Examining drinking water security and governance for rural coastal Nova Scotia within the context of climate change

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Drinking water security, which most broadly refers to water of adequate quality and quantity, has largely been understudied within a Canadian context. This may coincide with the common misperceptions that Canada has an abundance of clean freshwater, despite documented cases that indicate otherwise. Moreover, the effects of climate change are anticipated to exacerbate the quality and quantity of water, especially in coastal regions around the world. When examining drinking water, it is important to consider the biophysical features and the human dimensions, as both have the capacity to diminish water security. However, the latter often receives less attention and focus than the former.

This research presents an empirical case study on drinking water security for Nova Scotia's tourism sector in light of climate change. More specifically, this paper explores the vulnerabilities associated with water security for private and municipal drinking water sources. The rural coastal communities of Shelburne and Queens serve as the context for this research. A participatory approach was used to gain an understanding of key issues, and involved the use of semi-structured interviews and participant observation.

The results of this research reveal that many well owners are experiencing biophysical impacts (e.g. shortages, bacterial and saltwater contamination), as well as non-biophysical water issues (e.g. limited access due to power outages and water testing barriers). These issues are likely to become more problematic with climate change. This analysis also explains how these vulnerabilities have the potential to be further compounded by governance issues, such as knowledge gaps, complacent attitudes and perceptions, as they pose challenges for adaptation and capacity building.

For municipal water, biophysical issues include high levels of organic matter, which makes the water not only more challenging and complex to treat, but it also demands a higher degree of knowledge and competence that may or may not exist within the water utilities. Moreover, access issues are experienced as a result of maintenance activities on aging and damaged infrastructure- often from extreme weather events, which again is anticipated to worsen with climate change. Additionally, governance issues for water utilities, such as mistrust, poor leadership, fragmented responsibilities and resource constraints, are also key contributing factors for undermining water security, as well as the ability to recruit and retain qualified staff.

Recommendations to help address these vulnerabilities, and in turn enhance water security include, well owners becoming better informed, observant and proactive to help adapt to changes in their drinking water situation. For water utilities, establishing stronger partnerships with neighbouring municipalities to build capacity through knowledge sharing and transfer is key, particularly with persistent resource constraints. For the province it involves implementing ongoing evaluation of its current policies and procedures (e.g. water testing requirements) to ensure they remain relevant, effective, and equitable. Additionally, the province needs to do a better job of both supporting and monitoring its water utilities, which includes taking a stronger leadership role to help with resource constraints and capacity building efforts.

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Chapter 1
Introduction and Overview

1.1 Problem Context

Water is irreplaceable and essential to sustaining all forms of life on earth, as well as providing basic human dignity (Ziervogel et al., 2010; Vörösmarty et al., 2010). Water embodies powerful concepts of purity and nature, symbolizing the very essence of life, and is fundamental to supporting various systems including energy and food production, economic development and health services (Grey & Sadoff, 2007; Driedge & Eyles, 2003). Despite being considered the most critical natural resource on earth, water continues to be threatened by anthropogenic interventions (Vörösmarty et al., 2010), bringing into question how water is valued. Moreover, there lies a deep-seated myth that there is an abundance of safe, clean water in Canada despite the fact that there have been many documented cases of poor quality and quantity (de Loë et al., 2007; Sprague, 2007). For instance, from 1974-2001 over 200 infectious disease outbreaks were reported in Canada due to drinking water contamination (Environment Canada, 2008; Schuster et al., 2005). Additionally, Schuster et al. (2005), report the existing quality of information available with respect to waterborne disease outbreaks are inadequate, as basic data are often missing (e.g. exact outbreak date and location, source, number of people ill), further illustrating low value and priority for water.

The water abundance myth also purports that Canada has one of the largest freshwater reserves in the world. However, this assertion does not take into consideration what portion is standing water and what is renewable, thus overestimating actual supplies (Sprague, 2007). Moreover, Bocking (1972 as cited in Sprague, 2007, p. 27) argues that "the water supply in Canada is…about average for the area of the country as compared to other parts of the world". It is misguided perceptions such as these that de Loë et al. (2007) argue have led to issues of misuse and complacency. This notion is further supported by the fact that Canadians are the highest water users per capita in the world after the US (Environment Canada, 2014). These factors may lend themselves in rationalizing why water resources are undervalued in Canada (Environment Canada, 2013), as well as highlighting the lack of attention and priority in examining Canadian water security, despite the imminent and ensuing impacts of climate change.

Water security can be described as having water of adequate quality and quantity, as well as acceptable levels of water-related risks to support humans in terms of livelihoods, health and national security, and surrounding environments, ecosystems and ecosystems services (Bakker & Morinville, 2013). The definition emphasizes how various factors can influence water security, such as the physical dimensions of water (e.g. bacterial contamination, water shortages, and climate change impacts) as well as the political, social and governance conditions. These factors have the capacity to shape and undermine water security, which can also stem from issues of poor leadership, lack of legitimacy, complacency and limited knowledge (Smith & Patrick, 2011).

