERATNG DIALOGUE FROM DESIGN IDEAS

The proposed methods for impact and vulnerability assessments presented here are intended to provide a foundation of information on which to approach the public for the generation of dialogue on the subject of sea level rise. Because these assessments are grounded in the context of the community, residents will be able to compare how the projected impacts on their coastline relate to extreme scenarios projected in other parts of the world. The specific examples of design alternatives suggested are intended to address current development trends while still acknowledging the need for proactive adaptation for coastal flood projections of the future. These tools provide stakeholders and community residents with a method of visualizing the potential impacts through a more optimistic framework that acknowledges growth and development in the immediate future, rather than just providing flood risk maps of current conditions which depict an unresponsive future.

Residents are likely not going to like what they see, but better they become aware of the issues through graphic representations, than to experience it unprepared during the next big storm. Unfortunately, as the 'barer of bad news' within a community, there are potential legal ramifications which have prevented researchers from presenting their ideas directly to the public in the past. Greenpeace, for example, has been sued over the publication of *PhotoClima* (Greenpeace, 2009) which included visualizations of potential impacts of sea level rise on the Spanish community of La Manga. The suit was based on the assumption that the images published impacted property values (Flanders et al, 2009).

When impact assessments illustrate non-responsive dooms-day scenarios, the public perception may be to think that realistic alternatives are unobtainable. Alternatively, by also presenting design ideas from small do-it-yourself solutions to those ideas that are grand and possibly far-fetched, the community is provided with a decision – *respond or not, but if so, how?* An immediate action may not result from this initial communication of the information but when future development is proposed, the relevant stakeholders will already have a general understanding of the need for adaptation to be incorporated into the design, whether or not regulations have been adopted by the community yet or not. As adaptation practices become more common, further public participation can be used to discuss what has worked and what has not worked to date. When a future storm surge does hit the region, costs assessments can be made available to show impacts as they would have occurred, could have occurred, and did occur; further illustrating to the community how their pro-active actions have helped reduce vulnerability and where further work is still needed.

If a community has continued to resist adaptation policies, such a follow up workshop could be used to show how their lack of response has led to further destruction, and the cumulative expense of maladaptation. When new policies are finally proposed for the community, with residents already informed about the underlying issues, planners and policy makers will more likely have the support of the community. If designers however continue to resist incorporating adaptation into their work, their clients are likely to follow suit while continuing to blame "planners" for trying to enforce new regulations on their projects which don't suit the original design scheme.

The scale in which adaptation strategies are eventually taken will be relative to the number of people influenced by the initial stages of dialogue, however if local developers and particularly local designers are involved initially than new development proposals at larger scales will be more likely to incorporate such strategies with or without regulation to do so. If the general resistance to act is due to additional costs, than the cost of potential damage or property loss needs to be calculated at the on-set. The cost of replacing a single family home for example, may not warrant the cost of a protective sea wall. At the end of the day, a "no regrets strategy relative to the far-from-remote possibility of climatic change is, by the same logic, a way to insure our descendants against the possibility of disaster otherwise caused by our carelessness" (Orr, 2004, p. 150).

PROGRESS AND FUTURE INITIATIVES

Research has continued in a pursuit to precisely measure projected impacts despite the inability for anyone to accurately predict how the global community will mitigate climate change impacts by reducing greenhouse gas emissions in the future. The IPCC will "assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation" (IPCC, 2009, www.ipcc.ch); and will publish their findings once again in the Fifth Assessment Report (AR5) which is scheduled for release in 2014. In the mean time, the focus of local research appears to be shifting towards that of climate change adaptation.

Within Canada, six Regional Adaptation Collaboratives (RAC) have been proposed as recipients of Federal funding for such research with a total commitment of approximately $30M over the next two years. The Atlantic Provinces have been grouped within a single RAC and in contrast to previous investments made by Natural Resource Canada (NRC), this funding is specifically intended to address the development and implementation of adaptation strategies through capacity building, development of knowledge, information and tools, and through collaborative arrangements (Spencer, 2008). For the Atlantic Canadian provinces the three overlying issues to be investigated are inland flooding, coastal flooding and sea level rise (Penak, B. *pers comm.,* May 2009)

More recently, one of the four International-Community Research Alliances (ICURA) that have been awarded funding by the Social Science and Humanities Research Council of Canada (SSHRC) this year, is a project entitled Managing Adaptation to Coastal Environmental Change: Canada and the Caribbean. The project team involved in this initiative is multi-disciplinary, and has proposed to "build the capacity of local communities to face up to the inevitable climate changes and to anticipate and confront its consequences for their well-being. The research teams will develop community awareness of the environmental threat, proposals for new infrastructure, and tools for creating adaptation and mitigation strategies" (International Development Research Center [IDRC], 2009). Two of the proposed Canadian sites to be examined are within Atlantic Canada, including Charlottetown and a small town in Cape Breton, Nova Scotia (Lane D. *pers comm.* June 29, 2009).

With substantial funding backing both of this proposed projects, the potential to produce a large volume of knowledge base is very encouraging. However, if this knowledge is not disseminated beyond the academic realm, and if the communities are not involved in the process of conducting the research, than the challenges currently faced by municipal planners and policy makers are likely to remain unchanged.

POST PRACTICUM REFLECTIONS

EMBRACING CHANGE

Both natural processes and human uses leave traces on the land, and contribute to telling a story about the past. The landscape is a product of these layers of history that are recorded within it. The stories however are only specific to that moment. They are a snapshot of a time and place and are a unique record of all that has come before. As landscapes change the story is constantly rewritten. Events and new traces build upon the previous record, often making the previous story more difficult to read. These events may happen over geological time, as tectonic plates shift and collide and as glacial ice sheets expand and retract. Historic impressions that humans have made on the land are recorded in settlement and land use patterns, some indicating growth and expansion of civilizations, and other reflect times of destruction and abandonment. Landscapes change seasonally with the environmental processes of regeneration and decay and with the Earth's daily rotation between night and day. Landscapes do inevitably change.

Natural processes of change that occur over extended periods of time are often difficult to detect and may require an observer to displace themselves from the typical perspective. The path of a meandering stream is recorded in the adjacent land but is often only visible from an aerial perspective. Human induced changes often happen much more rapidly, with the clear cutting of a forest or through major earth works projects. Humans purposely alter and mold landscapes everyday and by nature we also resist that *change* that is out of our control.

But if change is inevitable, then to design for the future is to design for change. Landscape designs in particular must evolve and grow, and be flexible to change in both function and aesthetic. To be flexible and to accept change over time, is to *adapt*.

SUMMARY

This practicum has covered a large range of scales and concepts about how we assess impacts and vulnerability and how we generate ideas about adaptation through design. When I first started the project I anticipated that my process would involve conducting background research on the subject of climate change and sea level rise; that I would apply that research to a particular site and do an in-depth site analysis. As a grand finale, I would then produce an appropriate design solution for that site. The intent was to specifically address the reality of projected impacts of sea level rise on the coastline of Prince Edward Island and to encourage people to take the necessary steps towards implementing plans for phased no-regrets adaptation strategies. At the time, this proposal reflected my tendency to think that Landscape Architecture required a *design solution*.

Instead, what I found as I got further into the project was that the more background research that I did, the more in depth the site analysis and assessments became, and that the design ideas were generated through the process rather than as a bi-product of it. As I learned more about the scope of adaptation strategies, I realized that “adaptation” isn’t a design theme or style, but instead a design tool; and I would argue the same for any “mitigating” design practices as well. I came to embrace the concept that Landscape Architecture as a design process and a way of thinking, which in many cases leads to a design solution but is not necessarily defined by it.

In the end, I narrowed the intent of the project on addressing two specific questions: (1) How can we assess the potential impacts of sea level rise? (2) How can we make use of these assessments in planning and design practice? The final outcome of the project reflects this change in process and has resulted in an impact assessment which can be used as a resource tool to identify flood risk areas on the Island; and at a smaller scale, a method for conducting a vulnerability assessment for properties, which takes the impact assessment one step further and accounts for additional information relating to a property’s adaptive capacity. Examples of design ideas that have been included were generated throughout the assessments as a result of discussing the potential for implementing no-regrets adaptation strategies under different scenarios.

Where the majority of Canadian based publications on Adaptation reference "planners and policy makers" as those people that are responsible for taking action on these issues, I have continued to argue that designers and more specifically Landscape Architects should be the ones leading the cause. Landscape Architects have a unique opportunity to further explore these ideas through practice, and to incorporate adaptation strategies into design rather than as an add-on due to a regulation for it.

Over the past two years, I have been fortunate to have been given the opportunity to present some of these ideas to different professional organizations on the Island, and this act of knowledge dissemination, which resulted in some very interesting and sometimes intense and controversial conversations, signified the culmination of the work from my perspective. In the present context, when next to nothing is being done to acknowledge, to regulate or to enforce the inclusion of adaptation strategies in coastal development projects on PEI, what more could I hope for than for my research to generate dialogue between professionals practicing on the Island.

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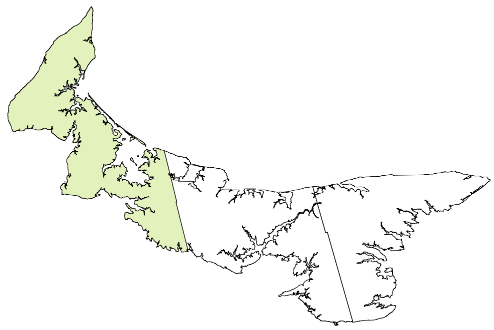
APPENDIX A

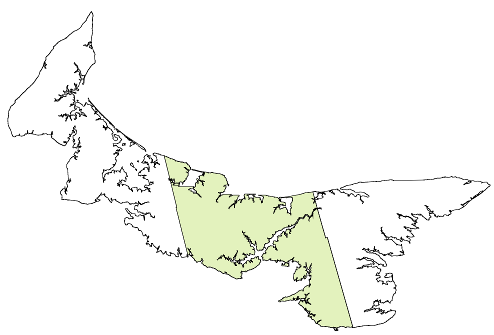
REGIONAL FLOOD RISK MAPS FOR PRINCE EDWARD ISLAND

P1-19 Prince County Maps



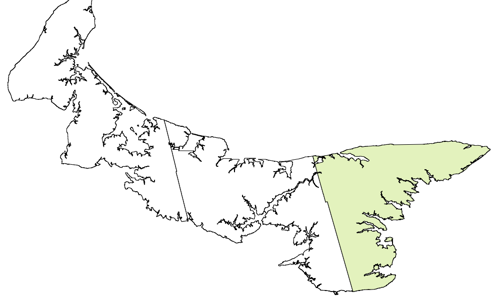
P1 - North Cape
P2 - Mininegash
P3 - Tignish
P4 - Bloomfield Corner
P5 - Alberton
P6 - O'leary
P7 - Cascumpec Bay
P8 - West Point
P9 - Percival Bay
P10 - Lennox Island
P11 - Higgins Shore
P12 - Tyne Valley
P13 - Cabot Beach
P14 - Cape Egmont
P15 - Wellington & Miscouche
P16 - Kensignton
P17 - Linkletter
P18 - Summerside
P19 - Borden-Carleton

Q1-16 Queens County Maps



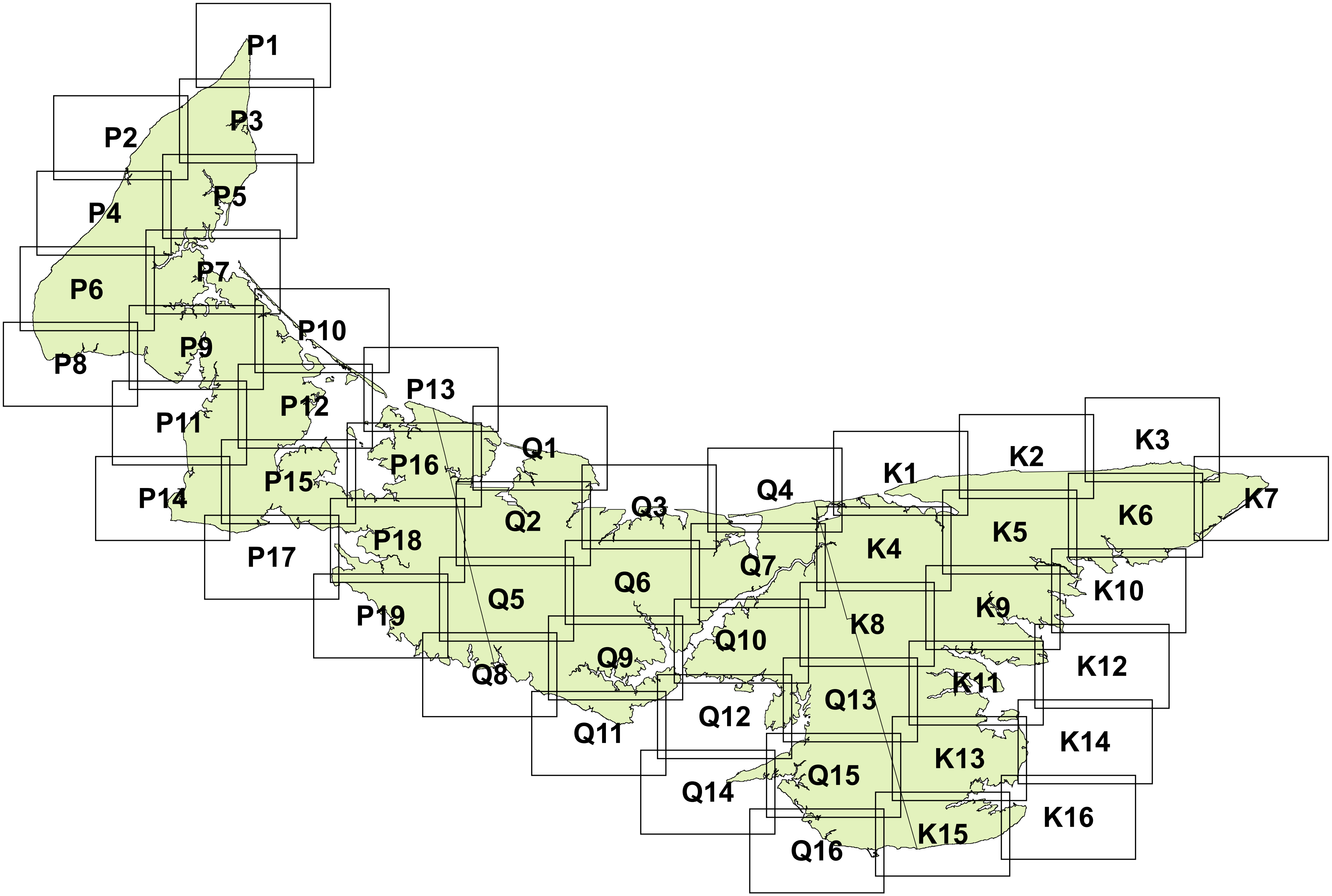
Q1 - Cavendish Beach
Q2 - Hunter River
Q3 - Brackley Beach
Q4 - Blooming Point
Q5 - Crapaud
Q6 - Greater Charlottetown
Q7 - Hillsborough River
Q8 - Victoria-by-the-Sea
Q9 - Cornwall
Q10 - Charlottetown & Stratford
Q11 - Canoe Cove
Q12 - Hillsborough Bay
Q13 - Orwell Bay
Q14 - Point Prim
Q15 - Belfast
Q16 - Wood Islands

K1-16 Kings County Maps



K1 - Greenwich National Park
K2 - Naufrage River
K3 - Campbells Cove
K4 - Morell
K5 - St. Peters Bay
K6 - Souris RIver
K7 - East Point
K8 - Cardigan
K9 - Broughton Bay
K10 - Souris & Rollo Bay
K11 - Montague, Georgetown & Panmure Island
K12 - Launching
K13 - Murray Harbour North
K14 - Panmure Island Provinical Park
K15 - Murray River
K16 - Beach Point

* All digital maps have been produced using the Land Use Inventory Dataset (2007) provided by the Province of Prince Edward Island. Labels on all digital maps have been adapted from the Prince Edward Island Map, Tourism PEI (n.d.), with additional information added from the author's field observations. All photographs are by the author unless otherwise stated.



REGIONAL ANALYSIS - KEY MAP

P1

NORTH CAPE

North Cape, offshore reef, northern tip of PEI ✳

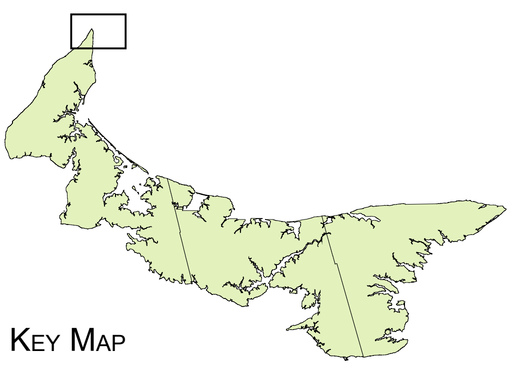
Atlantic Wind Test Site & Wind Farm, North Cape ✳

POINTS OF INTEREST

• The northern most point on PEI. Offshore is North America's longest natural rock reef which is exposed to the converging tides of the Gulf of St Lawrence and Northumberland Strait.

• The unique coastal black marsh ecosystem along this coast has adapted to extreme exposures to salt and wind.

• Sandstone cliffs, marshes, and sandy beaches are all highly vulnerable to erosion.



KEY MAP

MAP LEGEND

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- Land Use/Cover: Urban
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- Land Use/Cover: Forestry.
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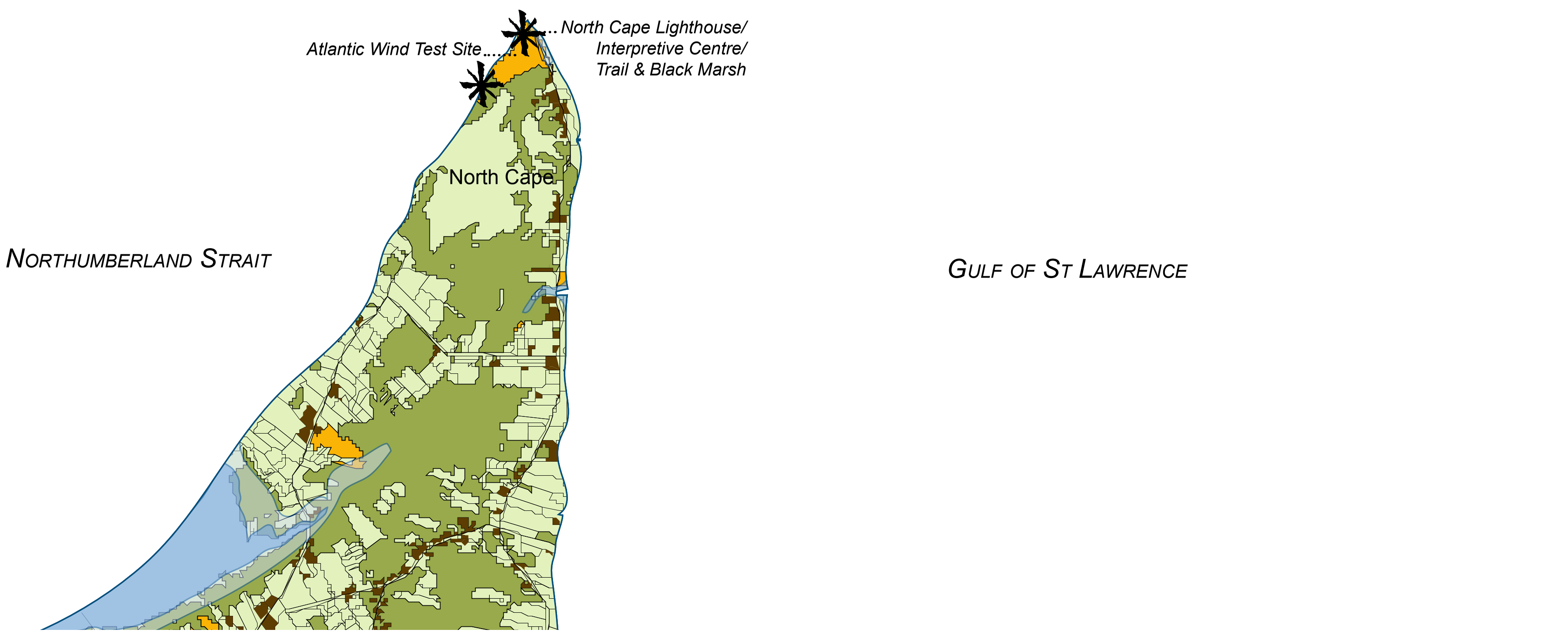
- Moderate Risk Flood Zone (< 6m Elevation) Projected Sea Level Rise + Storm Surge



P1. North Cape

P2

Mininegash

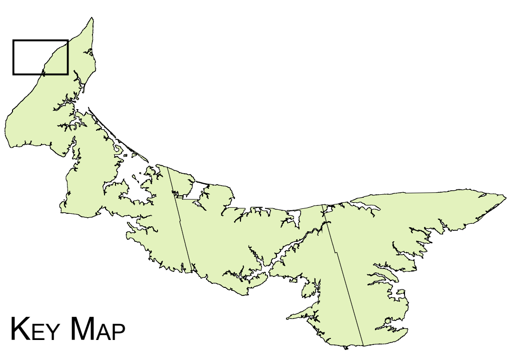
Pleasant View

Miminegash Harbour

Points of Interest

• Minimegash (176) and St. Louis (80).

• Red sandstone cliffs dominate this section of the west coast. Where low lying areas exist salt marshes have inundated the coast.



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P2 Mininegash

P3

Tignish

Anglo Tignish

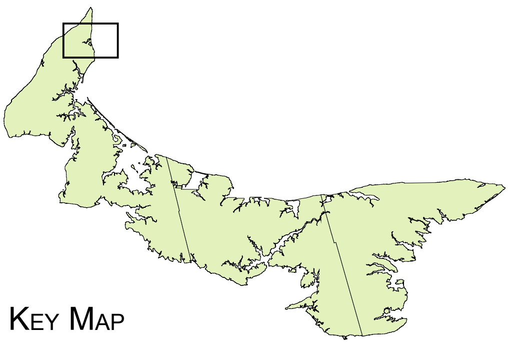
Skinner's Pond

Points of Interest

• Tignish (758)

• Low lying land is rapidly eroding on the Gulf Coast. Many houses on the seaward side of these coastal roads have already been relocated or removed.

• Red sandstone cliffs dominate much of this section of the west coast. Where low lying areas exist salt marshes have inundated the coast.



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National / Provincial Parks

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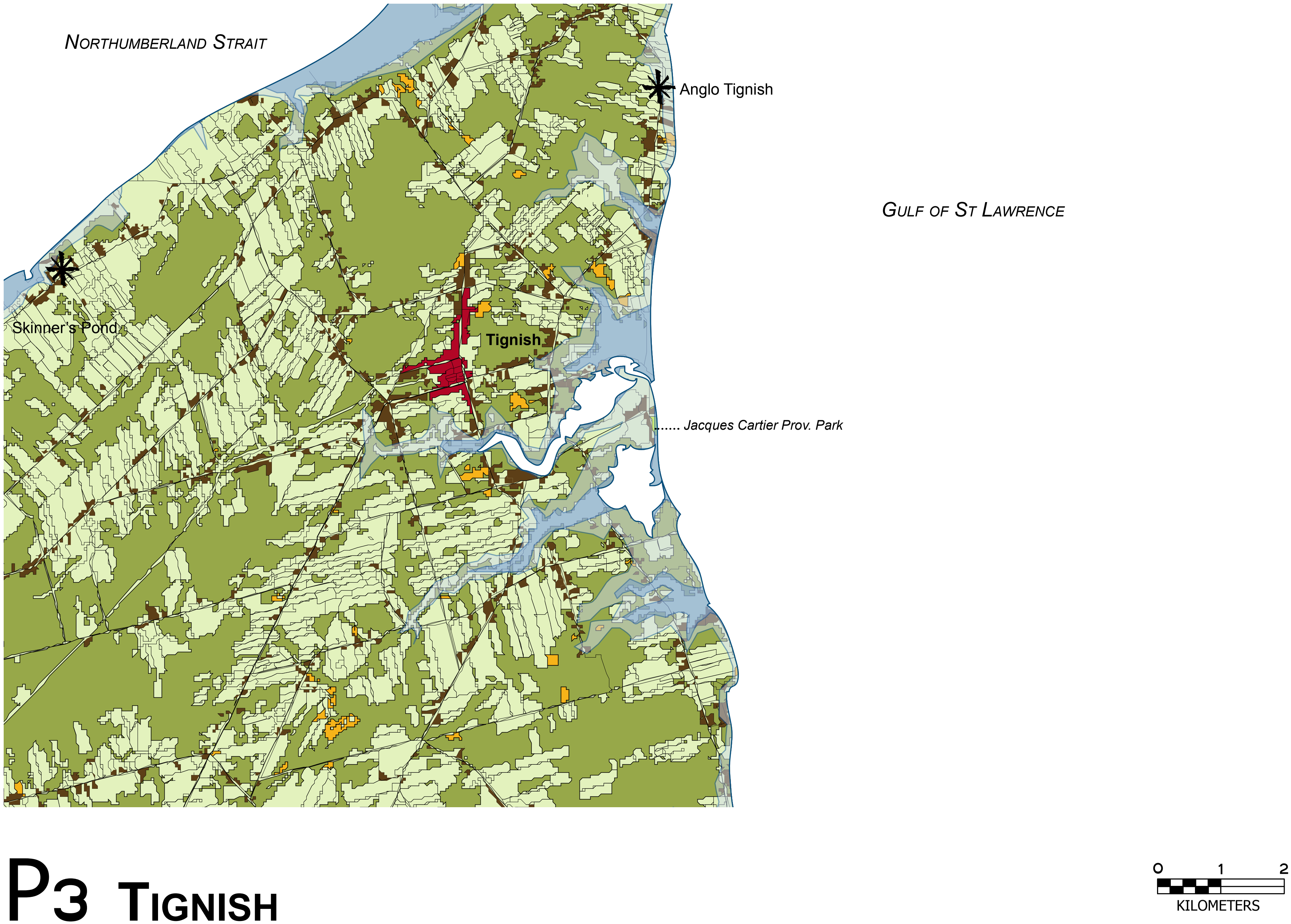

NORTHUMBERLAND STRAIT
Anglo Tignish
GULF OF ST LAWRENCE
Skinner's Pond
Tignish
Jacques Cartier Prov. Park
0 1 2
KILOMETERS

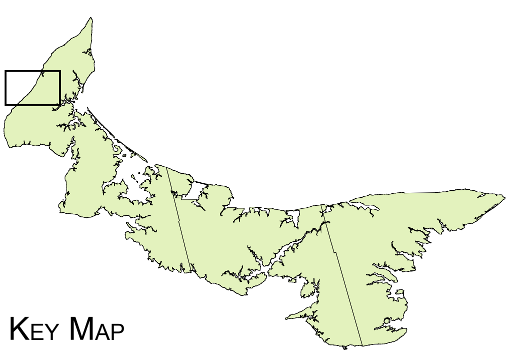
P3 TIGNISH

P4 Bloomfield Station

Miminegash Pond

Points of Interest

• Red sandstone cliffs dominate much of this section of the west coast. Where low lying areas exist salt marshes have inundated the coast.



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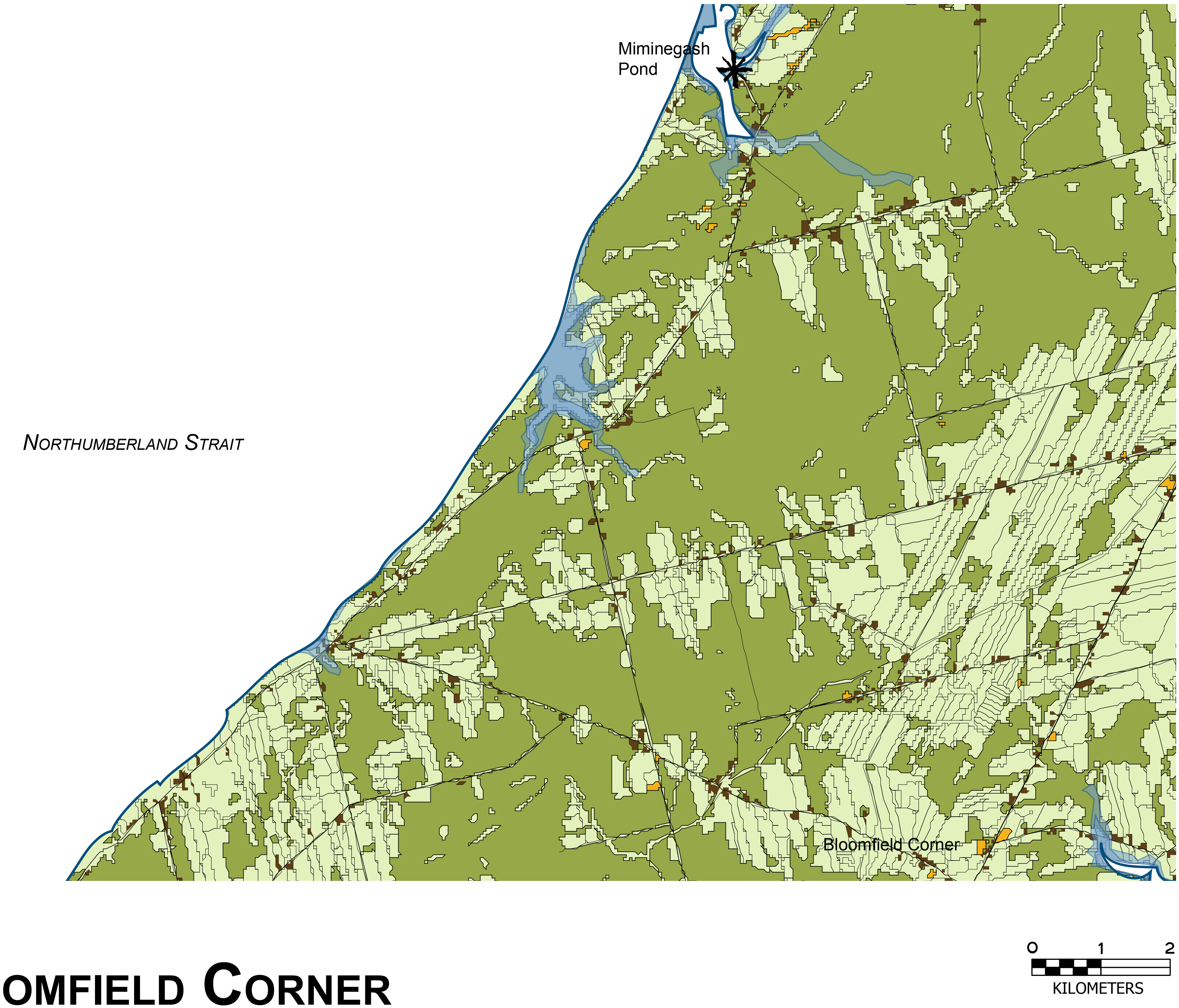


P4 Bloomfield Corner

P5 — Alberton

Pedestrian wharf, Alberton

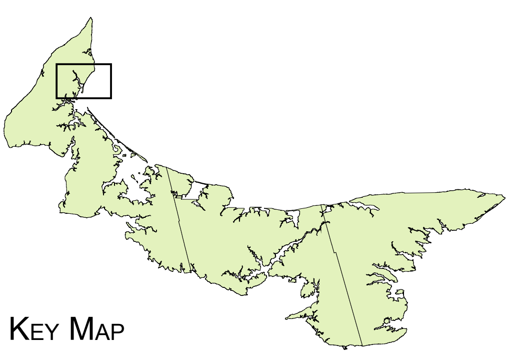
Lighthouse located on a sandy barrier island, east of Alberton

Points of Interest

• Alberton (1,081)

• The Alberton Harbour is sheltered by Oultons Island and other small, forested, sandy barrier islands. These offshore islands provide significant habitat to marine and avian species.

• Much of Alberton's community is located on a low lying peninsula in Cascumpec Bay.



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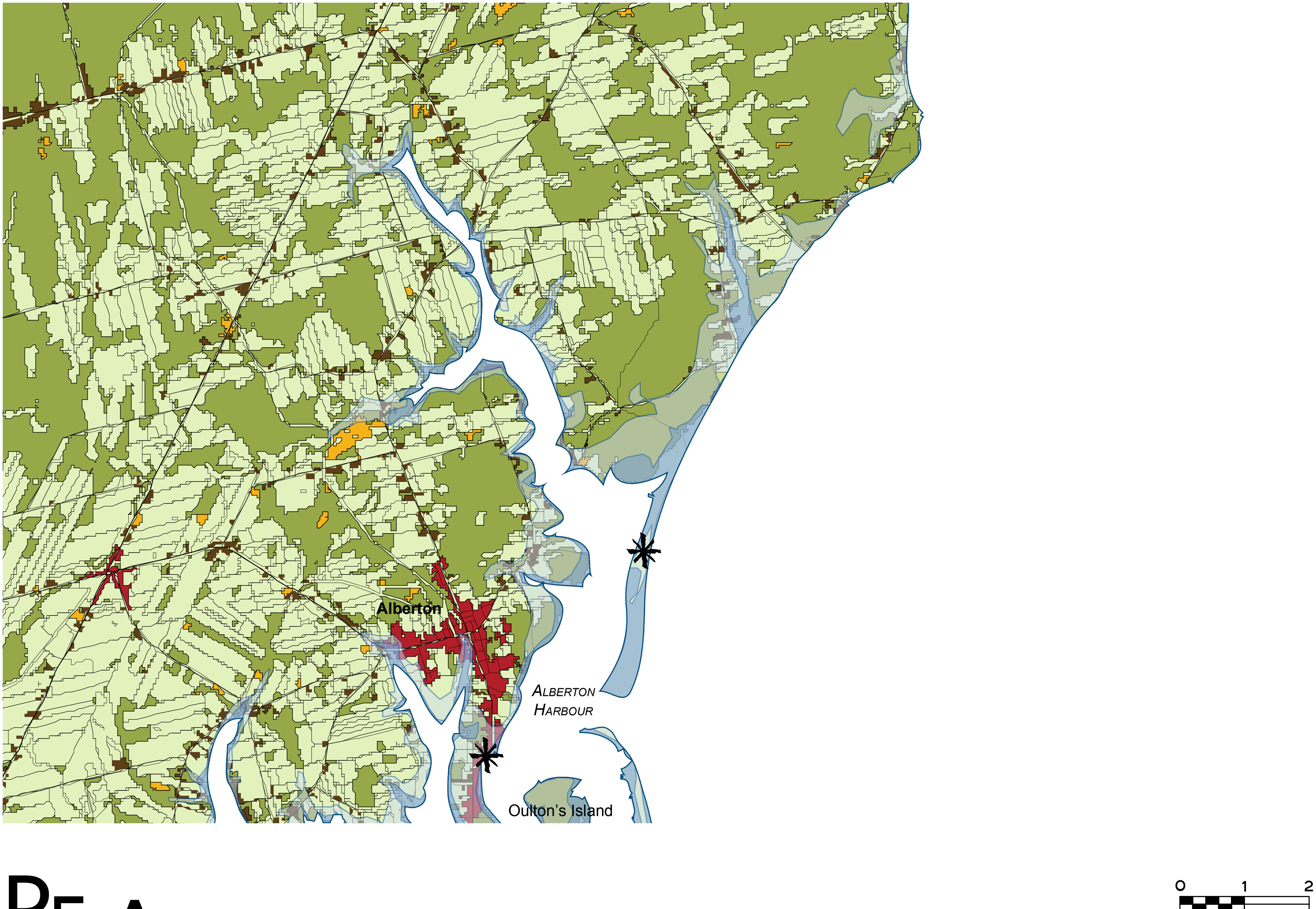


P5 ALBERTON

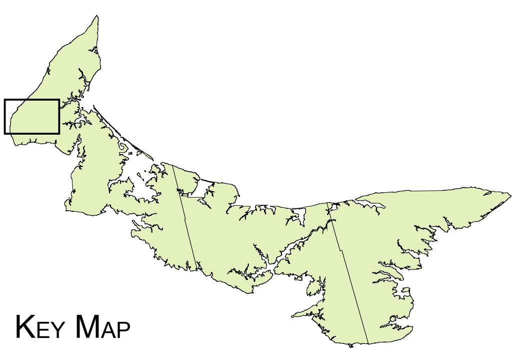
P6

O'Leary

Cape Wolfe

Points of Interest

- O'leary (861)
- Red sandstone cliffs dominate much of the west coast. Where low lying areas exist salt marshes have inundated the coast.



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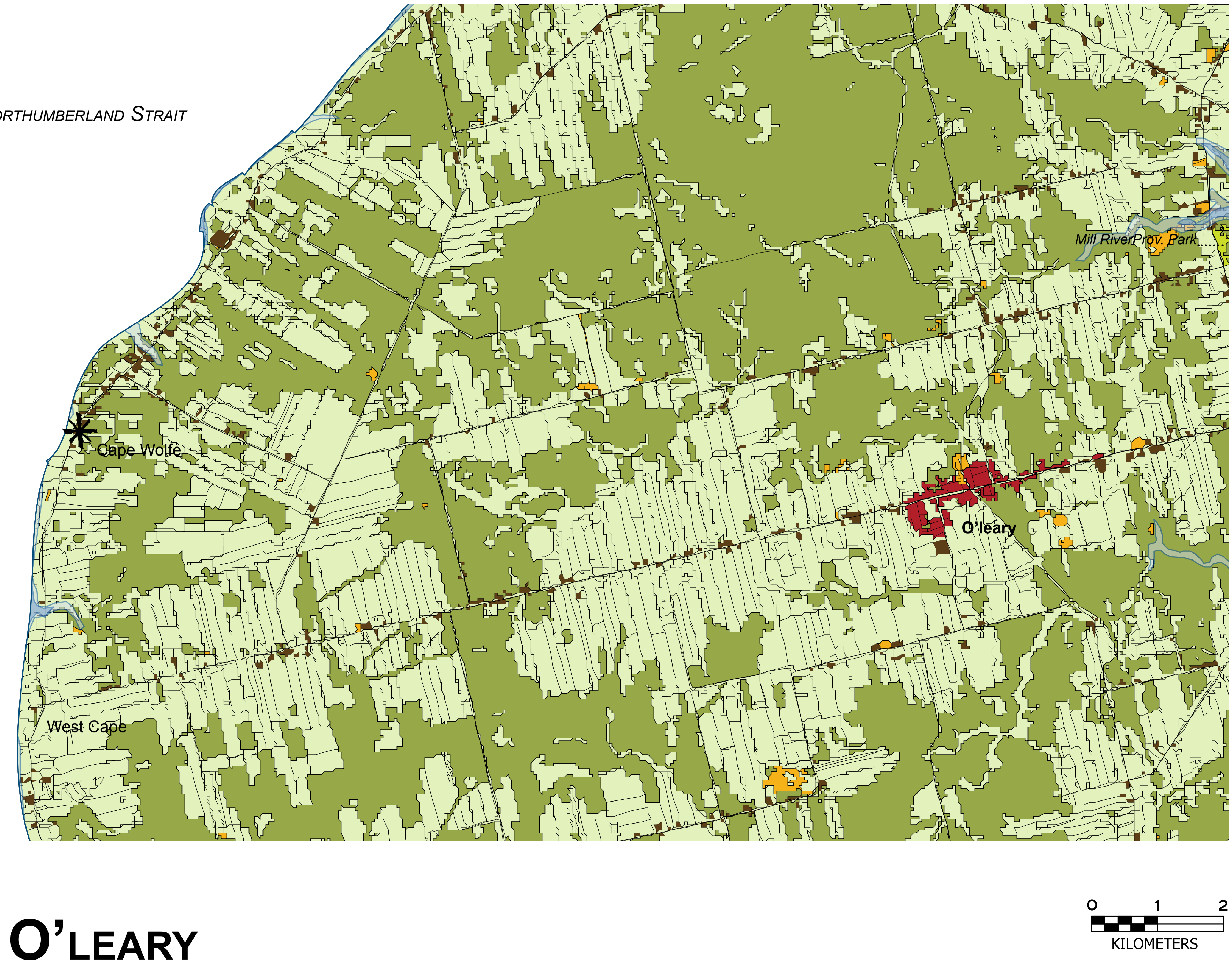


Northumberland Strait
Mill RiverProv. Park
Cape Wolfe
O'leary
West Cape
0
1
2
KILOMETERS

P6 O'Leary

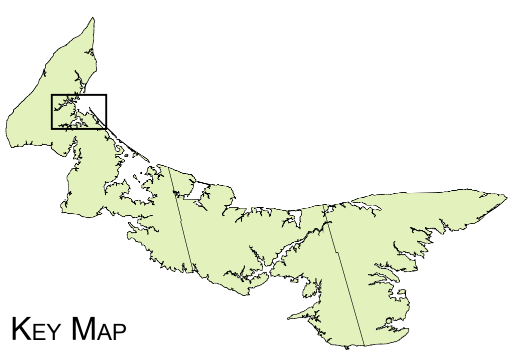
P7 Cascumpec Bay

Foxley River

Points of Interest

• Elongated sandy barrier islands shelter the coastline within Cascumpec Bay. These islands provide significant habitat to many species.

• Significant amount of low lying land surrounds estuaries in the southern shorelines of Cascumpec Bay and Foxley Bay, including over 700 acres within the Foxley River Demonstration Woodlot.



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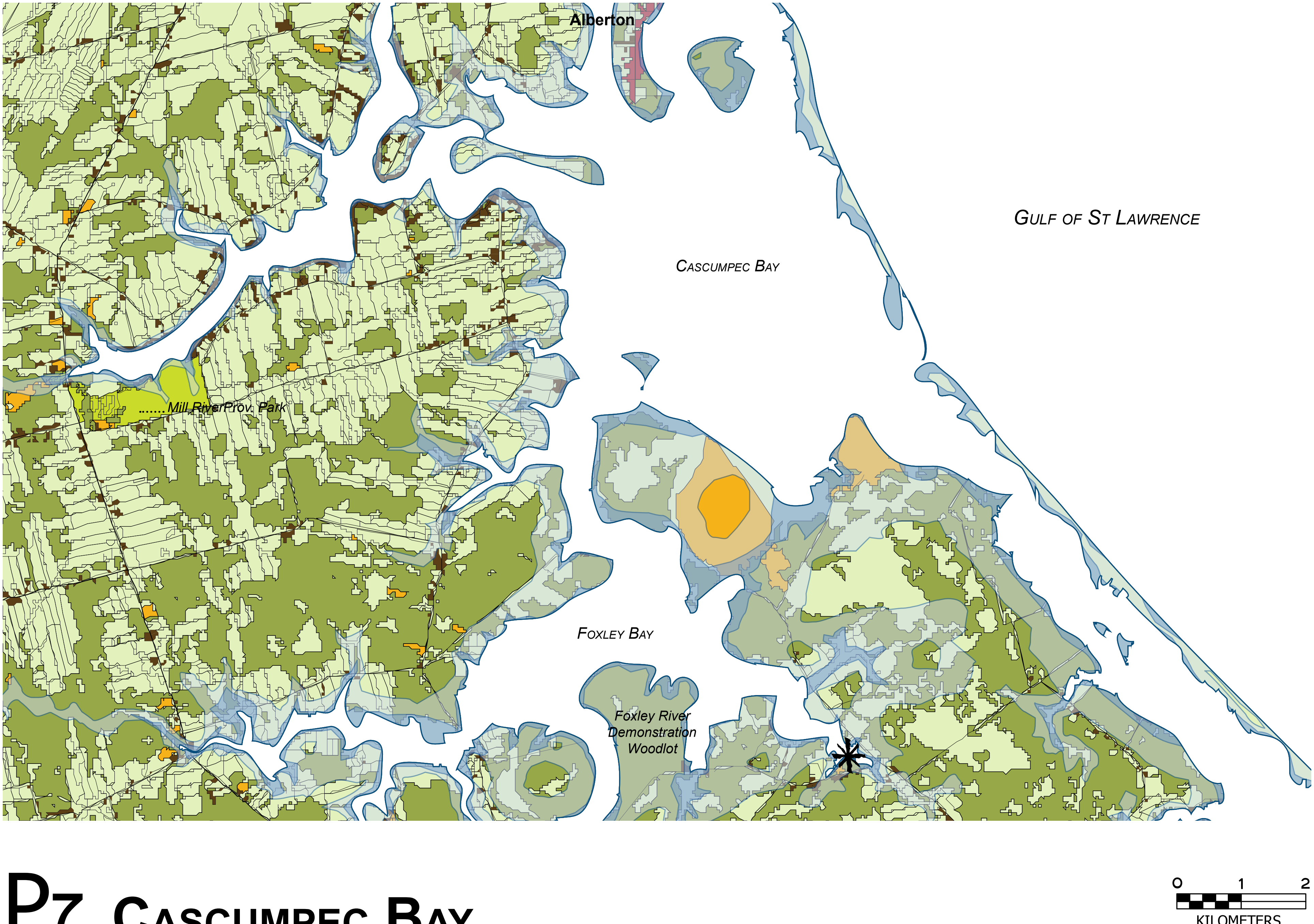


P7 Cascumpec Bay

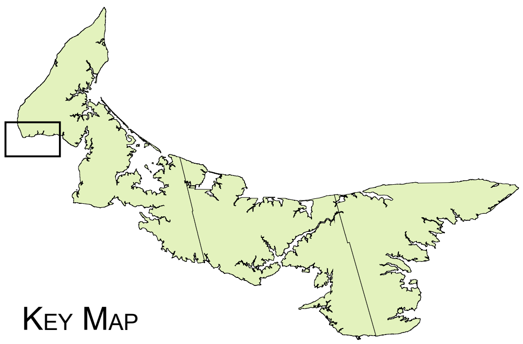
West Point

Carey Pt, West Cape

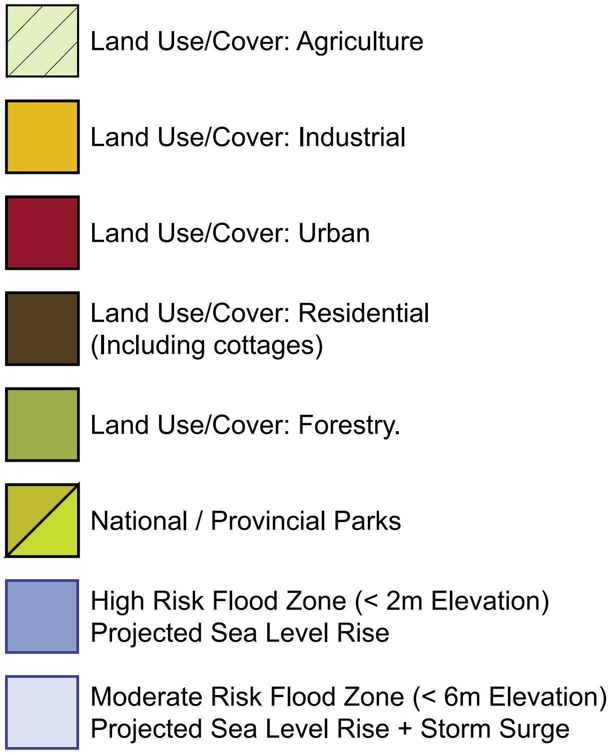
Fish ladder, Glenwood

Points of Interest

• Coastal land formations significantly drop in elevation on the south shore east of West Point, where many low lying estuaries flow into Egmont Bay.



Map Legend



P8 West Point

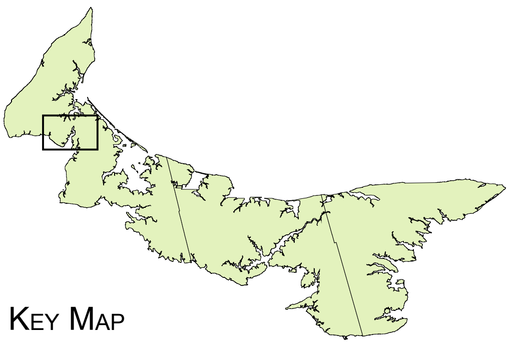
Percival Bay

West Devon

Points of Interest

• The lowest and narrowest portion of PEI is between Percival River and Foxley Bay. The Rte 2 Highway bridges this area connecting to the west end of the Island.

• Large tracts of low lying land border Percival Bay containing salt marsh, sand dunes and coastal bogs, which provide ideal habitat for diverse marine and bird populations.



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National / Provincial Parks

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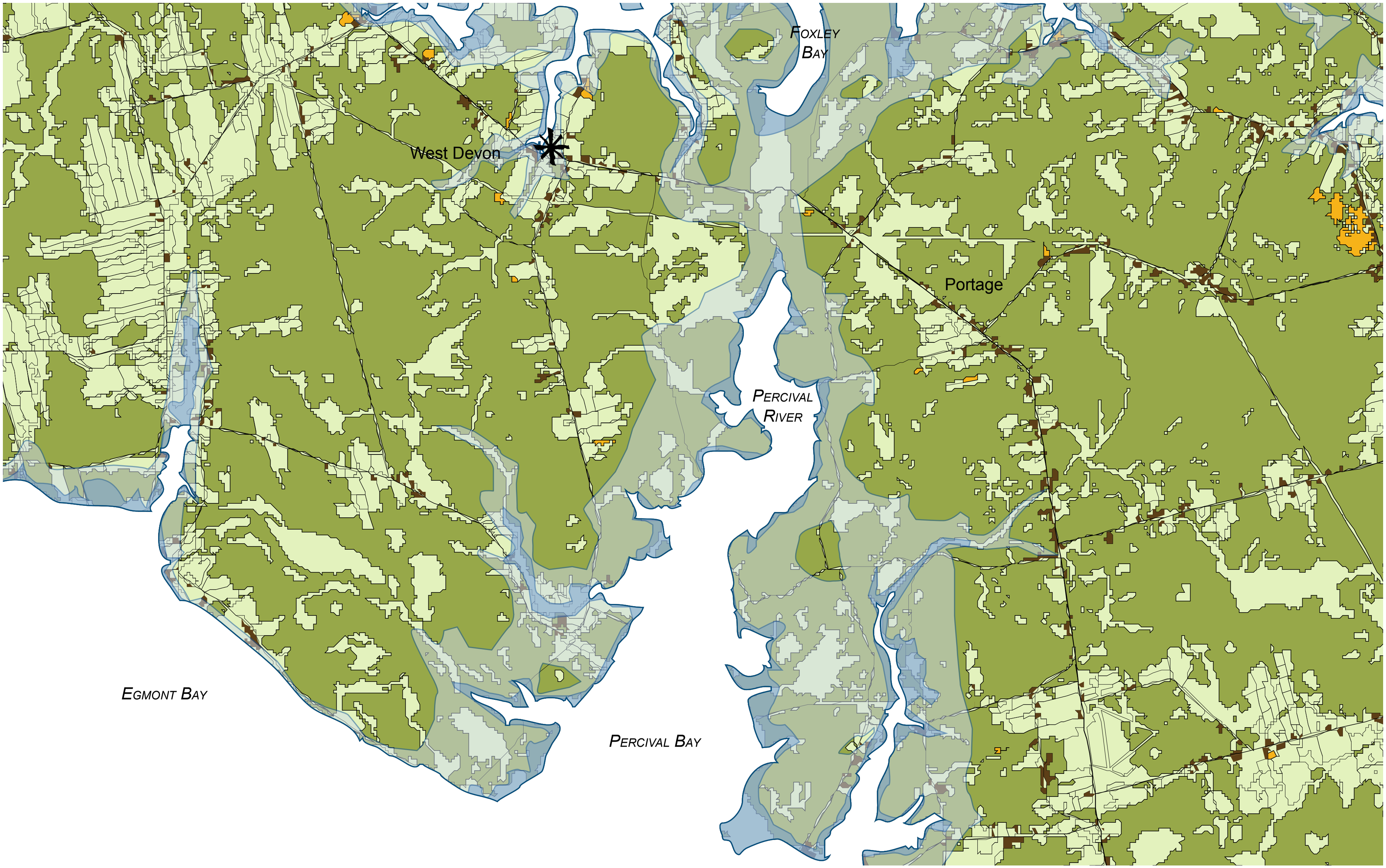
Moderate Risk Flood Zone (< 6m Elevation) Projected Sea Level Rise + Storm Surge



P9 Percival Bay

P10

Lennox Island

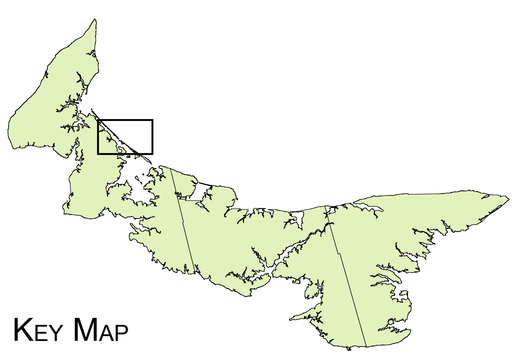
East Bideford

Lennox Island

Points of Interest

• Lennox Island First Nation (245), is connected to the Island by a short causeway and bridge.

• In this region the north shore and Lennox Island are broadly sheltered from the Gulf by natural sandy barrier islands.



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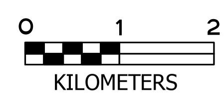


P10 LENNOX ISLAND

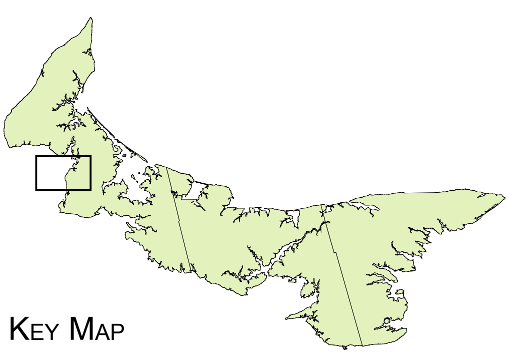
P11 HIGGINS SHORE

Victoria West

St. Chysostome

POINTS OF INTEREST

• Roads, settlements and agricultural land extend close to the shoreline on the east side of Egmont Bay.



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P11 Higgins Shore

P12

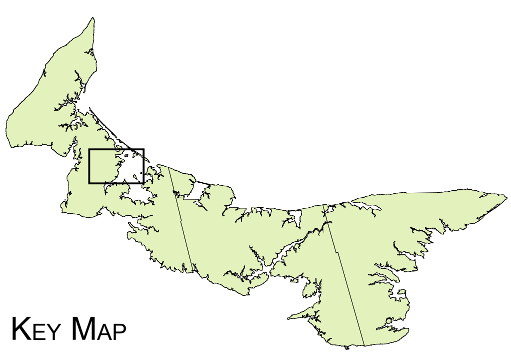
Tyne Valley

Shipbuilding Museum, Green Park Provincial Park

Tyne Valley

Points of Interest

- Tyne Valley (226), and Lennox Island First Nation (252)
- Green Park Provincial Park contains historic properties from the early shipbuilding days of the 19th century.
- The shallow waters of Malpeque Bay are protected from the Gulf by Hog Island, a long sandy barrier island, and are an ideal habitat for oysters for which the name is well known.



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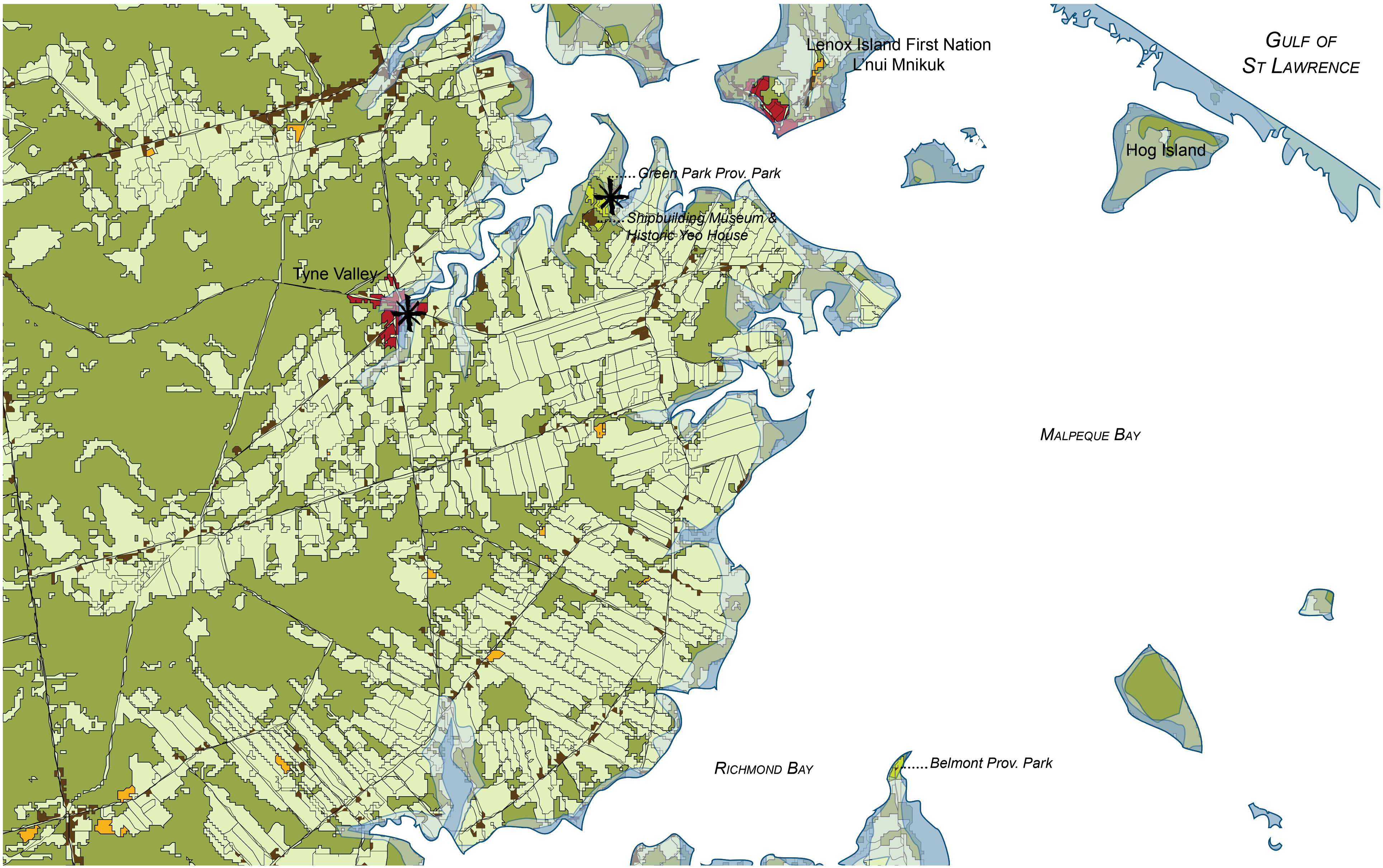


P12 Tyne Valley

P13 CABOT BEACH

Darnley Basin, Malpeque

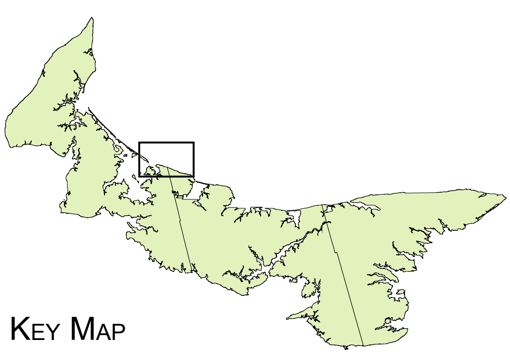
Cousin's Shore

POINTS OF INTEREST

• Darnley Basin in the eastern portion of Malpeque Bay.

• The shallow waters of Malpeque Bay are protected from the Gulf by Hog Island, a long sandy barrier island, and are an ideal habitat for oysters for which the name is well known.

• Cousin's Shore is an exposed coastline along the north shore with little to no existing forest cover on this coastline.



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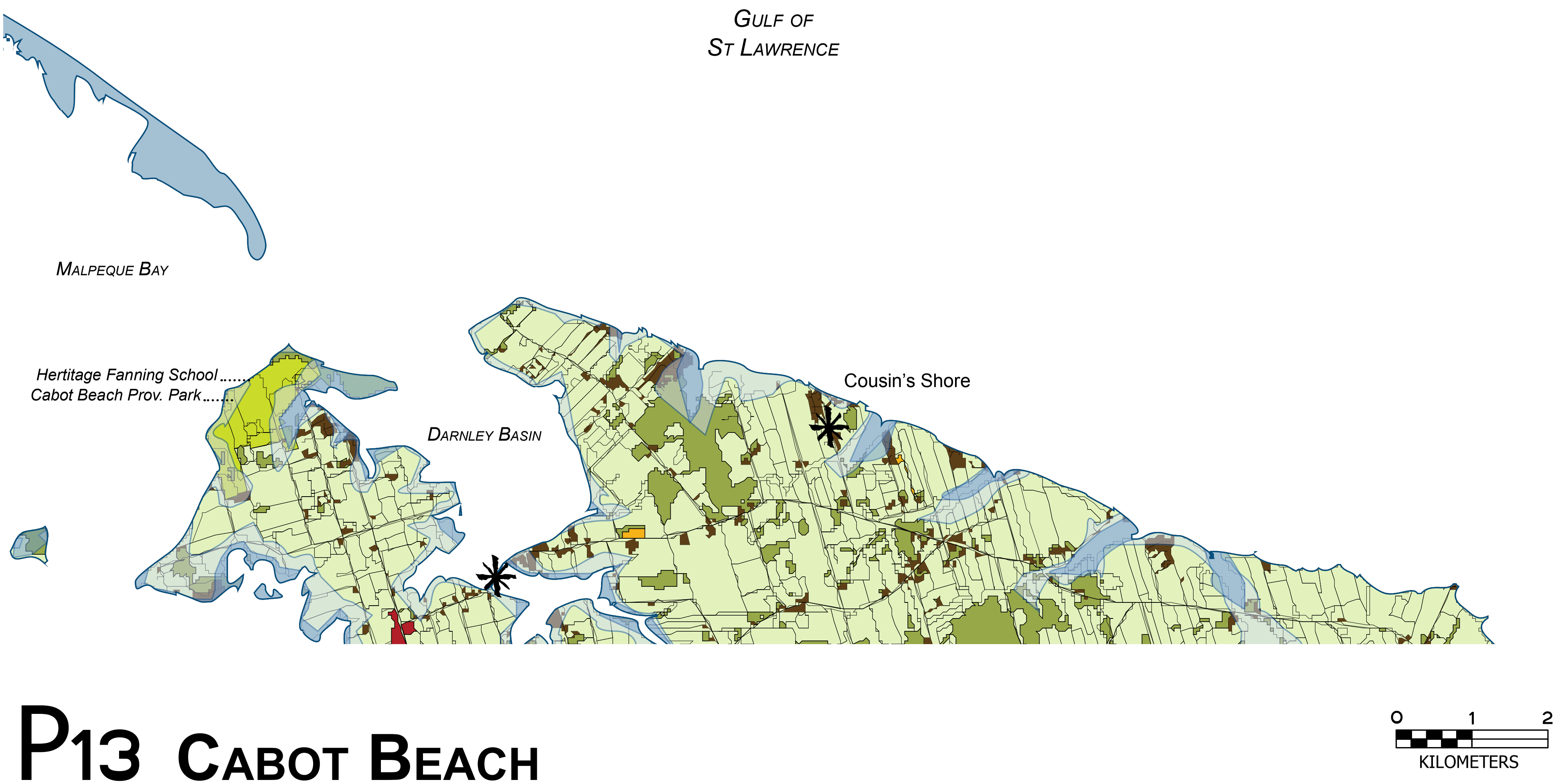
P13 Cabot Beach



P14

Cape Egmont

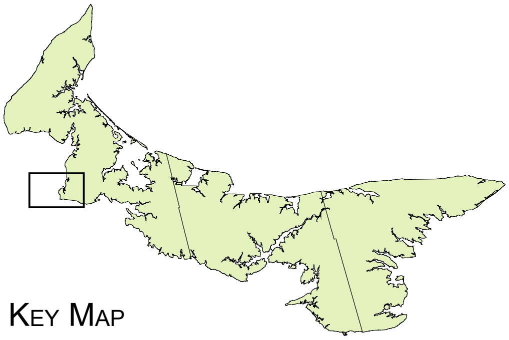
Cape Egmont

Maximeville

Points of Interest

• Abrams Village (266).

• Cape Egmont is a vulnerable point where the waters of Egmont Bay and Bedeque Bay merge. The low lying land between these shores is at risk of inundation, and access roads are particularily vulnerable as they run adjacent to the coastline.



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P14 Cape Egmont

P15 Wellington & Miscouche

Wellington ✳

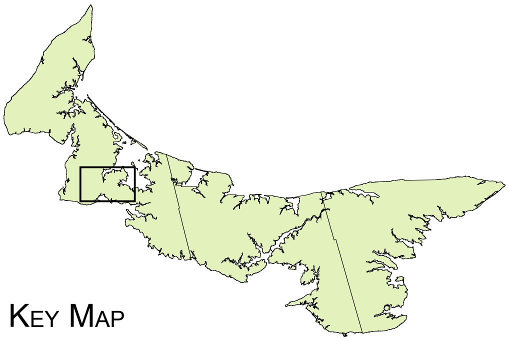
Grand River, Wellington ✳

Points of Interest

• Wellington (401), Miscouche (769) and the City of Summerside (14,500).

• This narrow portion of the Island is vulnerable on both coasts as the estuaries on Richmond Bay and Bedeque Bay deeply penetrate inland.

• Rte 2 Highway is the primary access road through this area for access to the west end of the Island.



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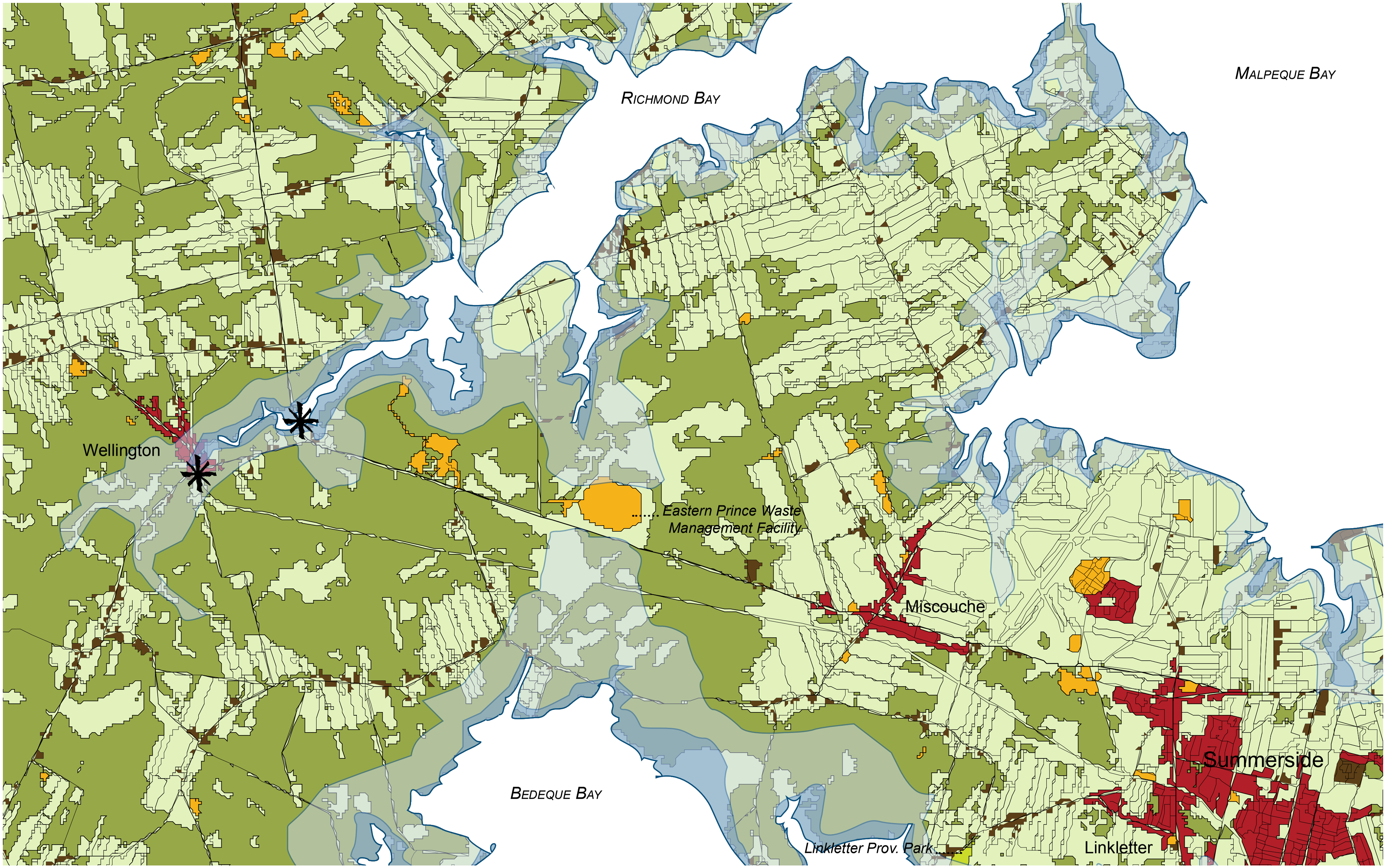


P15 Wellington & Miscouche

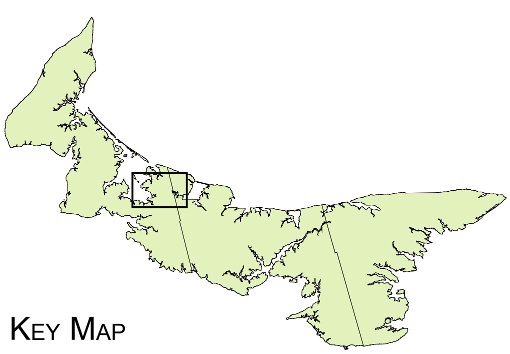
P16 KENSINGTON

Hamilton, Malpeque Bay

March Water, view of Ram Island

POINTS OF INTEREST

- Kensington (1,485)
- Low lying agricultural land merges with the shallow waters of Malpeque Bay with very little forest cover in this region.
- The shallow waters of Malpeque Bay are protected from the Gulf by Hog Island, a long sandy barrier island, and are an ideal habitat for oysters for which the name is well known.



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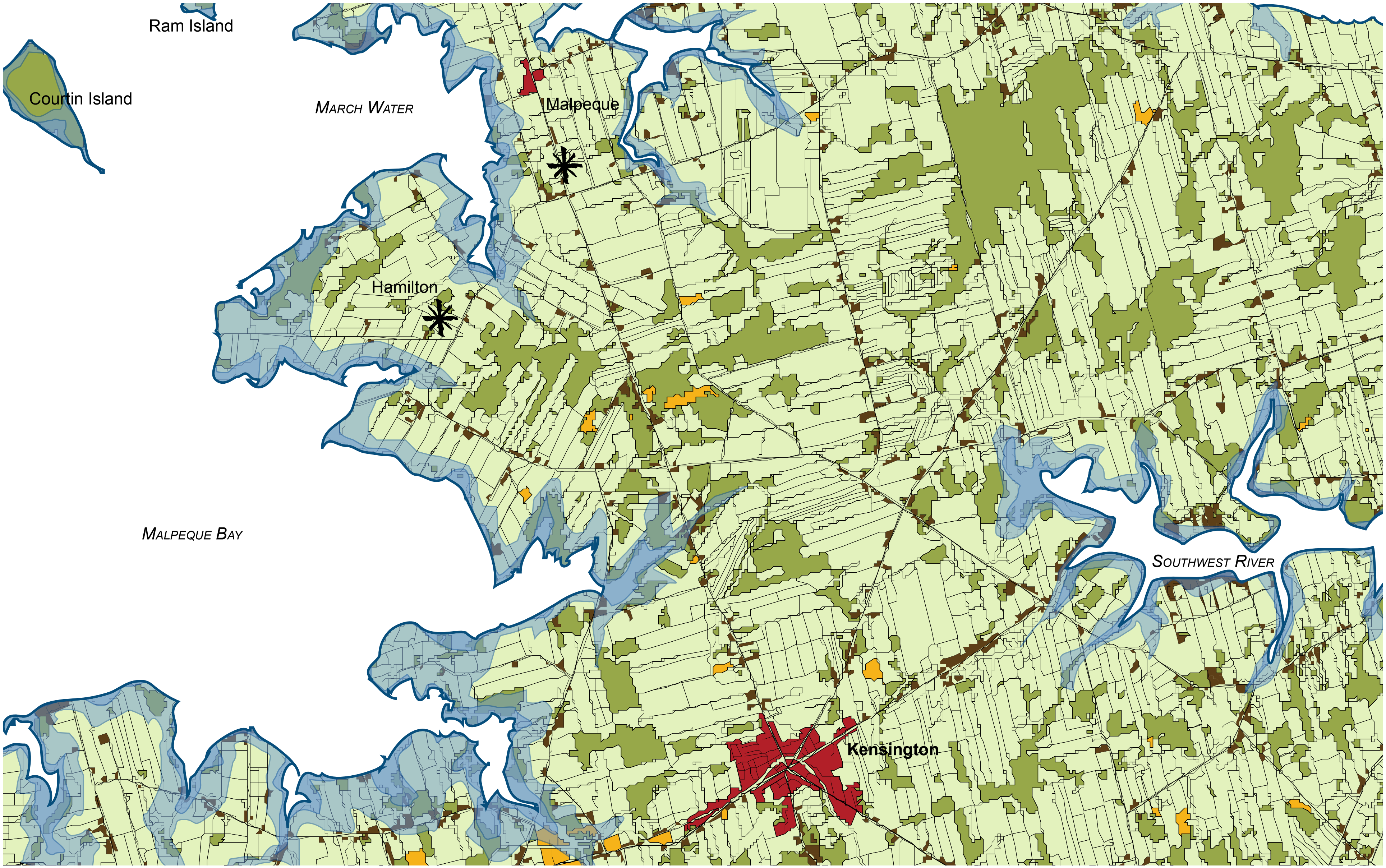


P16 Kensington

P17

Linkletter

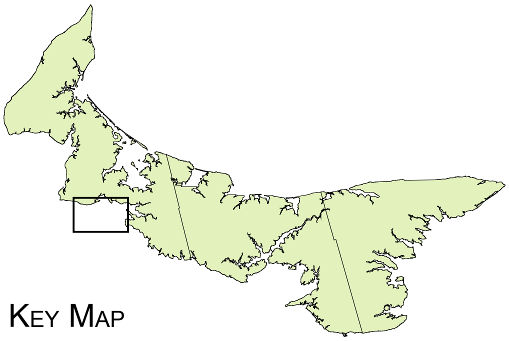
Union Corner Provincial Park

Mont-Carmel

Points of Interest

• City of Summerside (14,500)

• The wide mouth of the Bedeque Bay exposes the shorelines of Union Corner, Linkletter and the Summerside Harbour making this coats particularily vulnerable to storm surge impacts.



Key Map

Map Legend

Land Use/Cover: Agriculture

Land Use/Cover: Industrial

Land Use/Cover: Urban

Land Use/Cover: Residential (Including cottages)

Land Use/Cover: Forestry.

National / Provincial Parks

High Risk Flood Zone (< 2m Elevation) Projected Sea Level Rise

Moderate Risk Flood Zone (< 6m Elevation) Projected Sea Level Rise + Storm Surge

P17 Linkletter

P18 SUMMERSIDE

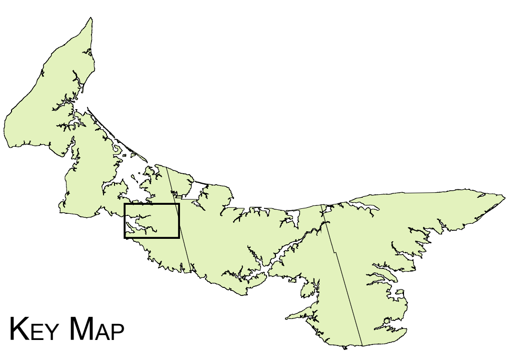
Wilmot River

Summerside Harbour, City of Summerside

POINTS OF INTEREST

• City of Summerside (14,500), Bedeque (139), Central Bedeque (149), Sherbrooke (168) and Kensington (1,485).

• The City of Summerside's deep water shipping port is widely exposed to the Northumberland Strait and related infrastructure is particularily vulnerable to future storm surge impacts.



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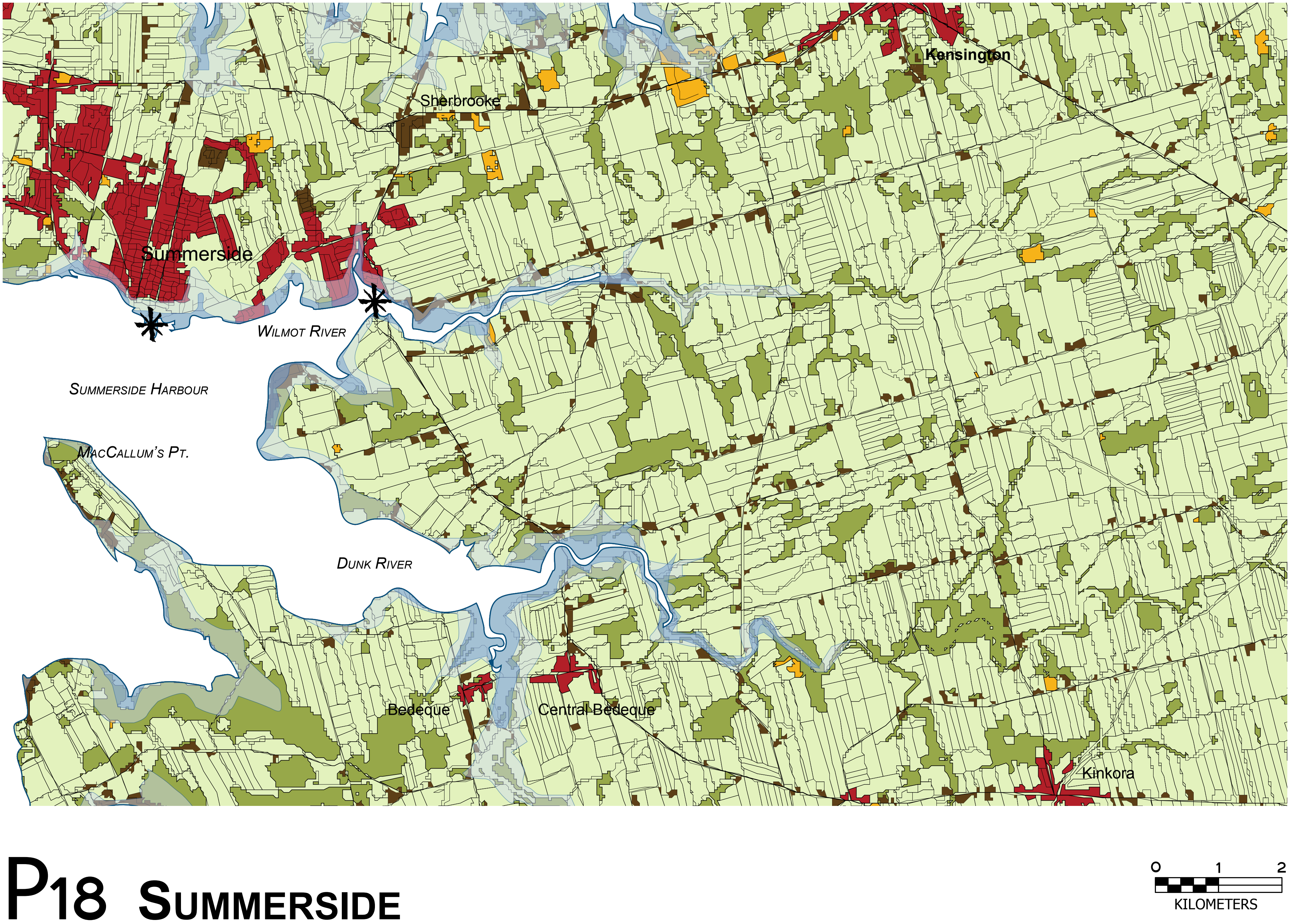


P18 Summerside

P19

Borden-Carleton

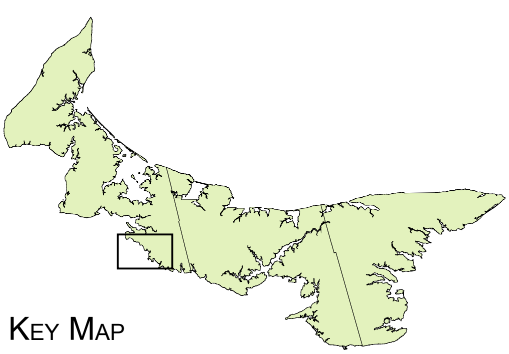
Borden-Carleton

Sevenmile Bay

Points of Interest

• Borden-Carleton (786) and Kinkora (326)

• The Confederation Bridge connecting PEI with New Brunswick was built to withstand 1m sea level rise based on projections reported by Environment Canada in the 1988 study on the potential impacts of Sea Level Rise in Charlottetown.



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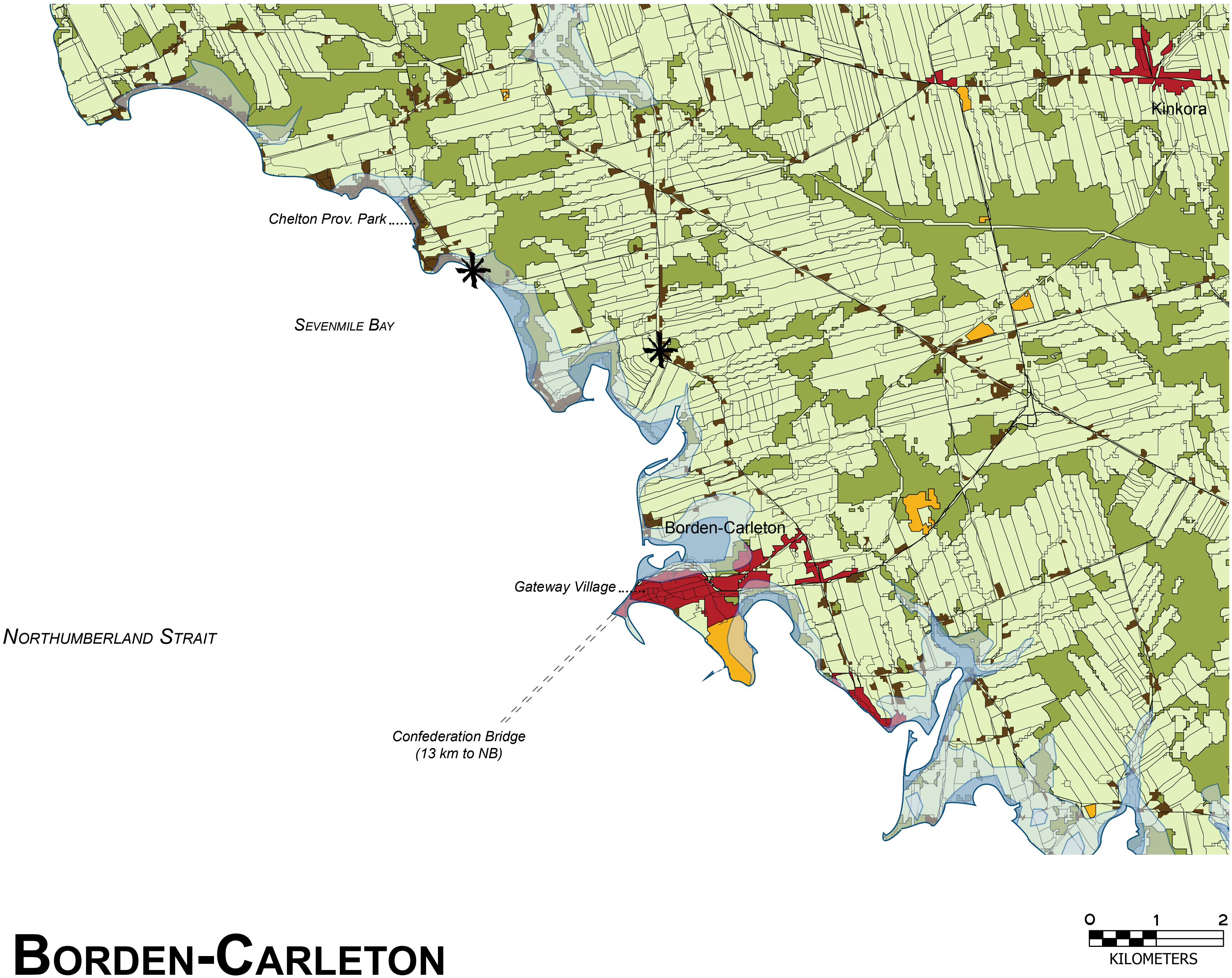


P19 Borden-Carleton

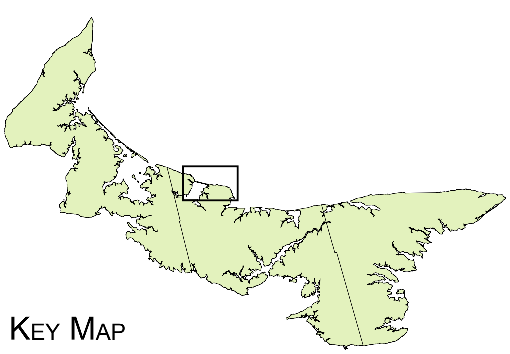
Q1 Cavendish Beach

Cavendish Beach, Prince Edward Island National Park

Springbrook, New London Bay

Points of Interest

- North Rustico (599)
- Prince Edward Island National Park extends along the North Shore east of New London Bay. Landforms within the Park include beaches, sand dunes, sandspits, barrier islands, sandstone cliffs, wetlands and forests.
- New London Bay is sheltered from a narrow sandspit barrier beach which is habitat to the endangered piping plover and other species.



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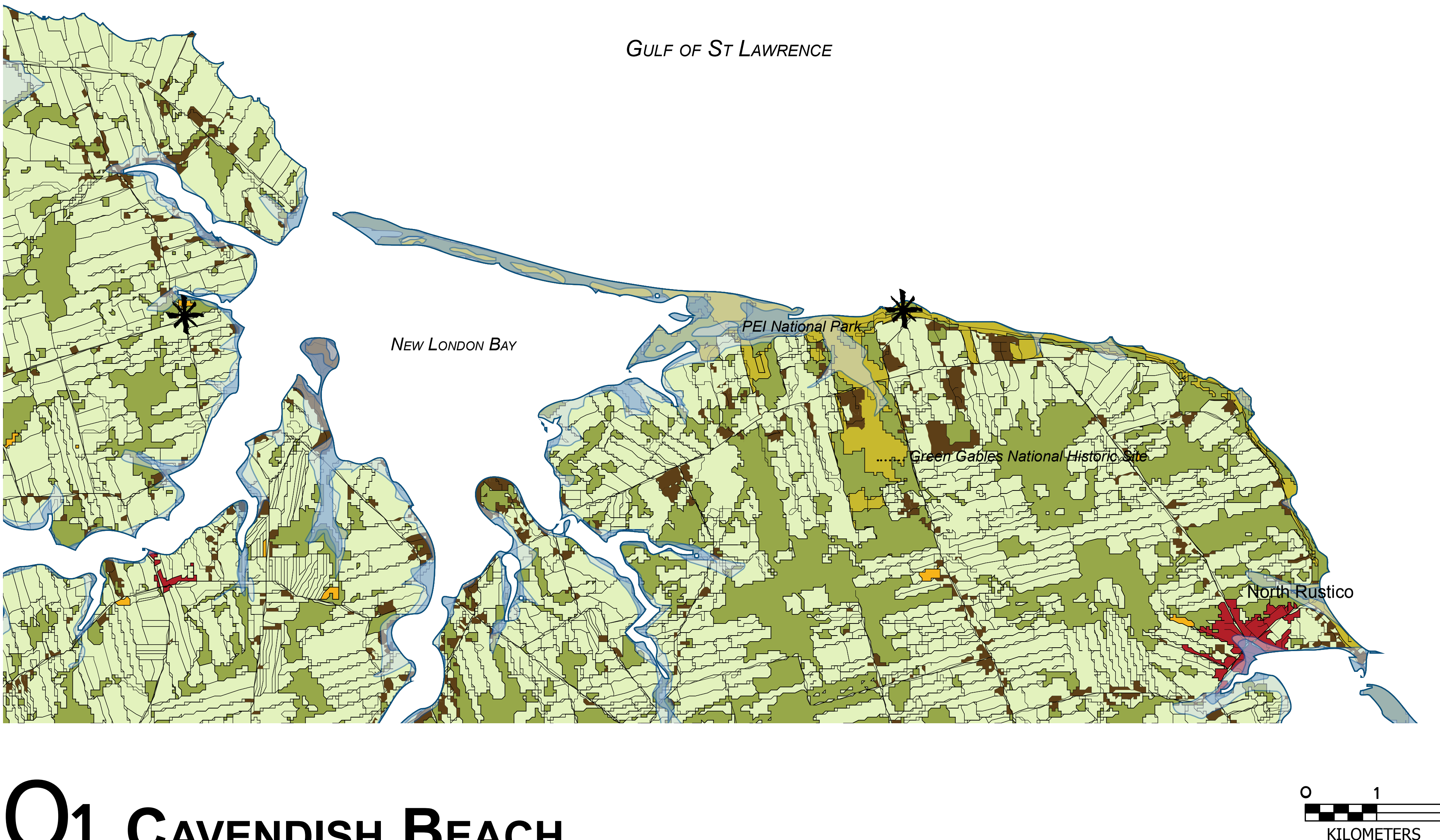


Q1 Cavendish Beach

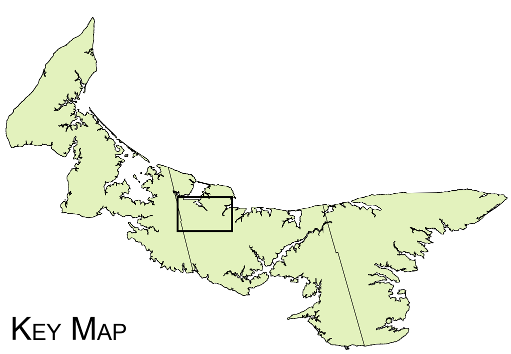
Q2 Hunter River

Stanley Bridge

New Glasgow

Points of Interest

- Hunter River (319) and North Rustico (599).
- River estuaries and other inland waters are particularily sensitive to saltwater intrusion and runoff from inland flooding.



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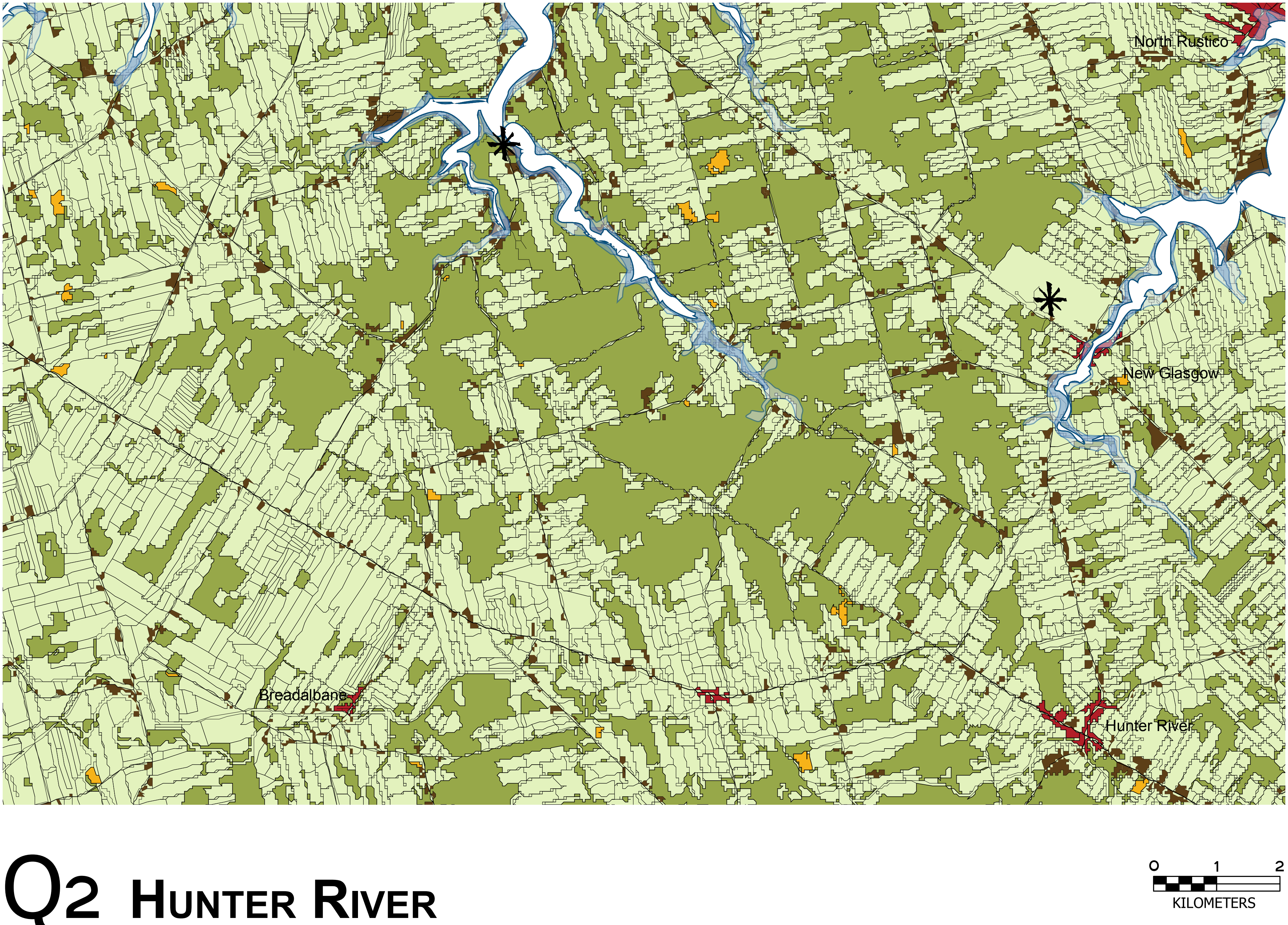


Q2 Hunter River

Q3 Brackley Beach

North Rustico Harbour

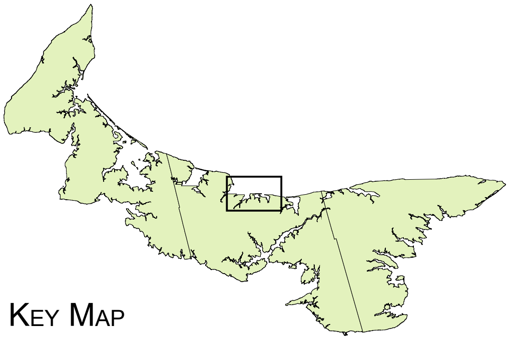
Brackley Beach, Prince Edward Island National Park

Points of Interest

• North Rustico (599)

• Prince Edward Island National Park extends along the North Shore east of New London Bay. Landforms within the Park include beaches, sand dunes, sandspits, barrier islands, sandstone cliffs, wetlands and forests.

• The waters of Rustico Bay are sheltered by Robinsons Island, a long sandy barrier island.



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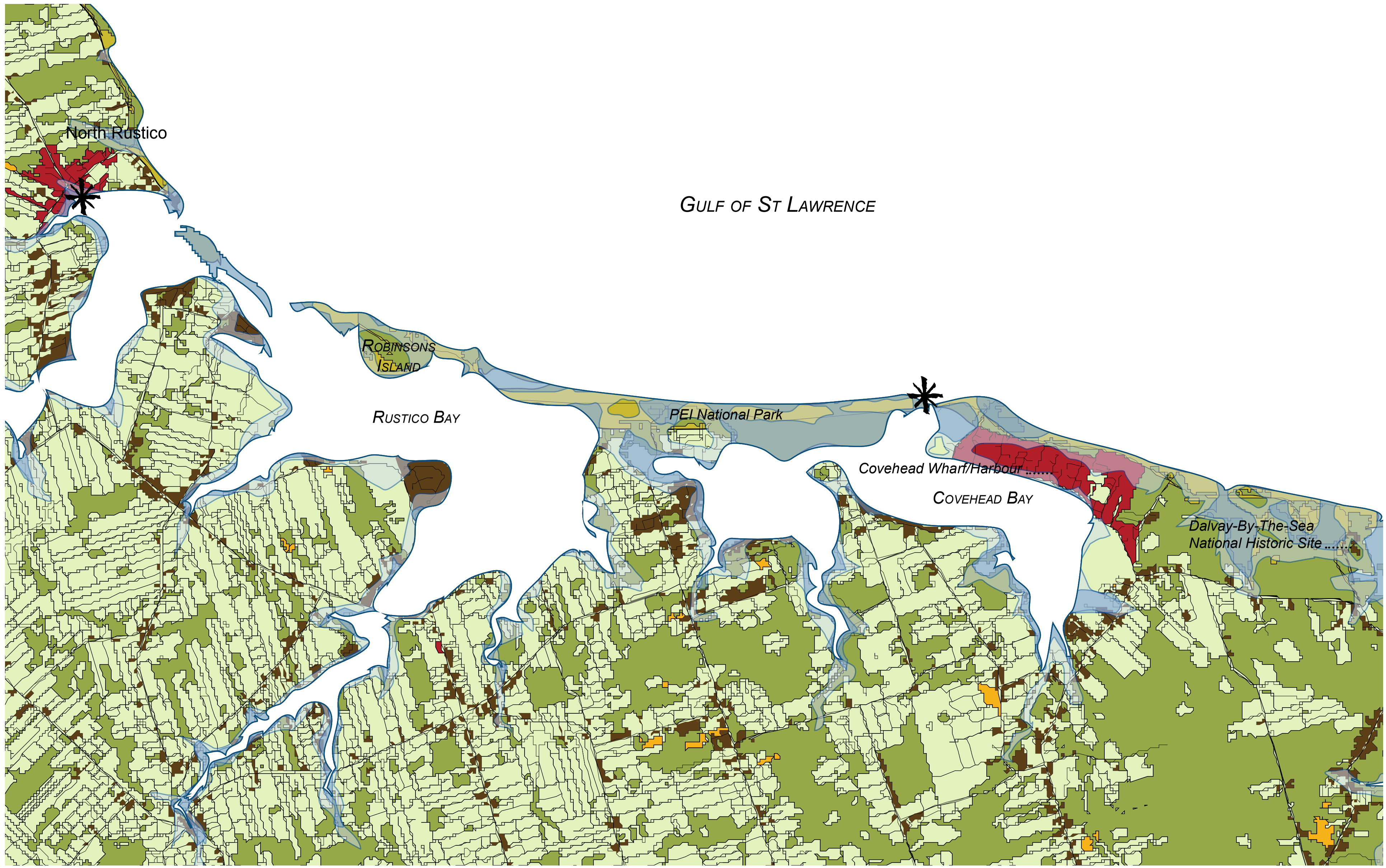
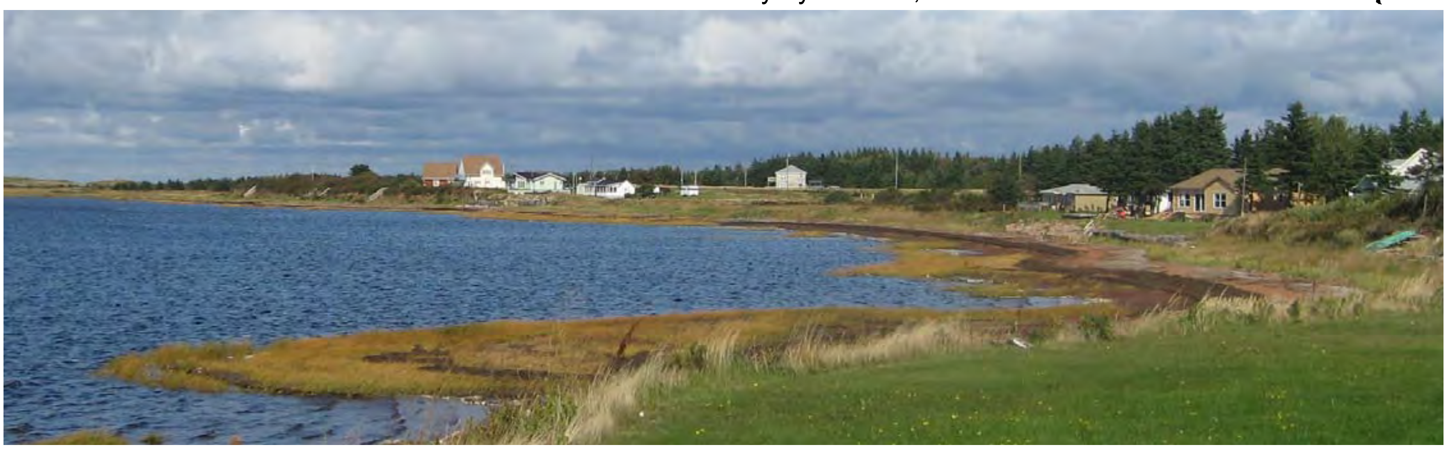


Q3 Brackley Beach

Q4 BLOOMING POINT

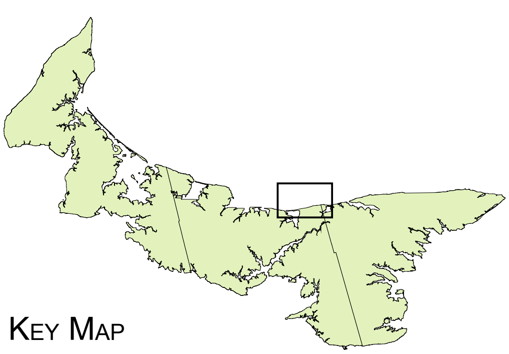
Dalvay-by-the-Sea, Prince Edward Island National Park



Blooming Point, Tracadie Bay

POINTS OF INTEREST

- Dalvay-By-The-Sea National Historic Site of Canada is located within the National Park which extends along the North Shore west of Tracadie Bay, and includes the barrier islands and sandspits within the Bay.
- Significant amount of low lying land between Tracadie Bay and Savage Harbour.



KEY MAP

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National / Provincial Parks

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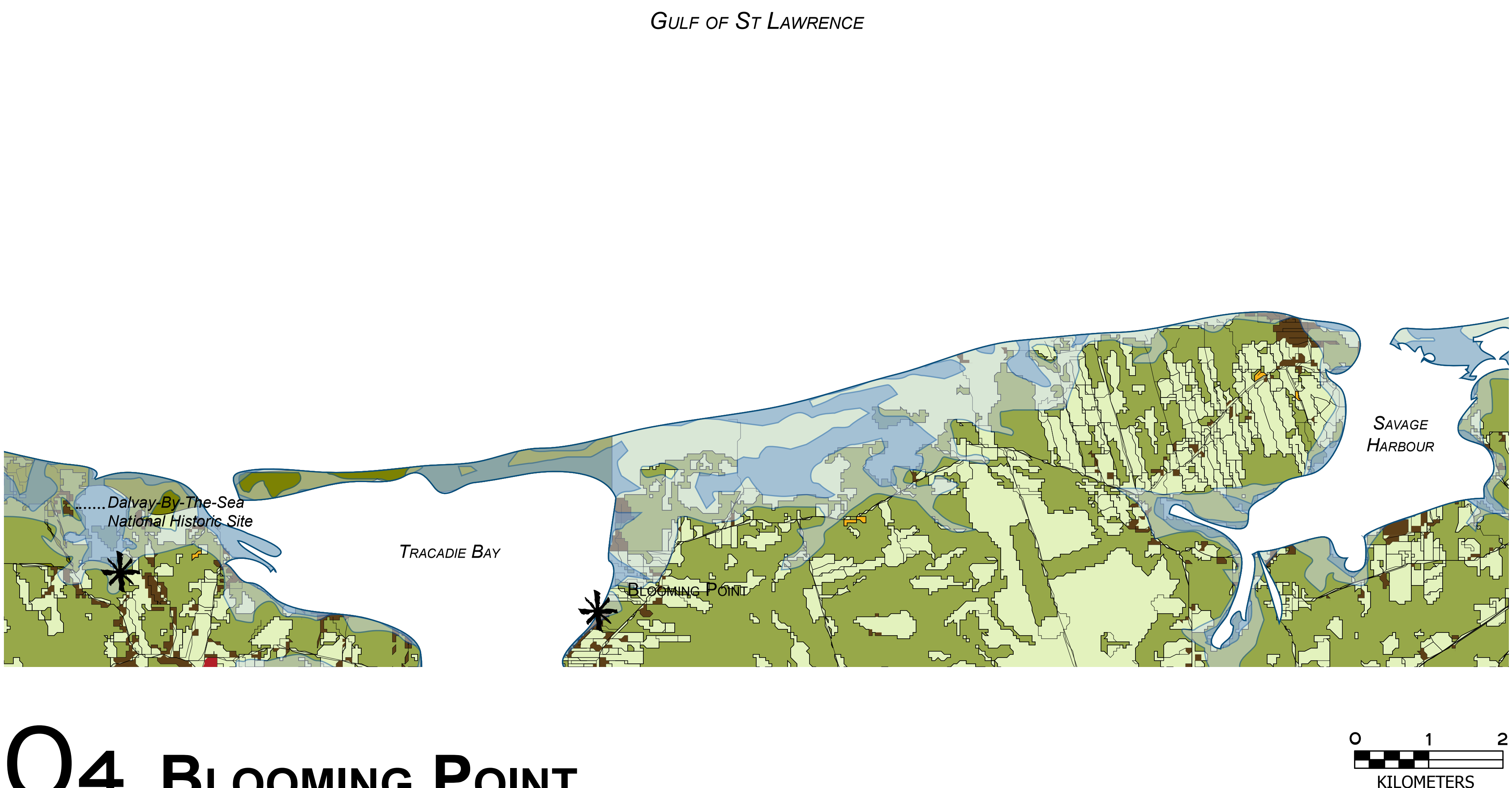


Q4 BLOOMING POINT

Q5

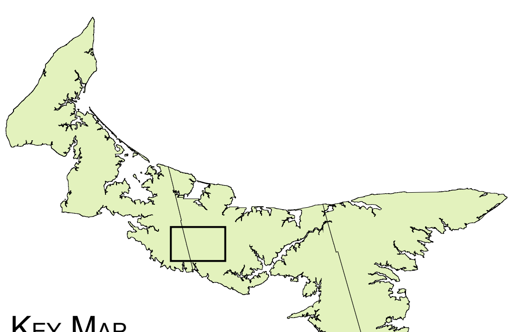
Crapaud

Crapaud

Points of Interest

• Crapaud (353), Kinkora (326) and Hunter River (319)

• Interior map illustrating the extent that the river estuaries penetrate inland into non-coastal communities. These inland waters are particularily sensitive to saltwater intrusion and runoff from inland flooding.



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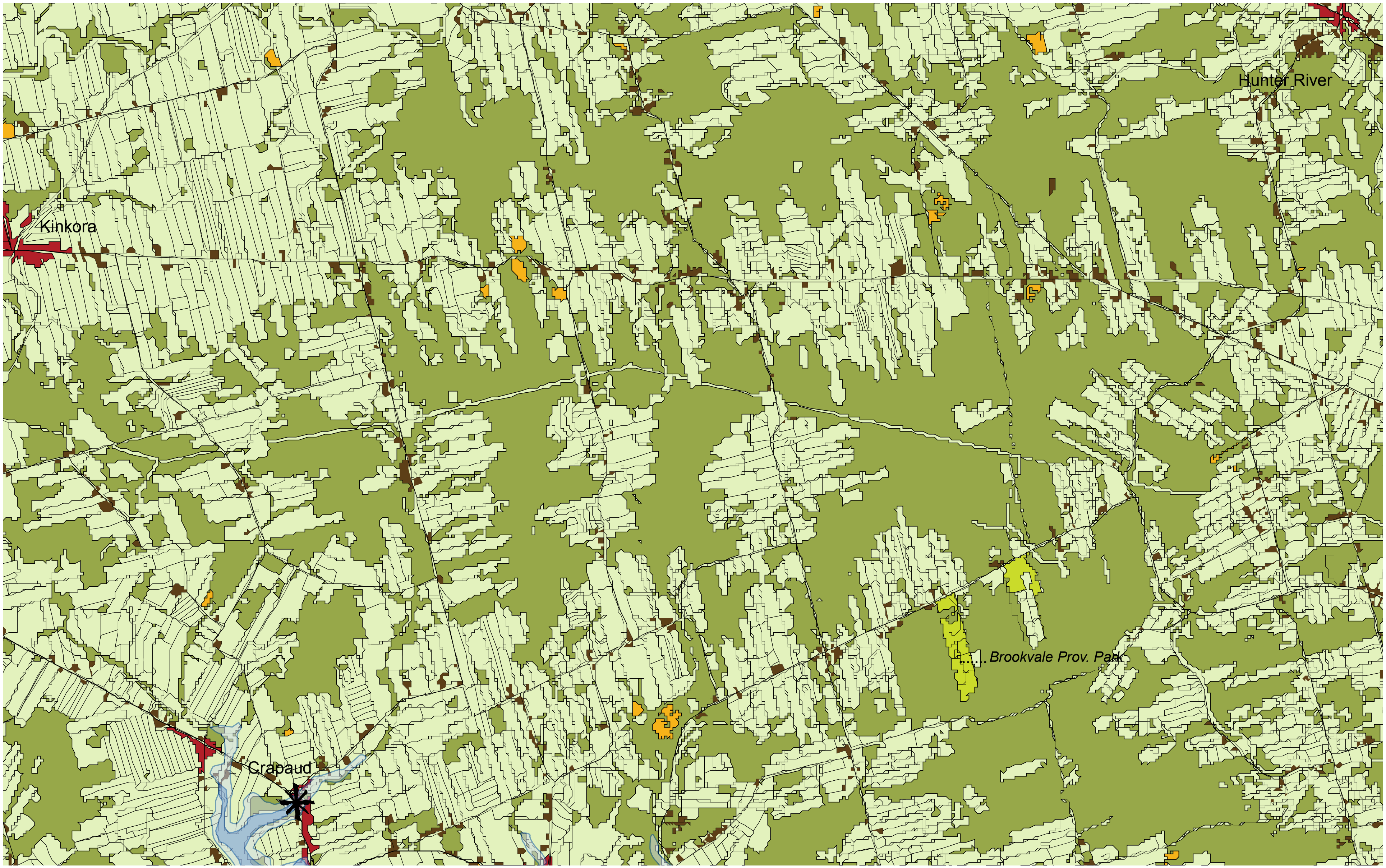
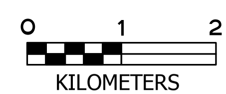
National / Provincial Parks

High Risk Flood Zone (< 2m Elevation) Projected Sea Level Rise

Moderate Risk Flood Zone (< 6m Elevation) Projected Sea Level Rise + Storm Surge


Hunter River
Kinkora
Brookvale Prov. Park
Crapaud

Q5 CRAPAUD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KILOMETERS

Q6 Greater Charlottetown Area

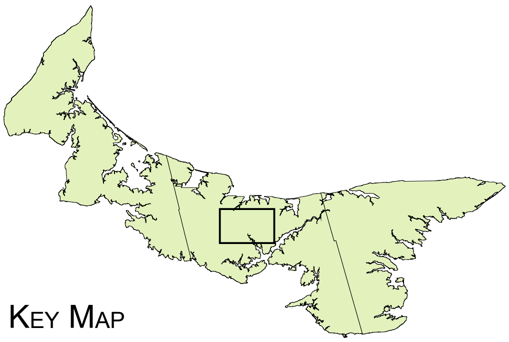
North River, Miltonvale

North River Causeway

Points of Interest

• Hunter River (319), Warren Grove (341), Miltonvale Park (1,163), Winsloe South (198), Union Road (245), Brackley (336) and the City of Charlottetown (32,174)

• The North River extends from the Charlottetown Harbour northwards. Inland waters are particularily sensitive to saltwater intrusion and runoff from inland flooding.



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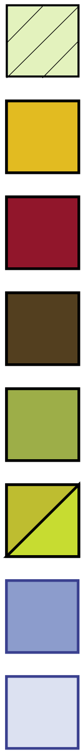

Land Use/Cover: Agriculture

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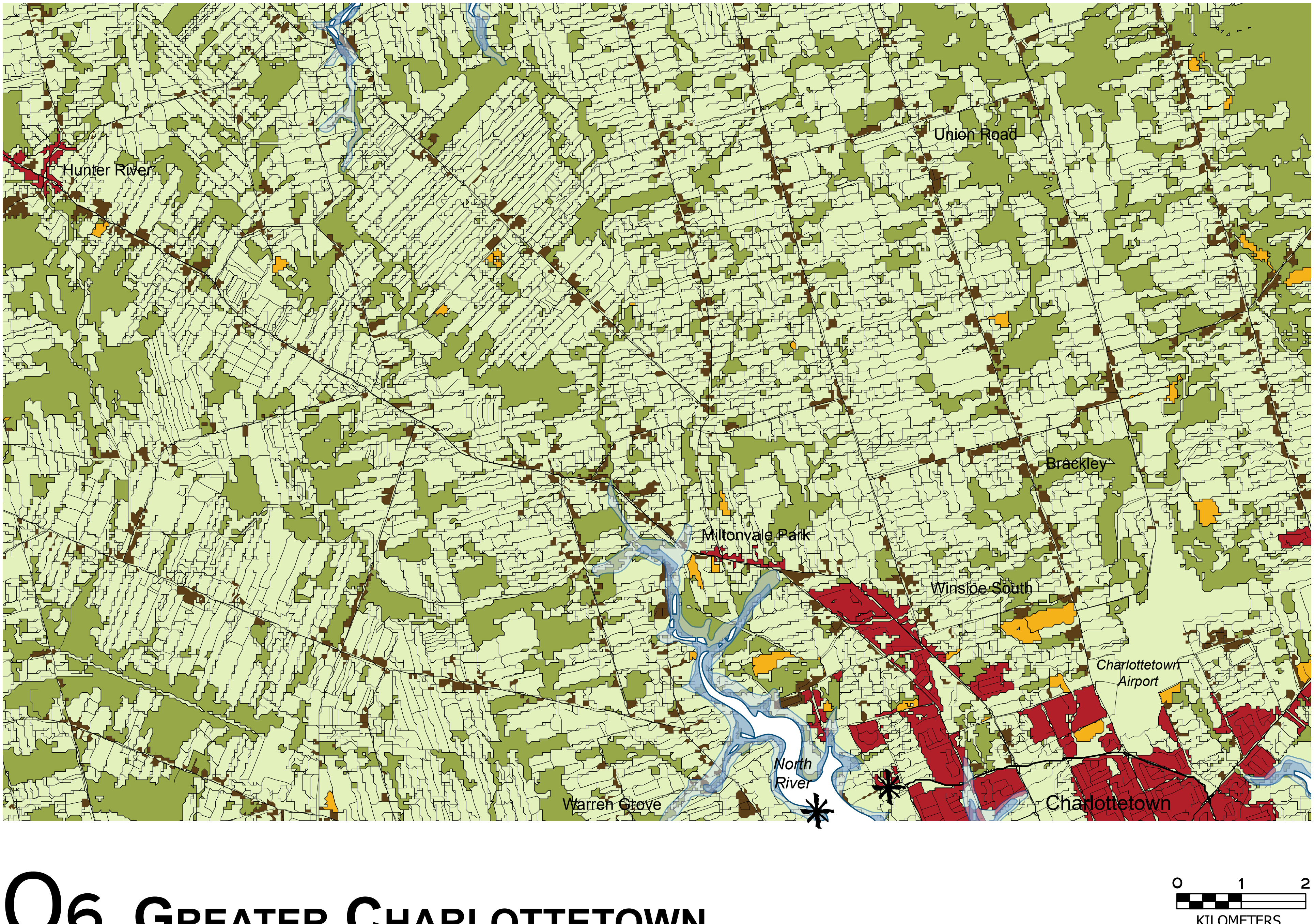
National / Provincial Parks

High Risk Flood Zone (< 2m Elevation) Projected Sea Level Rise

Moderate Risk Flood Zone (< 6m Elevation) Projected Sea Level Rise + Storm Surge



Q6 GREATER CHARLOTTETOWN

Q7

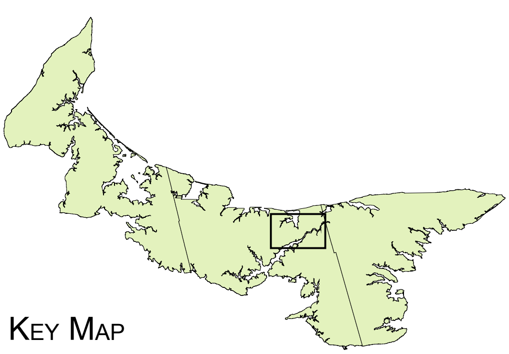
Hillsborough River

Hillsborough River, Scotchfort

Points of Interest

• Mount Stewart (261) and Scotchfort (137)

• The Hillsborough River is the longest river on PEI (45 km) and extends from the Charlottetown Harbour on the south shore to a point that is just 3 km away from Tracadie Bay on the north shore. Over half of its length is ocean estuary where salt and fresh water mix and where it is influenced by the tides, and storm surge events.



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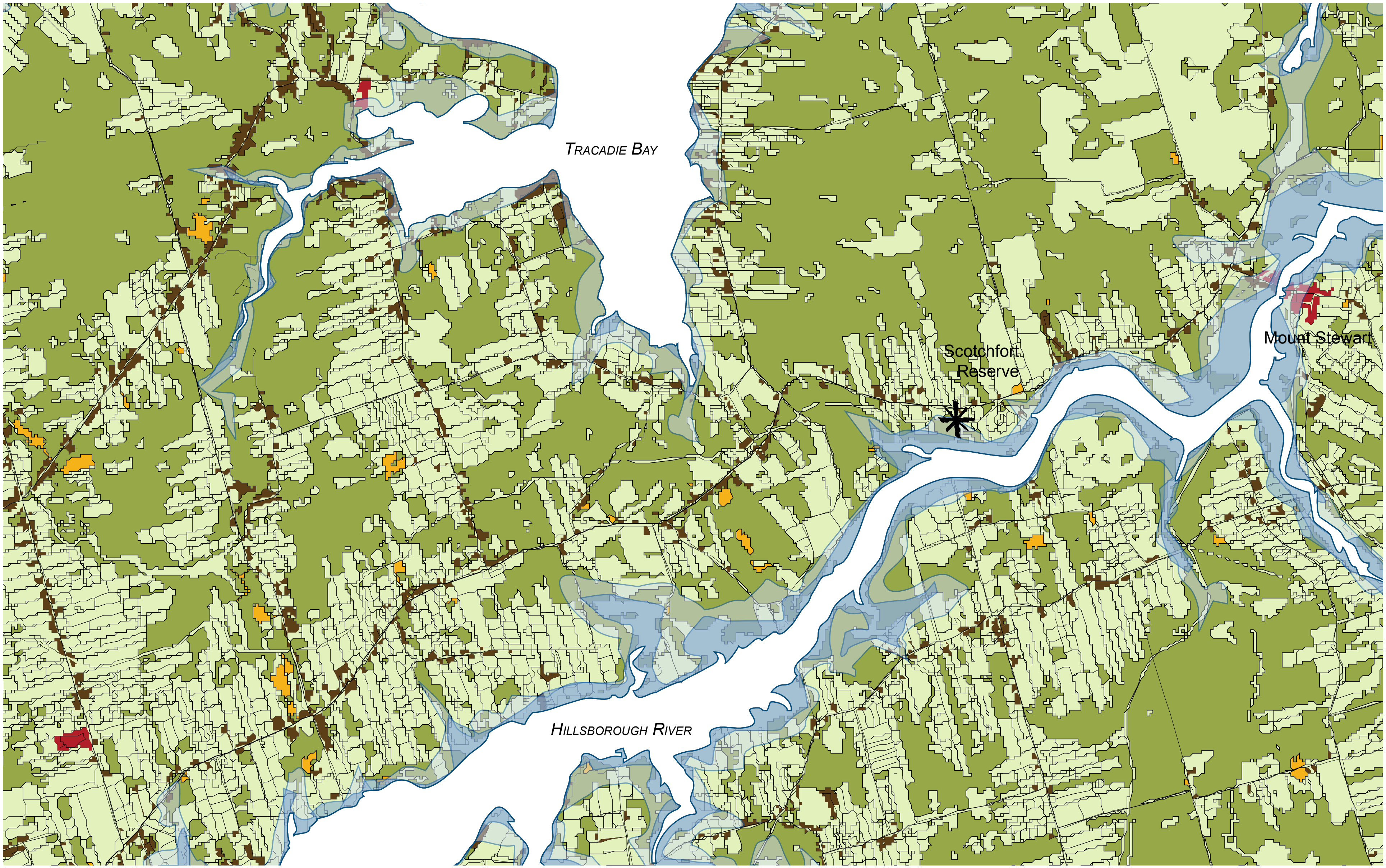
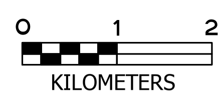




Q7 Hillsborough River

Q8 Victoria by the Sea

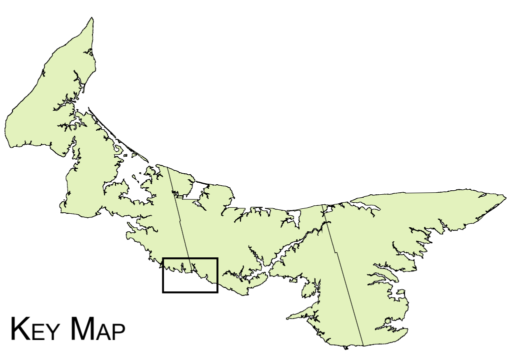
Victoria by the Sea ✳

Desable ✳

Points of Interest

• Crapaud (353) and Victoria (77)

• The south shore contains a mix of sandy beaches, ocean estuaries and sandstone cliffs, and for the most part the land is used for agricultural purposes with little forest cover on the coastlines.



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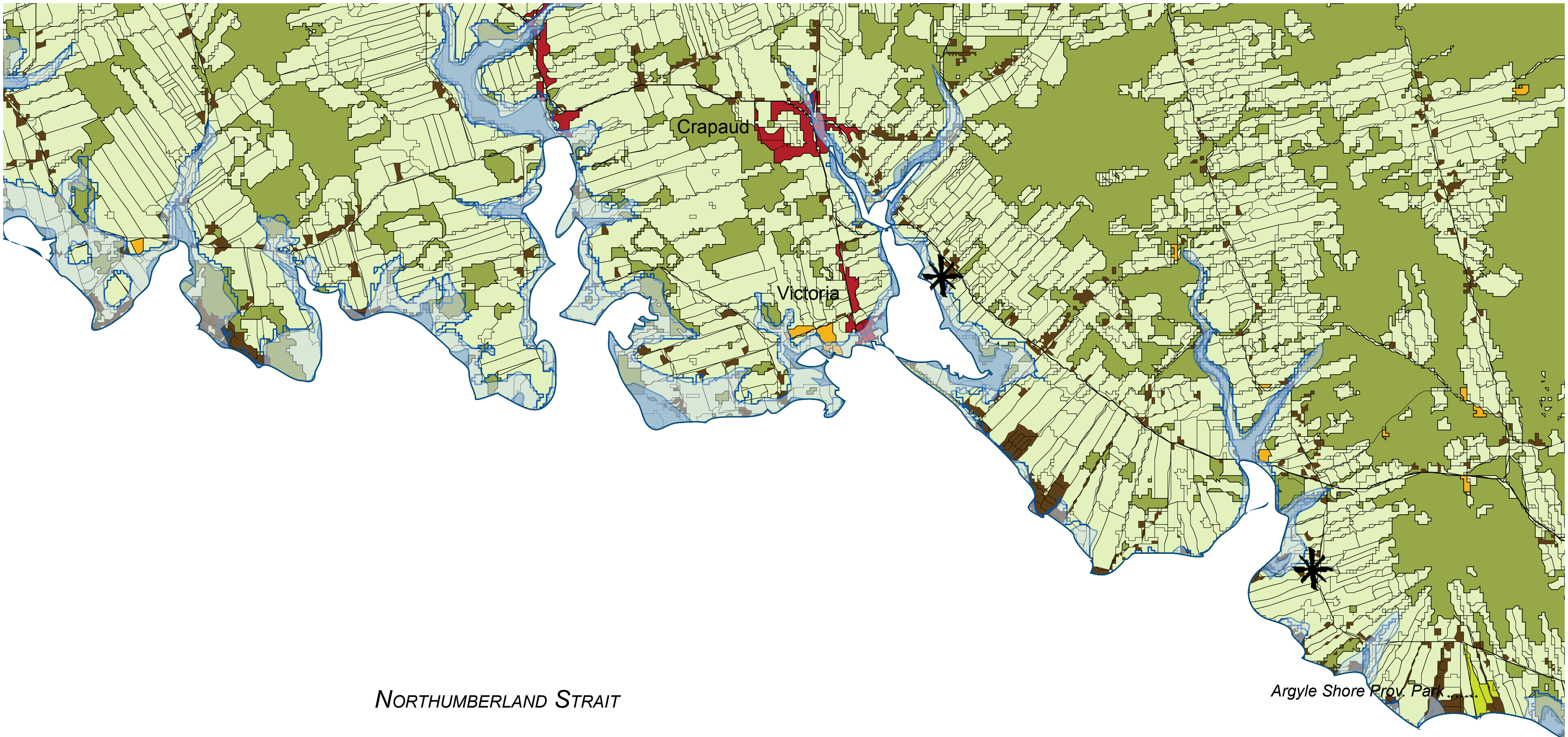
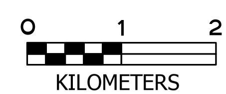


Q8 VICTORIA BY THE SEA



Q9

Cornwall

West River, Meadowbank

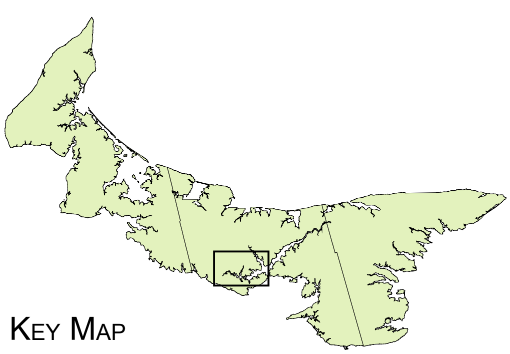
Charlottetown Harbour, view from Rocky Point

Points of Interest

• Cornwall (4,677), Clyde River (618), Meadowbank (364), Warren Grove (341), Rocky Point (41) and the City of Charlottetown (32,174)

• The West River extends westward from the Charlottetown Harbour.

• The historic City of Charlottetown is located on a low lying coast that is exposed to storm surge events.



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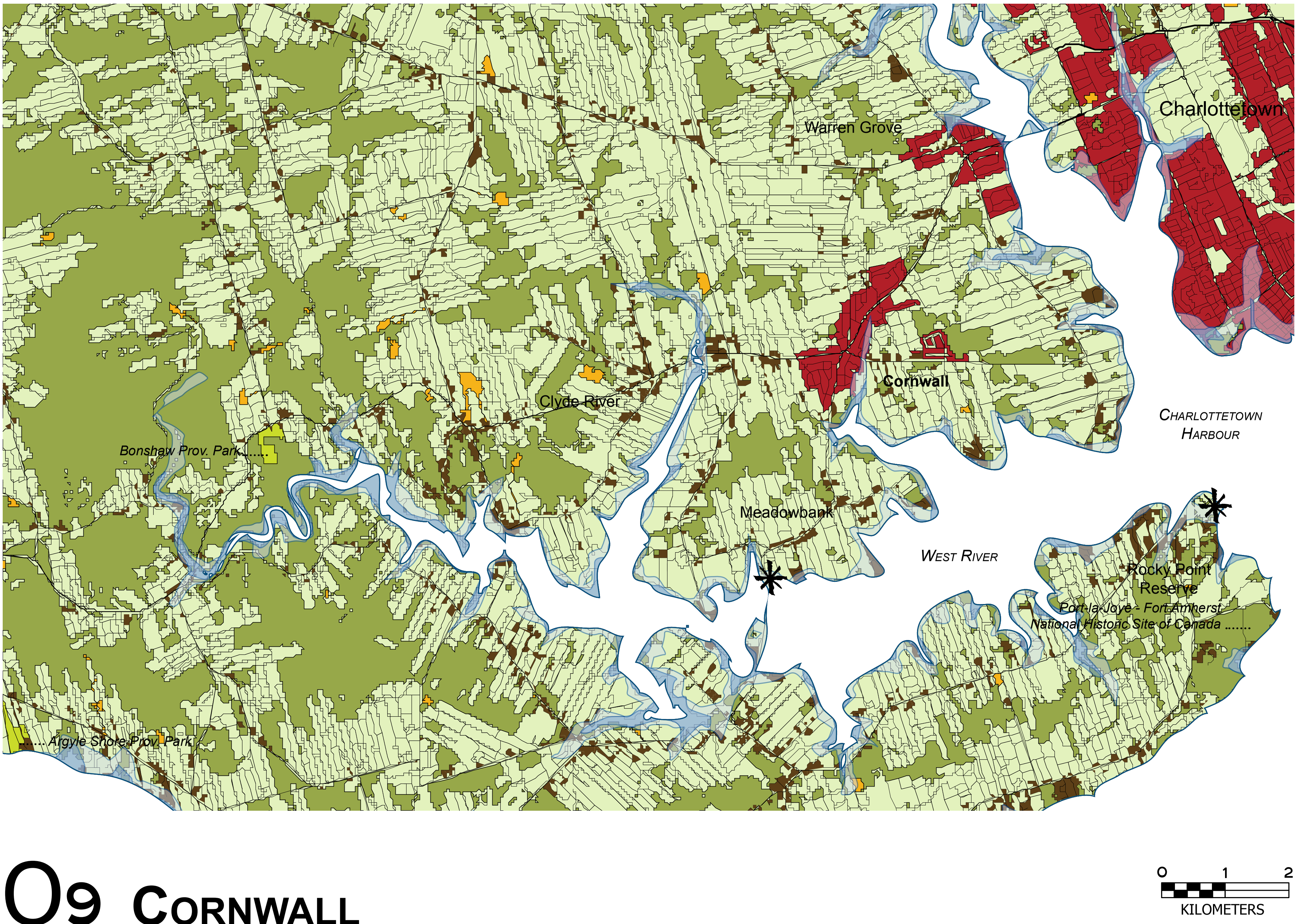
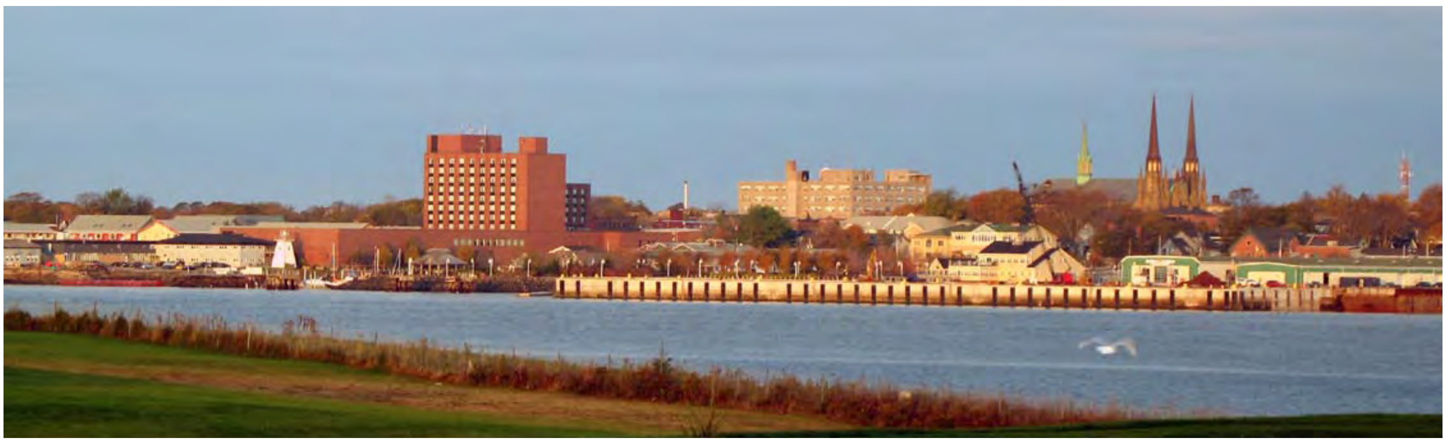
Q9 CORNWALL



Charlottetown
Warren Grove
Cornwall
Charlottetown Harbour
Clyde River
Bonshaw Prov. Park
Meadowbank
West River
Rocky Point Reserve
Port-la-Joye - Fort Amherst National Historic Site of Canada
Argyle Shore Prov. Park
0 1 2
KILOMETERS

Q10 Charlottetown & Stratford

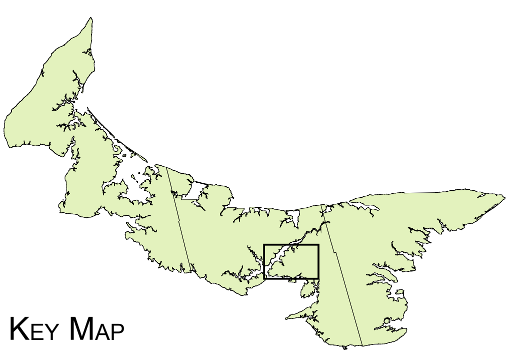
Mount Herbert, Hillsborough River



Charlottetown Harbour

Points of Interest

- City of Charlottetown (32,174), Stratford (7,083), and Rocky Point (41)
- The City of Charlottetown's waterfront contains significant amounts of low lying land.
- The town of Stratford is relatively sheltered with primarily residential development on a relatively higher coastline.



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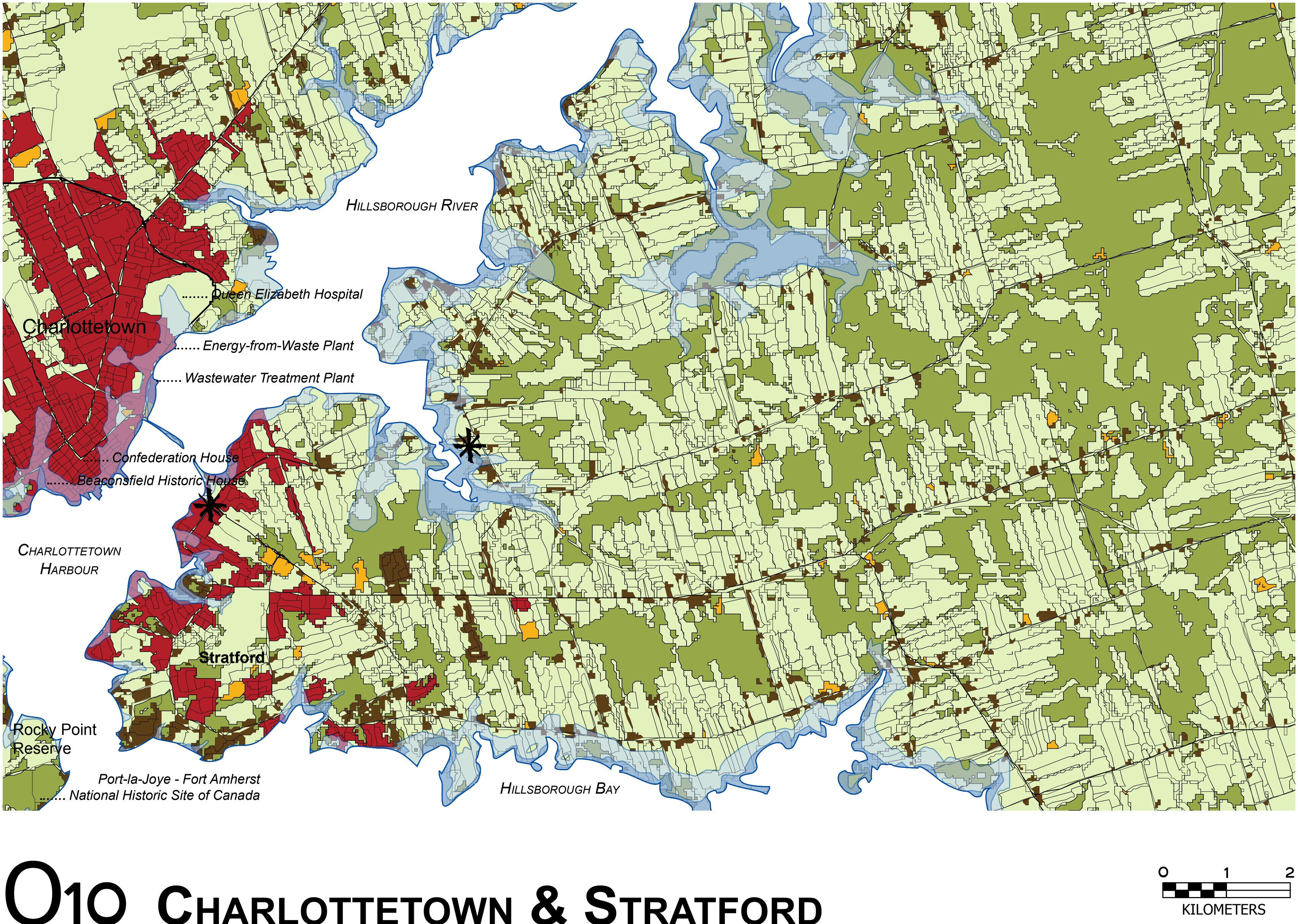


Q10 Charlottetown & Stratford

Q11

Canoe Cove

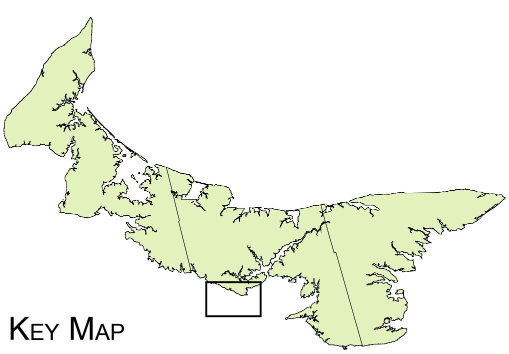
Cumberland

Nine Mile Creek

Points of Interest

• The south shore is primarily characterized by high sandstone cliffs and agricultural land uses dominate this landscape with little forest cover on the coastline.

• St. Peter's Island located within the Northumberland Strait is well known for its lighthouse located on the south side which stands high above red sandstone cliffs.



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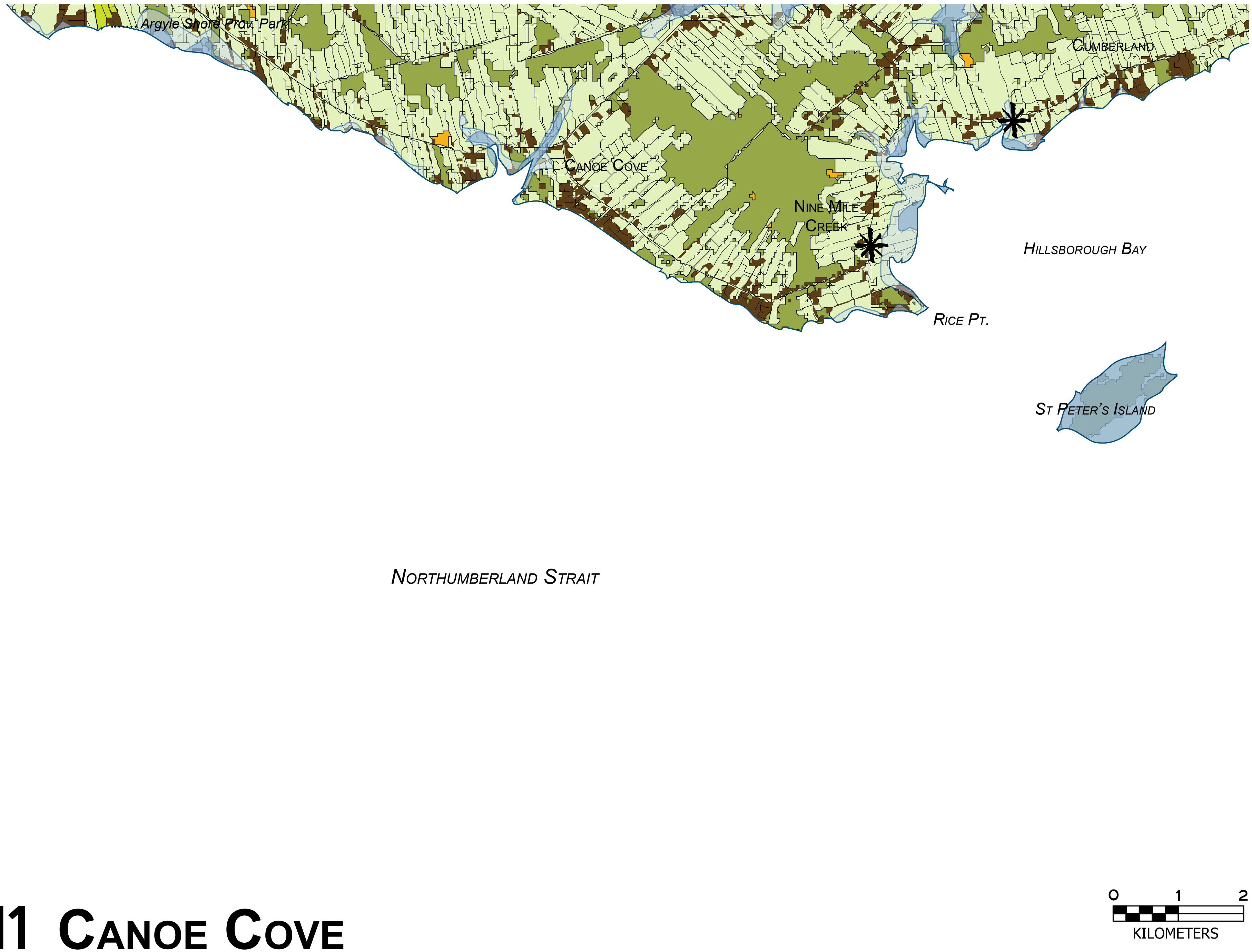


Q11 Canoe Cove

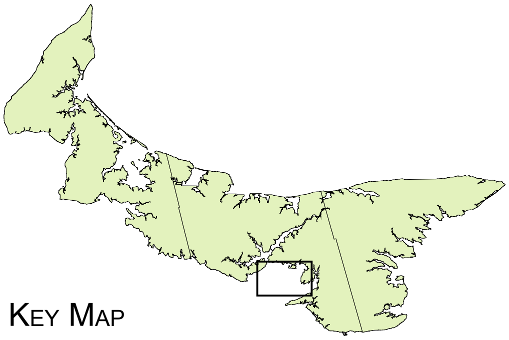
Q12 HILLSBOROUGH BAY

Ernscliffe, Pownal Bay

POINTS OF INTEREST

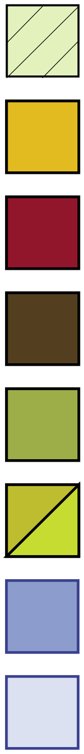
• Stratford (7,083)

• In contrast to the high sandstone cliffs on the Rocky Point side of Hillsborough Bay, the shoreline around Pownal Bay and Orwell Bay is low lying with gently rolling hills, with primarily agricultural land uses.



KEY MAP

MAP LEGEND



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National / Provincial Parks

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Moderate Risk Flood Zone (< 6m Elevation) Projected Sea Level Rise + Storm Surge

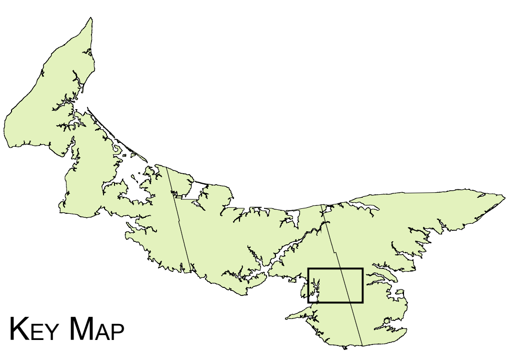
Q12 Hillsborough Bay

Q13 ORWELL BAY

Orwell Bay

POINTS OF INTEREST

• Where the shallow waters of the Vernon and Orwell rivers converge in the estuary in Orwell Bay the area is characterized by mud and sand tidal flats.



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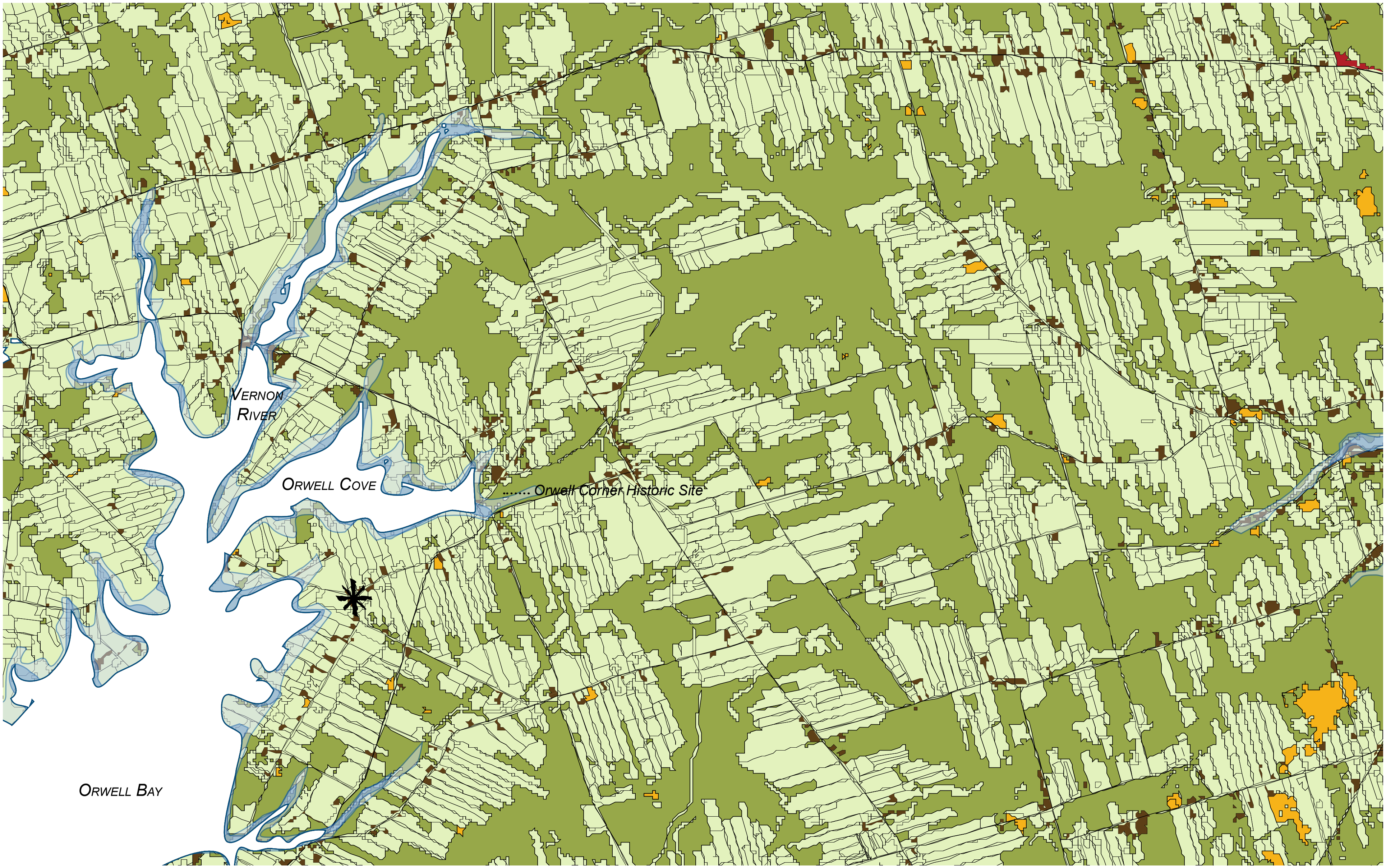


Q13 Orwell Bay

Q14 — Point Prim

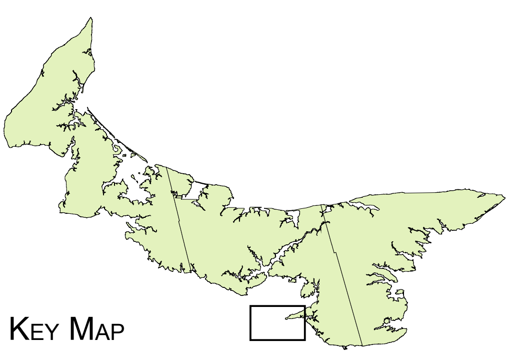
Point Prim, seawall

Point Prim

Points of Interest

• Point Prim penninsula extends out at the eastern limits of Hillsborough Bay and is highly exposed to the marine conditions of the Northumberland Strait.

• The Point Prim Lighthouse is the oldest lighthouse on PEI (built in 1845) and is frequented by tourists. The area is primarily occupied by seasonal cottage residents.



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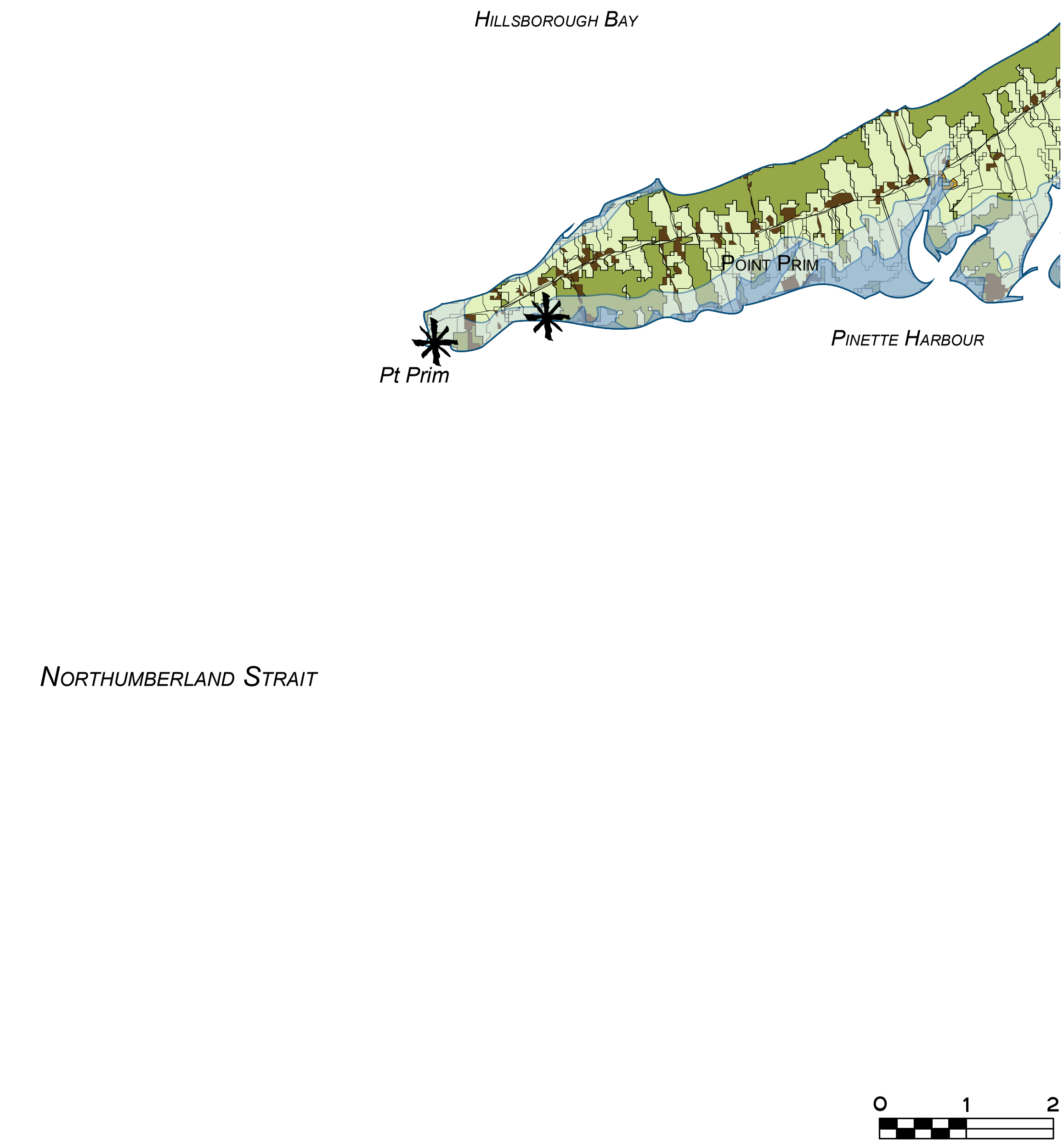


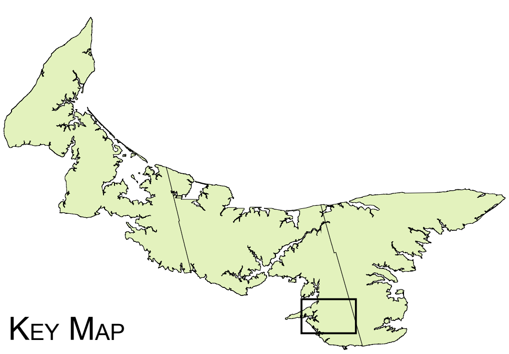
Q14 POINT PRIM

Q15 BELFAST

Lord Selkirk Provincial Park

Points of Interest

- The rivers of Pinette Harbour and Hillsborough Bay penetrate inland where the Point Prim peninsula connects. The single road access to the peninsula is vulnerable to inland flooding of these rivers.



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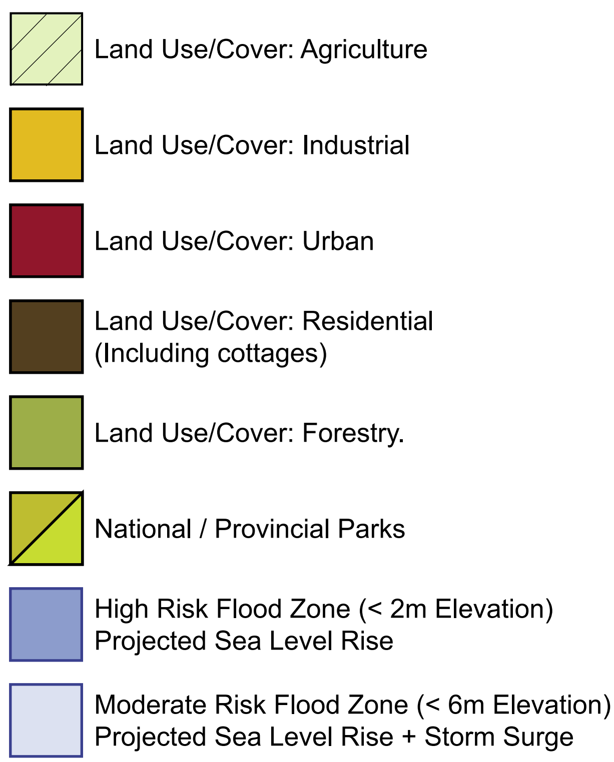
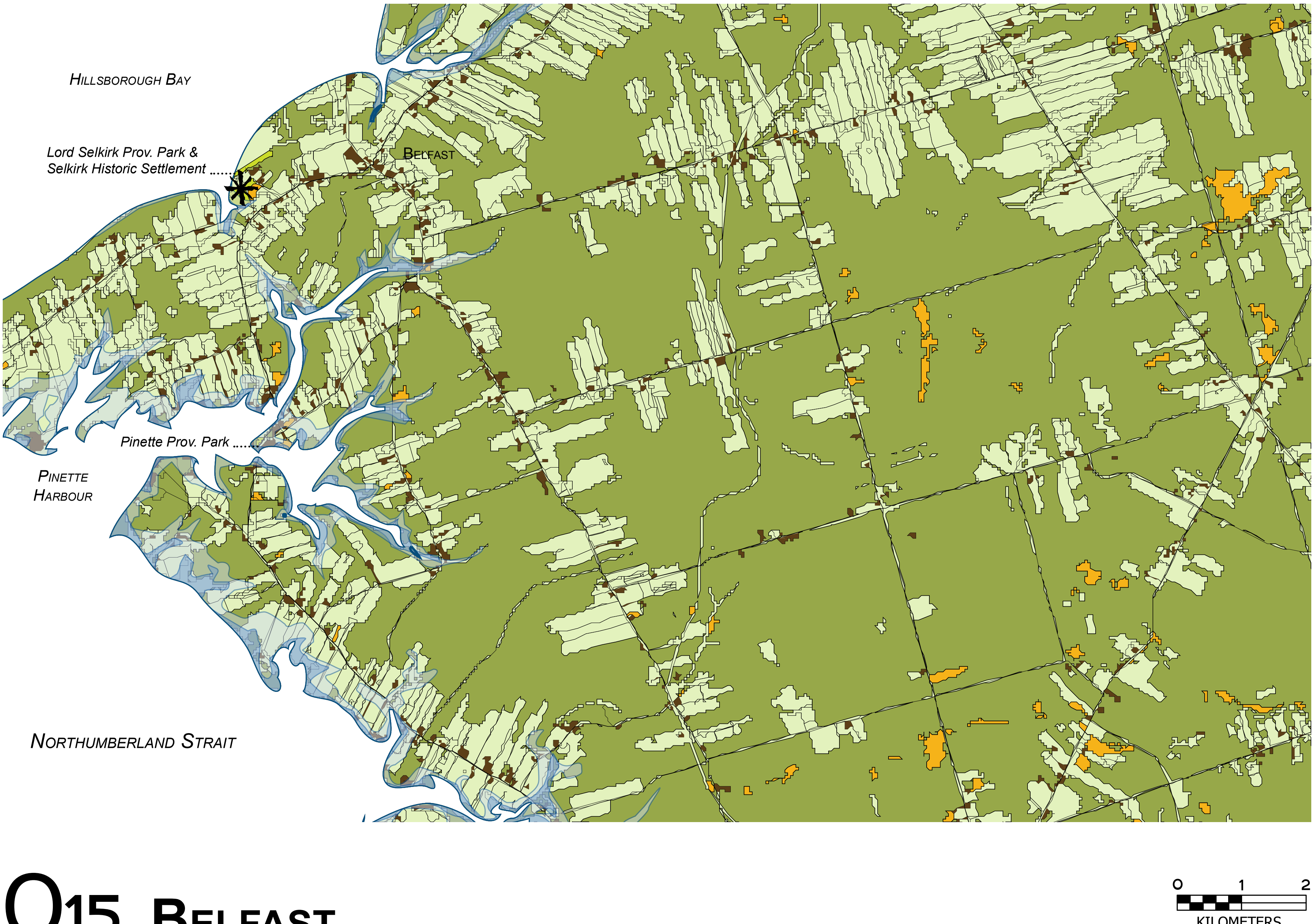



Hillsborough Bay
Lord Selkirk Prov. Park &
Selkirk Historic Settlement
Belfast
Pinette Prov. Park
Pinette
Harbour
Northumberland Strait
0 1 2
KILOMETERS

Q15 Belfast

Q16

Wood Islands

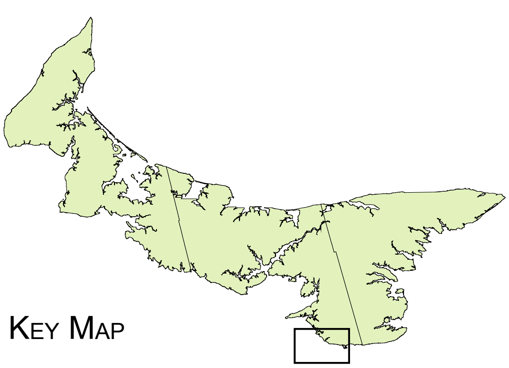
Gascoigne Cove

Wood Islands

Points of Interest

• Wood Islands Provincial Park and the Northumberland Ferry Terminal are located on a series of small forested islands that are permanently connected by sandbars and which shelter Wood Islands Harbour.

• Significant amount of low lying land around Flat River through which the Trans Canada Highway runs.



Key Map

Map Legend

Land Use/Cover: Agriculture

Land Use/Cover: Industrial

Land Use/Cover: Urban

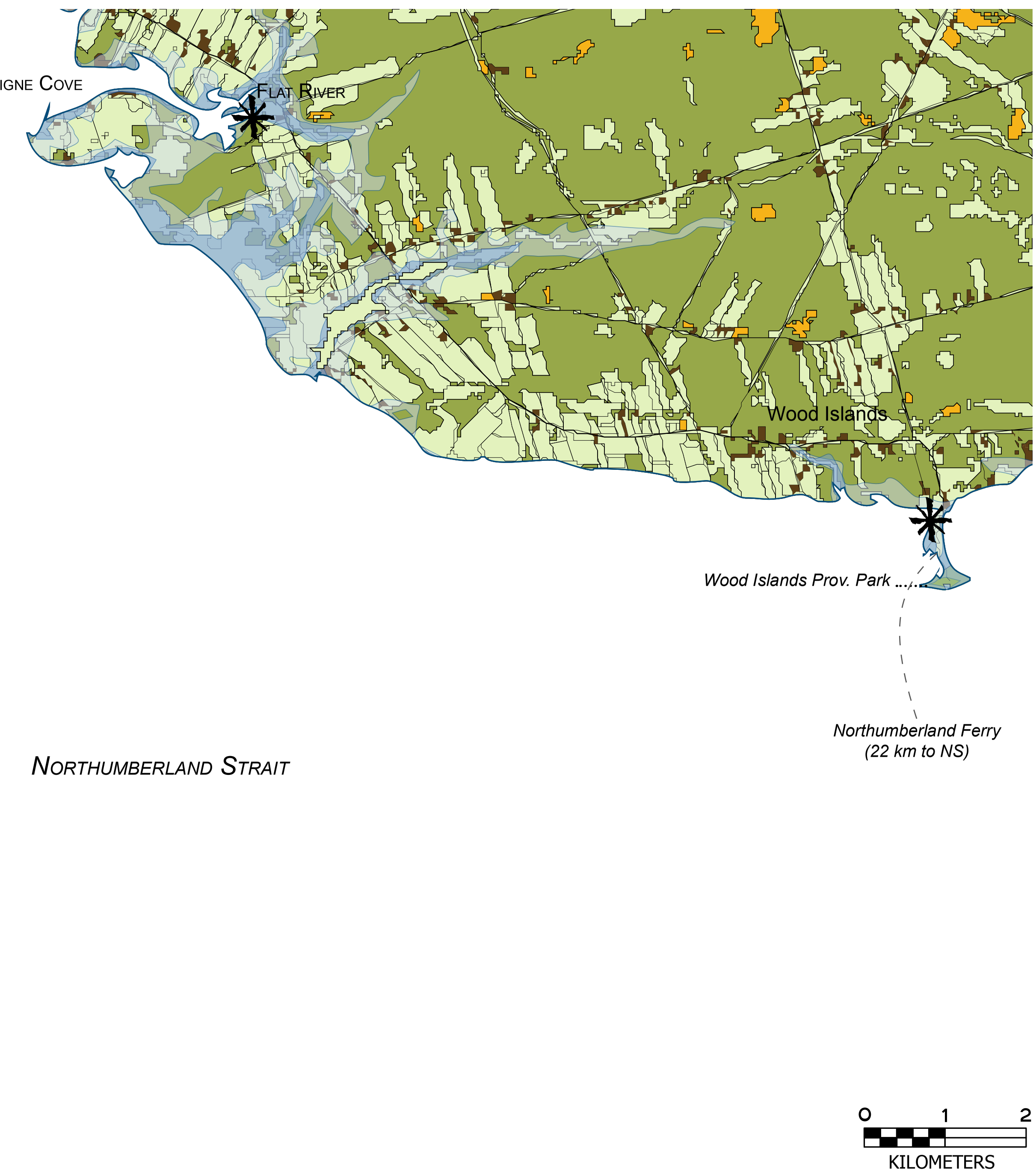
Land Use/Cover: Residential (Including cottages)

Land Use/Cover: Forestry.

National / Provincial Parks

High Risk Flood Zone (< 2m Elevation) Projected Sea Level Rise

Moderate Risk Flood Zone (< 6m Elevation) Projected Sea Level Rise + Storm Surge



Q16 Wood Islands

K1 Greenwich National Park

St. Peters Bay, Morell

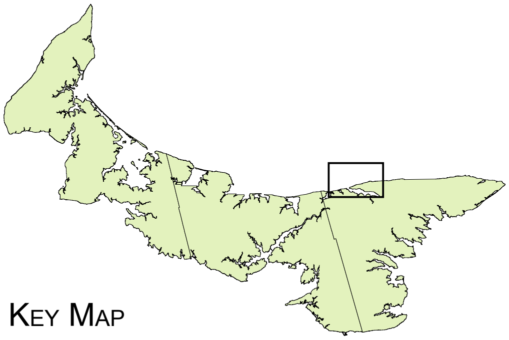
Mobile Parabolic Dune System, Greenwich National Park

Points of Interest

• St. Peter's Bay (248), Morell (306) and Morell Native Reserve (15).

• Greenwich PEI National Park is characterized by the rare ecosystem of high, mobile parabolic sand dunes and deep marsh.

• Seasonal cottages along the north shore are concentrated in the Crowbush resort area.



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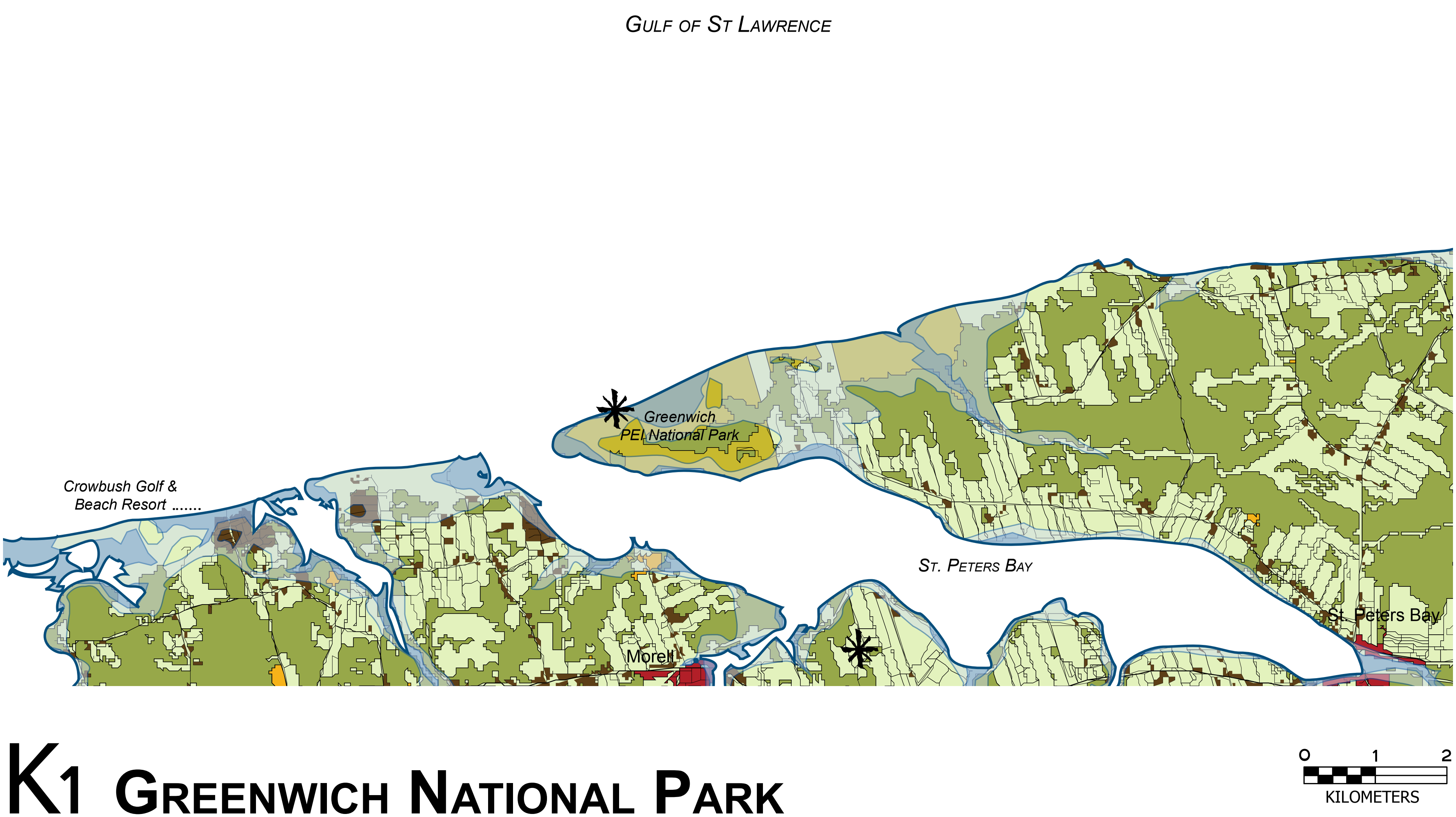


K1 GREENWICH NATIONAL PARK

K2

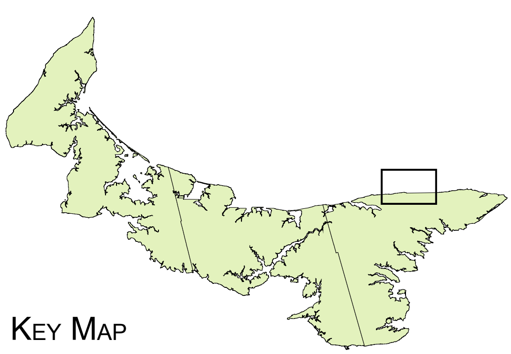
Naufrage River

Naufrage Harbour

Bear Shore Rd Beach

Points of Interest

- Naufrage Harbour
- There are seasonal cottages along the north shore with most permanent residents further inland on the NorthSide Rd (Rte 16).
- North shore sandstone cliffs are subject to increased rates of erosion due to decreased ice cover in the Gulf and a reduced depth of the frost line.



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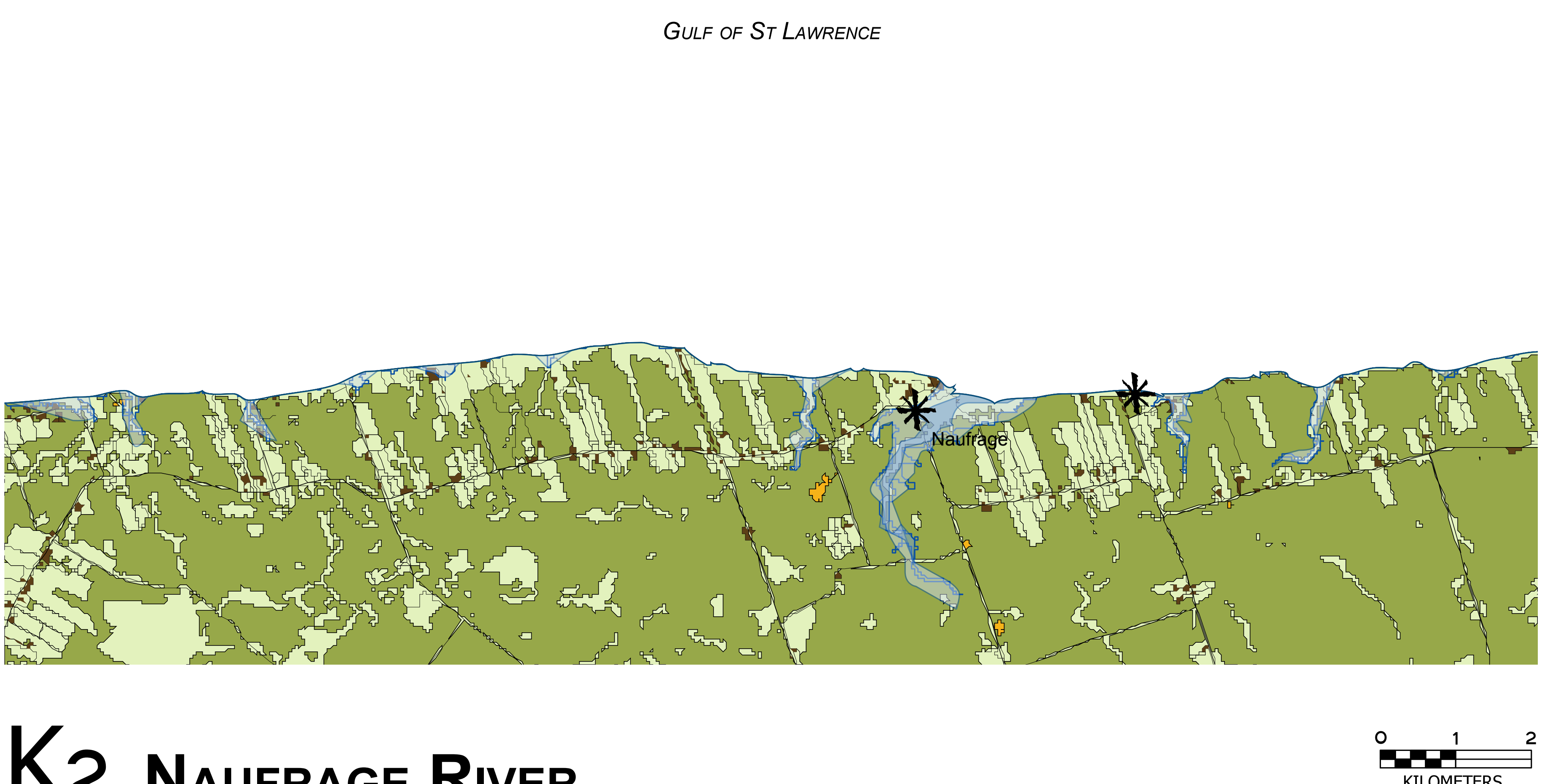
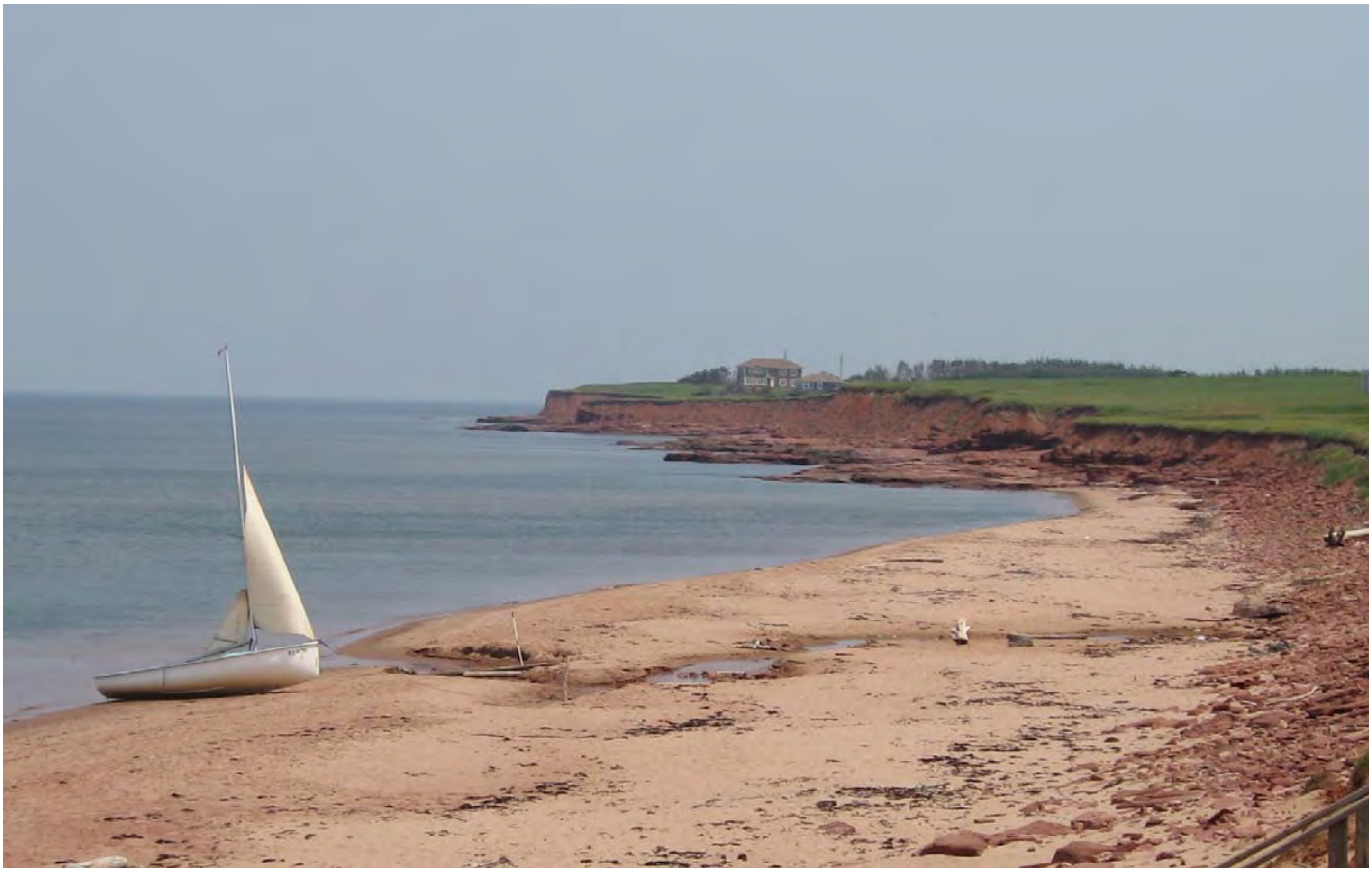


K2 Naufrage River

K3

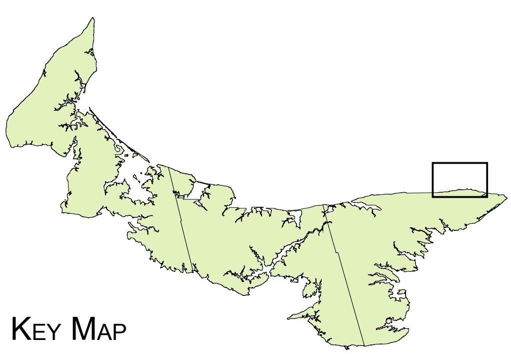
Campbells Cove



Campbells Cove Provincial Park and Campground ✳

Points of Interest

- Campbells Cove Provincial Park
- Seasonal cottages along the north shore with most permanent residents further inland on the NorthSide Rd (Rte 16).
- North shore sandstone cliffs are subject to increased rates of erosion due to decreased ice cover in the Gulf and a reduced depth of the frost line.



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K3 Campbells Cove

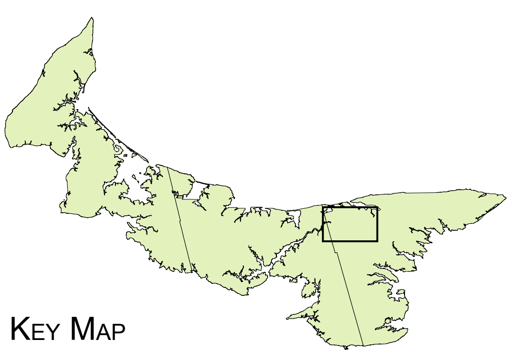
K4 Morell

Community of Morell

Points of Interest

• Morell (306) and Morell Native Reserve (15), and Mount Stewart (261).

• Significant amount of low lying land at the head of Hillsborough River (north of Mount Stewart) and along other river estuaries.



Key Map

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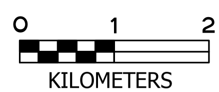
Savage Harbour
St. Peters Bay
Morell
Mount Stewart

K4 Morell



0
1
2
KILOMETERS

K5

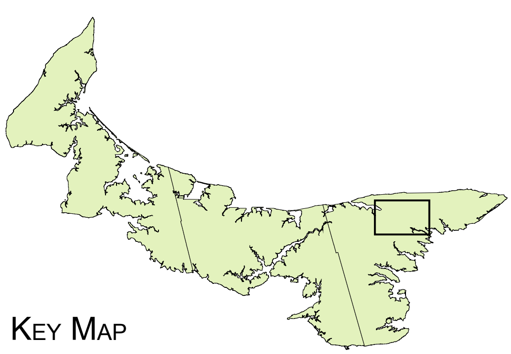
St. Peters Bay

Community of St. Peters Bay

Points of Interest

• St. Peters Bay (248)

• Significant amount of low lying land at the head of Fortune River and in St. Peters Bay.



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K5 St. Peters Bay

K6

Souris River

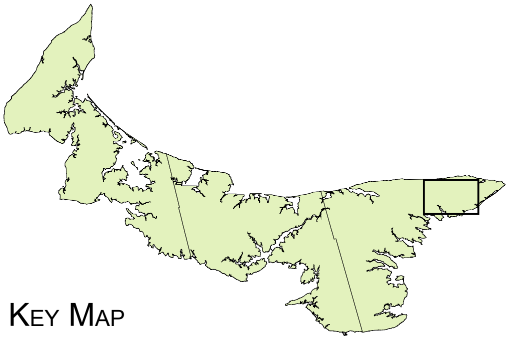
Basin Head Provincial Park and Fisheries Museum ✳

Points of Interest

• Town of Souris (1232)

• Rte 2 and the Souris Provincial Park are located on a low lying sandspit which crosses the Souris River

• The historic wharf at Basin Head was severly damaged by a storm surge in 2004 and has since been rebuilt to withstand a 1m rise in sea level rise (*Pers. Comm.*, CBCL Engineering).



Key Map

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Land Use/Cover: Urban

Land Use/Cover: Residential (Including cottages)

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National / Provincial Parks

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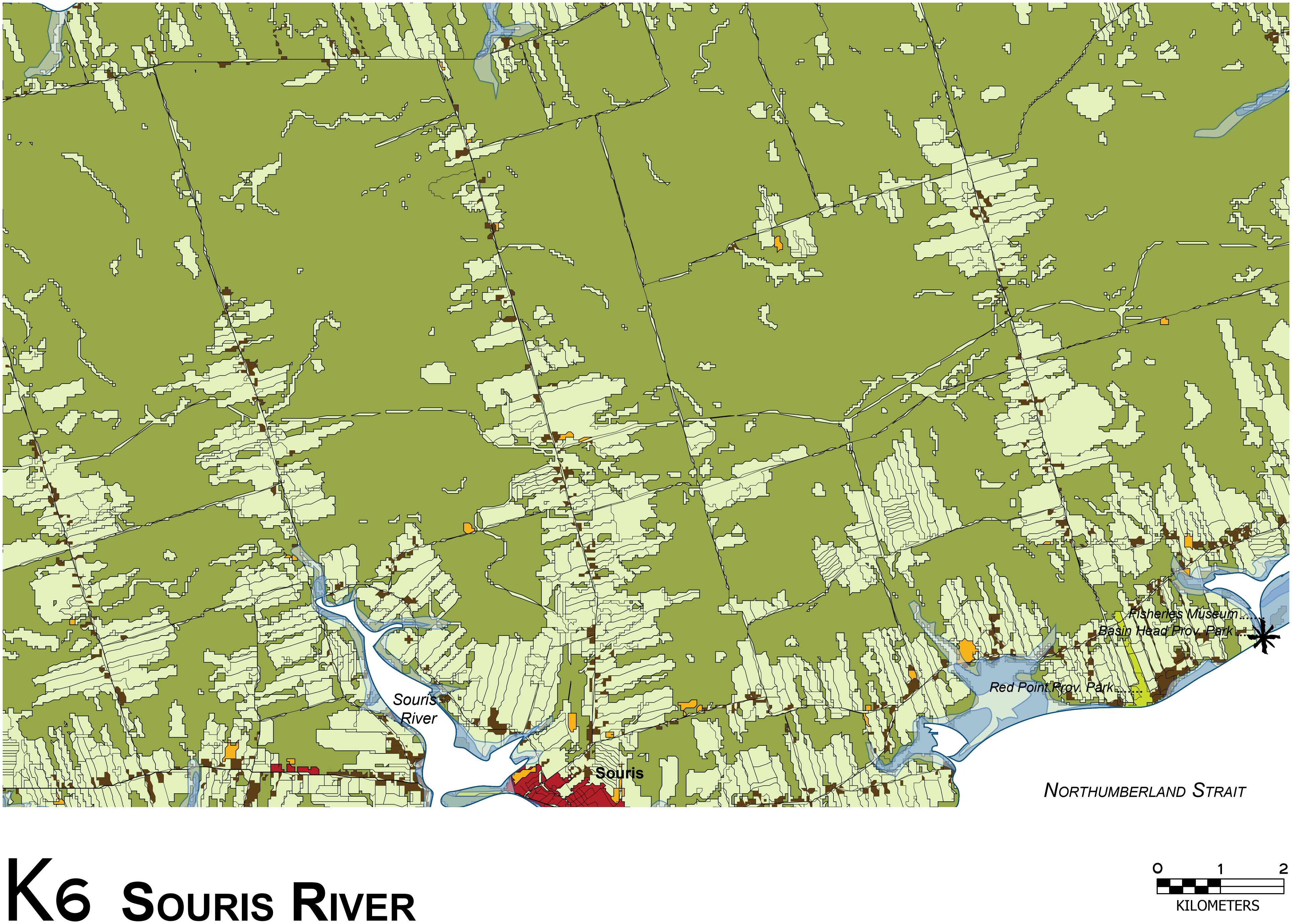


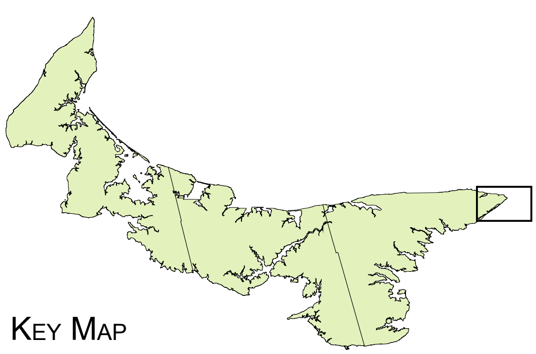
K6 SOURIS RIVER

K7 EAST POINT

East Point Lighthouse ✱

POINTS OF INTEREST

- North Lake Harbour
- East Point Lighthouse has been moved 3 times due to current erosion rates of 2-3 ft/year (*Pers. Comm.*, Parks Canada Representative)
- Low lying land on the south shore is predominantly sand dunes, salt marsh and swamp. The coast on the north shore is relatively much higher with sandstone cliffs and sand dunes characterizing the area.



KEY MAP

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K7 EAST POINT

K8

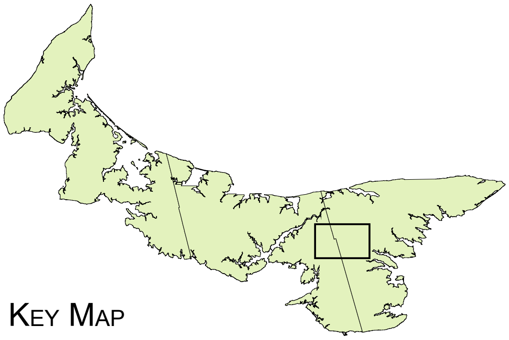
Cardigan

Community of Cardigan ✳

Points of Interest

• Cardigan (374)

• River estuaries and other inland waters are particularily sensitive to saltwater intrusion and runoff from inland flooding.



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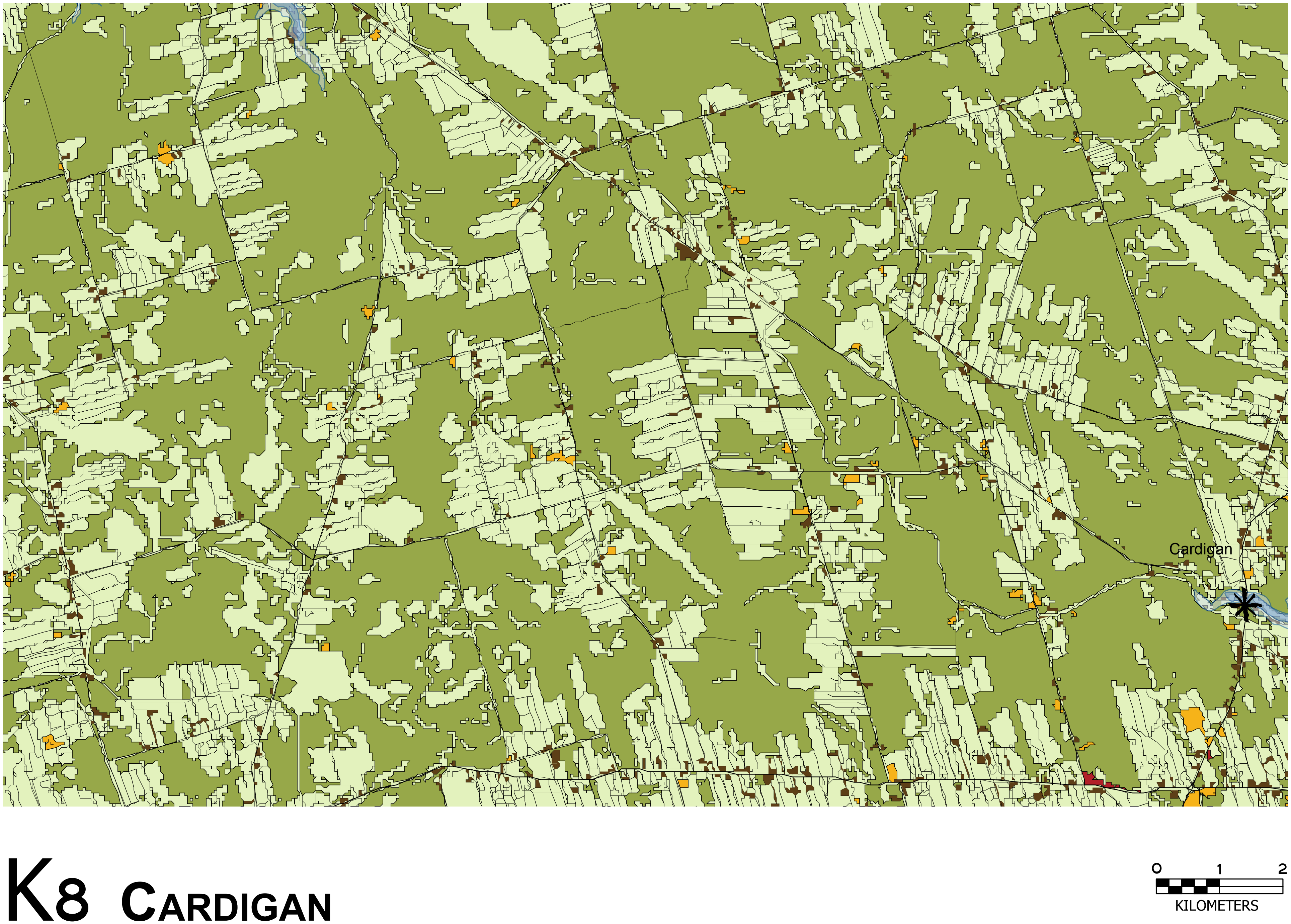


K8 Cardigan

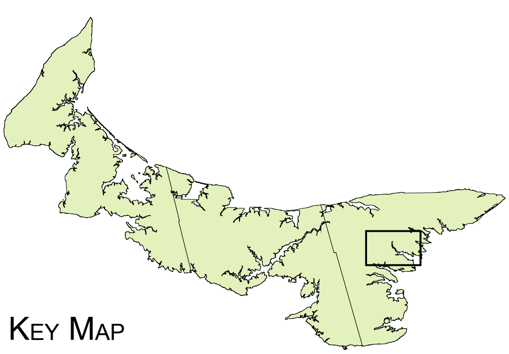
K9

Broughton Bay

Annandale Harbour ✱

Points of Interest

- Cardigan (374)
- Annandale Harbour is located on a particularly low lying peninsula in Boughton Bay.
- Low lying land at the head of Fortune River extends into this region from the North.



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K9 Broughton Bay

K10

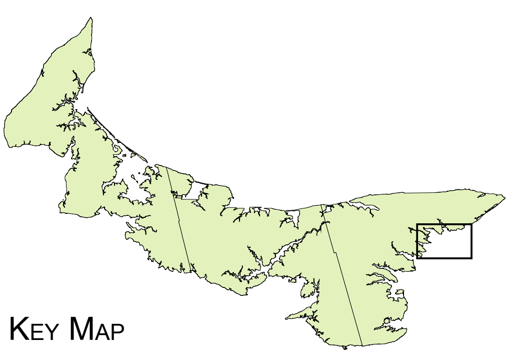
Souris & Rollo Bay

Eglington Bay

Town of Souris

Points of Interest

- Souris (1232)
- Low lying sandspit formations shelter the many fishing harbours in Rollo Bay
- Town of Souris residential and commercial properties are washing away as storm surge impacts are eroding cliffs at an accelerated rate. Some homes are now as little as 3 ft from the cliff edge (The Guardian, August 20, 2008).



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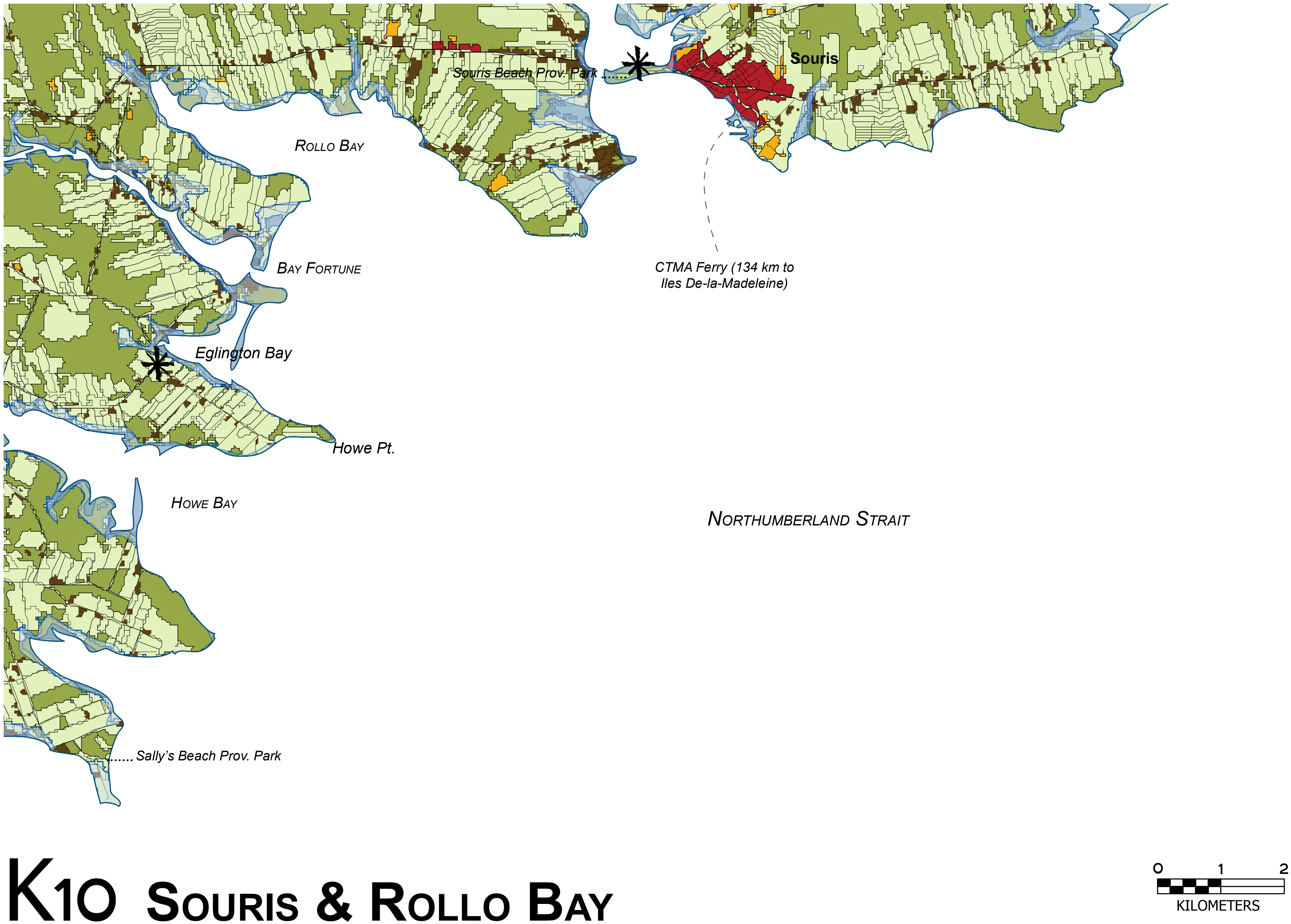


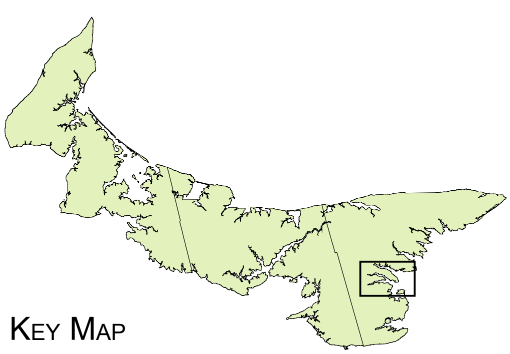
K10 Souris & Rollo Bay

K11 MONTAGUE, GEORGETOWN & PANMURE ISLAND

Town of Montague

POINTS OF INTEREST

- Montague (1,802), Georgetown (634) and Cardigan (374).
- Significant amount of low lying land at the tip of the Georgetown Royalty Peninsula and along the Georgetown Harbour.
- Panmure Island is partially sheltered with higher elevations on the east side, however access is vulnerable along the Panmure Island Provincial Park causeway.



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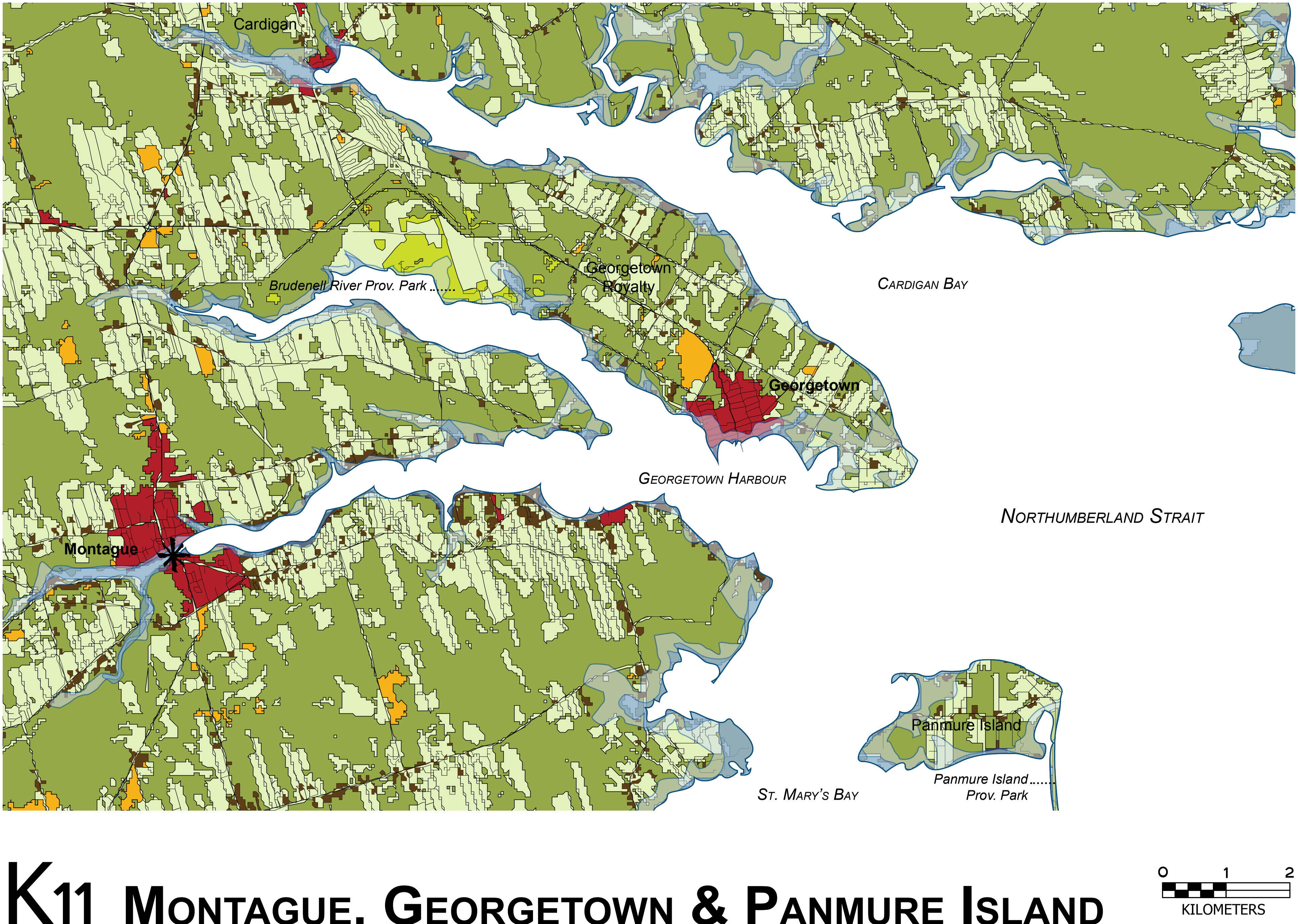


K11 Montague, Georgetown & Panmure Island

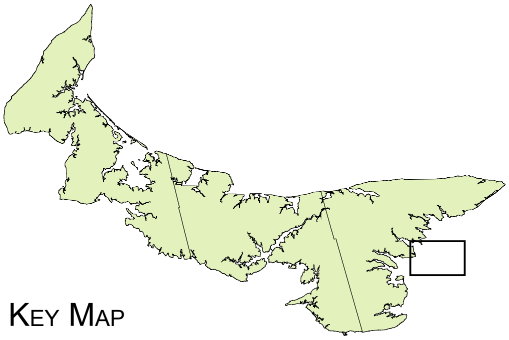
K12 LAUNCHING

View of Boughton Island, Launching

Launching Harbour

POINTS OF INTEREST

- Boughton Island is a secluded island connected only at low tide by a natural sandspit. It has been uninhabited for over 60 years and now contains a diverse ecosystem and habitat for many species including the endangered piping plover. (Nature Conservancy Canada, 2009)
- Launching Harbour



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K12 Launching

K13

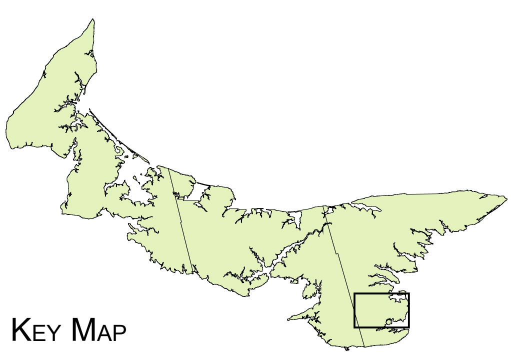
Murray Harbour North

Panmure Island Provincial Park

Mink River, Murray Harbour North,

Points of Interest

- Low lying land around Mink River and along the open shore line of Murray Harbour North is heavily forested.
- The majority of the fisheries related infrastructure located within Murray Harbour is currently sheltered by the Murray Islands within the Harbour. These landforms however are low lying and are vulnerable to permanent inundation.



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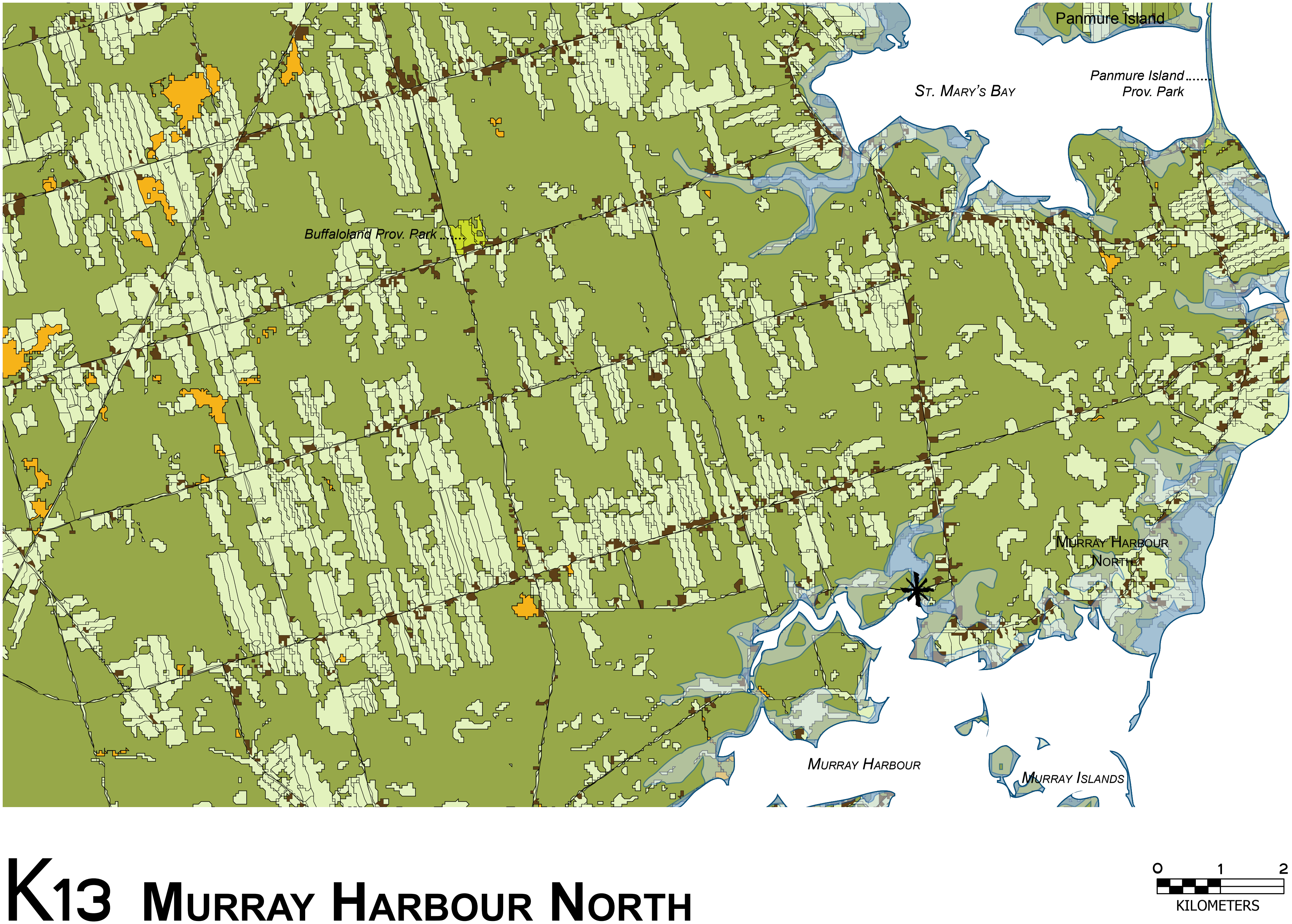


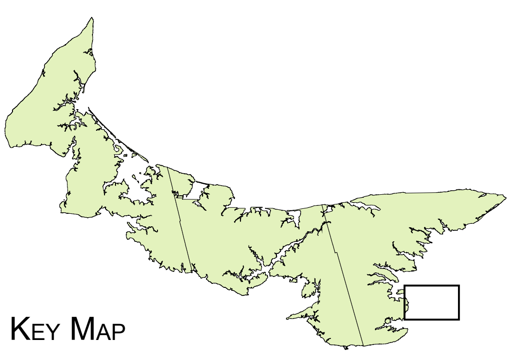
K13 Murray Harbour North

K14 Panmure Island Provincial Park

The Road to Panmure Island, Panmure Island Provincial Park

Points of Interest

- Panmure Island Provincial Park extends across a low lying sand spit which contains the only access road onto Panmure Island. This sand spit formation is highly sensitive to erosion.
- Graham's Pond Harbour



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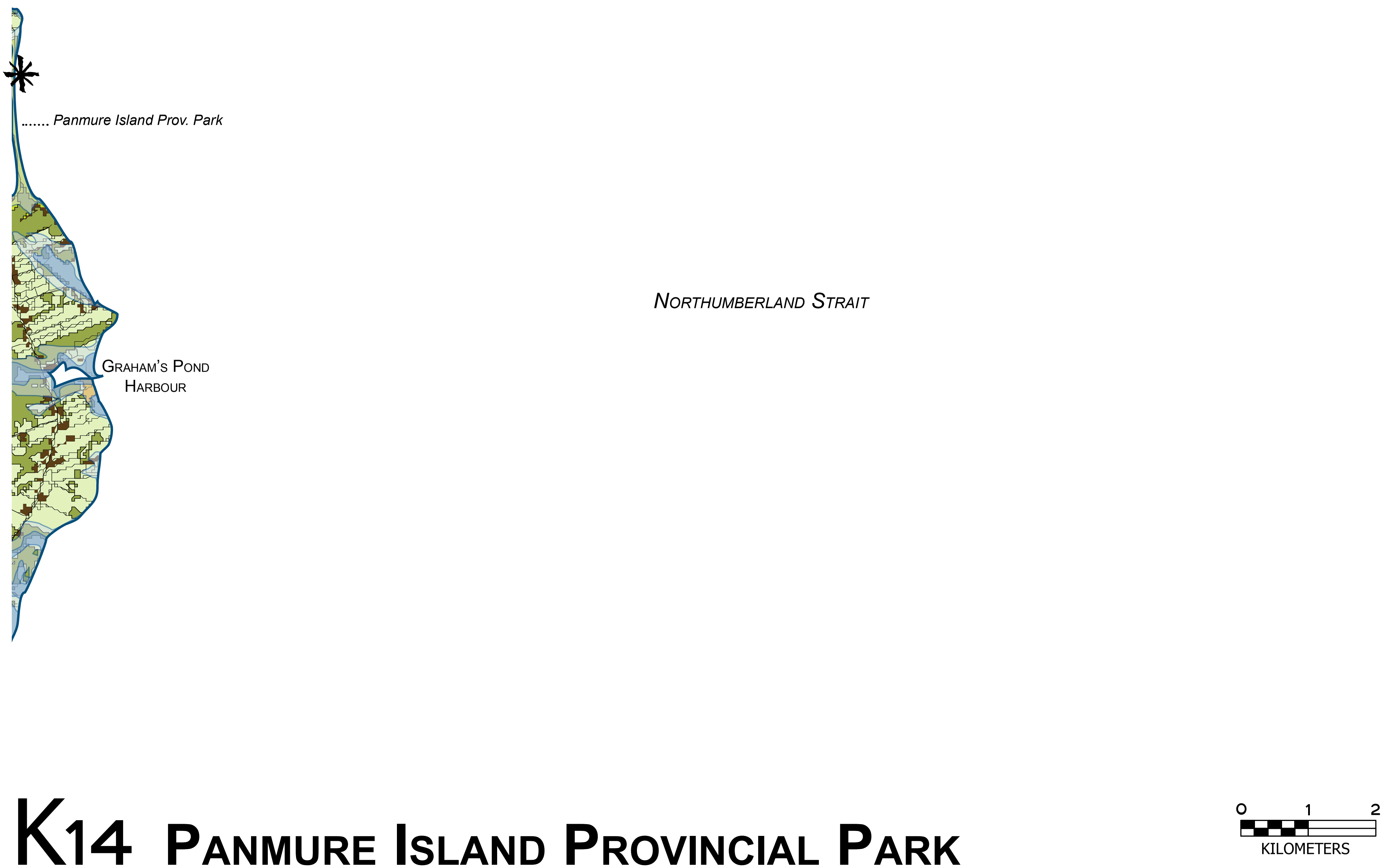


K14 Panmure Island Provincial Park

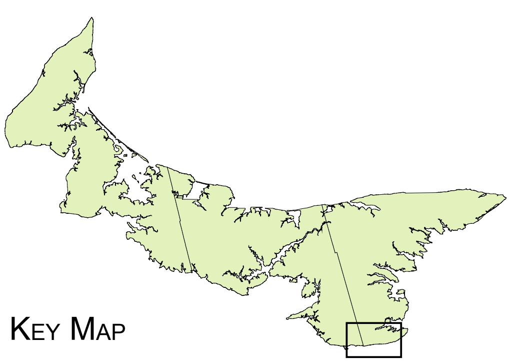
K15 Murray River

Southern Kings, south shore.

Murray River

Points of Interest

- Murray River (430) and Murray Harbour (358).
- The majority of the fisheries related infrastructure located within Murray Harbour is currently sheltered by the many small islands and sandspit formations that cross the mouth of the Harbour.
- Steep cliffs on the south shore are highly susceptible to erosion.



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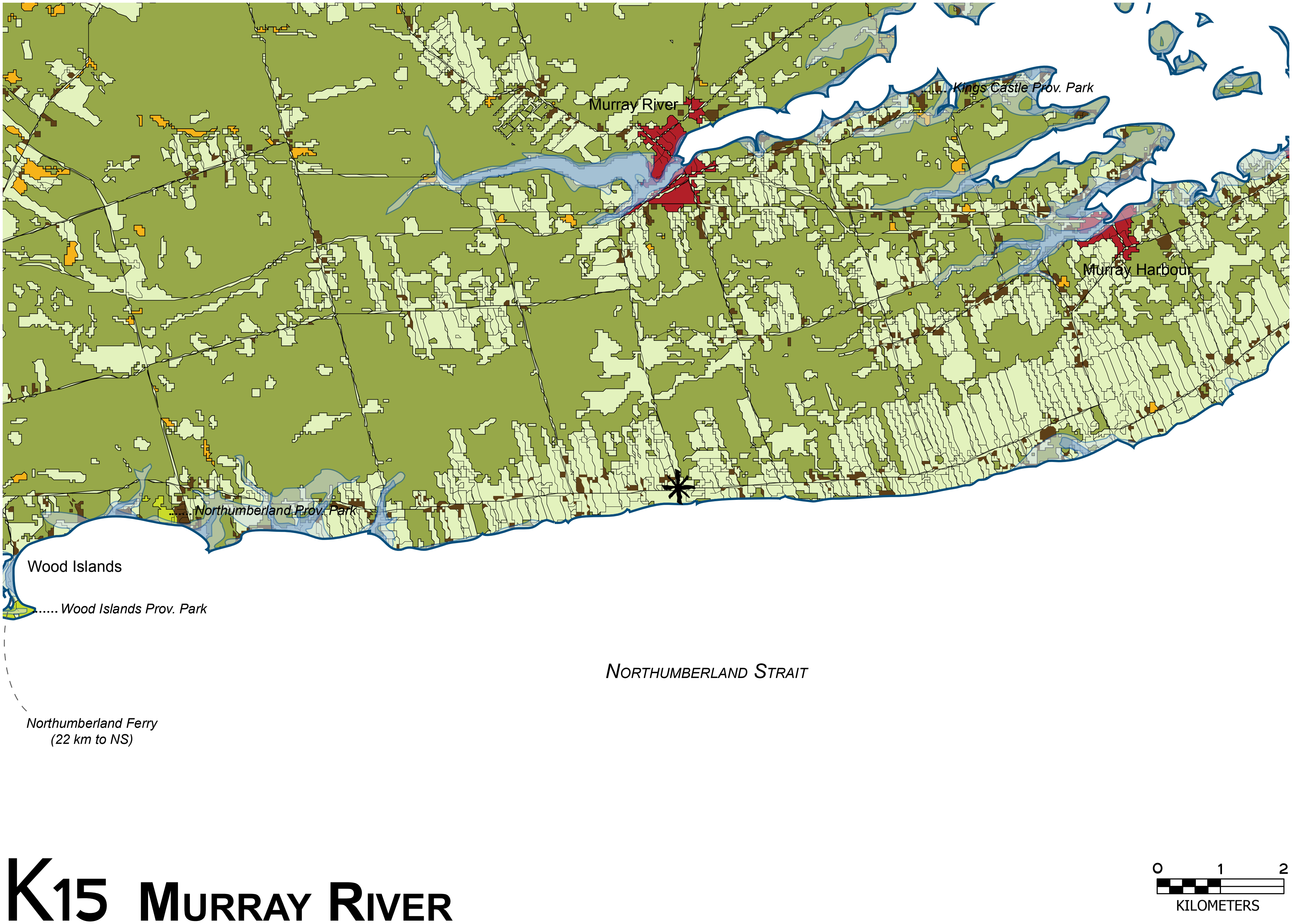

K15 Murray River

K16 BEACH POINT

Beach Point

POINTS OF INTEREST

• Beach Point Harbour

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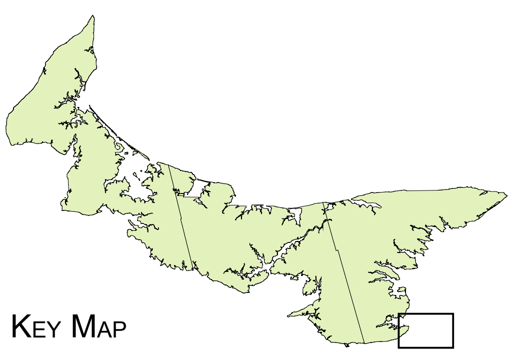

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K16 BEACH POINT