From a physical perspective, one of the biggest threats to water security are the effects of climate change, as the impacts can negatively affect both quality and quantity of ground and surface waters due to increased precipitation variability (e.g. heavy rainstorms), glacier melt, and flooding (Ziervogel et al., 2010; Doll, 2009). Groundwater resources in coastal areas around the world are particularly vulnerable as they are highly susceptible to sea level rise, inundation, erosion, and saltwater intrusion (Yashura et al., 2012; Moser et al., 2012; Kebede et al., 2012), which is of concern for many rural communities given that groundwater is often the main source of potable/household water (Doll, 2009). For example, in Canada, 80 percent of the rural population relies on groundwater supplies (Bruce, 2011), yet there remains a lack of empirical research for sustainable water management in coastal areas (Kebede et al., 2012; Knüppe & Pahl-Wostl, 2011; Doll, 2009). Moreover, emerging literature continues to reveal that climate change is not only an ensuing environmental problem, but also a socio-economic and political crisis that challenges the global community (Hill, 2013; Scott et al., 2012; Wiek & Larson, 2012; Parkes et al., 2010; Pahl-Wostl, 2002). Water security narratives highlight the importance of the non-physical dimensions of water such as monitoring, regulation, access and water rights, which strongly link to the concept of water governance.

Water governance speaks to the overarching processes and institutions that guide how decisions are made, as well as who makes them (Armitage et al., 2012; Nowlan & Bakker, 2010). However, there are many barriers to achieving strong water governance such as leadership, resources, responsibilities as well as perceptions and complacency (Simms and de Loë, 2010; Kreutzwiser et al., 2010; Doria, 2010). Case in point, the Walkerton tragedy in 2000 that took the lives of seven individuals and left over 2000 people ill due to bacterial contamination from municipal water, was found to be

preventable as contributing factors were entrenched in governance issues. For example, the water plant operator was negligent and intentionally deceived authorities. Moreover, monitoring of water utilities had recently become more challenging due to significant budget cuts (Kreutzwiser & de Loë, 2010). Thus, the Walkerton incident serves as a reminder of the importance for strong, multi-scalar water governance, not just within Canada but worldwide.

By the same token, good water governance is just as important for private well owners. For instance, Chappells et al. (2014), Coleman et al. (2013), Kreutzwiser et al. (2012), Imgrund et al. (2011), Jones et al. (2006) and Goss et al. (1998) reveal that despite high levels of bacterial and/or chemical contaminants found in wells, issues of complacency and knowledge gaps are prevalent among well owners. This again, is of particular importance for rural areas where wells are the primary source of water.

While discussions on water security have already begun in Canada, literature review suggests Atlantic Canada is largely understudied (Cervoni et al., 2008) as the focus primarily tends to be on provinces west of Quebec. This may be due to the fact that the Atlantic region has a low population and as such, has one of the lowest water consumption rates in the country (Environment Canada 2009b as cited in Kreutzwiser & de Loë, 2010), and also boasts a rich collection of freshwater systems. However, water supplies are not the only dimension of water security. With the occurring and impending effects of climate change, water quality and access are also areas of concern that are often consequences of limited governance for water resources.

1.2 Research Context

As Section 1.1 alludes, water security for Atlantic Canada has generally been understudied (Cervoni et al., 2008). For example, Nova Scotia Environment (2014a) contends that water is the most valuable resource the province has. Yet despite the importance, there has been limited research to examine water security, particularly in the face of climate change and its impacts on water vulnerability (Ferguson & Beebe, 2012). In Nova Scotia 50 percent of households are on private groundwater wells, the highest in Canada, and approximately 70 percent of these are located in coastal areas (Ferguson & Beebe, 2012). Moreover, high levels of arsenic and other chemical contaminants are prevalent in groundwater sources throughout the province. At the same time Nova

Scotia also has one of the highest incidence rates for cancer in Canada (Goodwin et al., 2009), which may be linked to low or moderate levels of arsenic in drinking water (Saint-Jacques et al., 2014).

Accordingly, these conditions stress the importance of evaluating water security, including climate change vulnerability on water resources. This is of particular relevance in rural coastal communities such as Shelburne and Queens, Nova Scotia where there is high dependence on groundwater fed wells that is largely governed at household scales. However, climate change vulnerability has traditionally been assessed through scientific and quantitative approaches, using biophysical and climatic factors such as temperature, sea level rise, heat waves and heavy rainstorms that often lack human dimensions of vulnerability (Yoo et al., 2011; Ford et al., 2007). Scholars suggest that non-climatic forces, such as socio-economic and political factors also play key roles in determining a community's vulnerability, as well as their capacity to adapt (Hill, 2013; Scott et al., 2012; Wiek & Larson, 2012; Parkes et al., 2010; Van Aalst et al., 2008; Smit & Wandel, 2006; Pahl-Wostl, 2002).

1.3 Research Purpose and Objectives

The purpose of this research is to examine the vulnerabilities associated with water security in rural coastal communities for Shelburne and Queens, Nova Scotia, in order to identify adaptation options, as well as to explore the role of governance in maintaining and enhancing water security. Five objectives guide my research, to:

1. Identify and assess the current and projected human vulnerabilities associated with drinking water.
2. Identify existing barriers and enabling factors for the management and governance of drinking water.
3. Explore how stakeholders (i.e. community members, residents, decision-makers, water plant operators) may be able to, plan to, or have adapted to the identified vulnerabilities.
4. Summarize the general conditions related to climate change impacts and water resources.
5. Generate insight for policy and practice in support of strategies to enhance water security of coastal communities.

This research is also part of the Partnership for Canada-Caribbean Climate Change Adaptation (ParCA) initiative, which seeks to understand the various social and environmental factors that characterize the vulnerabilities and coping capacities of coastal communities, with a strategic focus on the fisheries and tourism sectors for learning sites in Nova Scotia, Prince Edward Island, Jamaica and Trinidad/Tobago. This is to be achieved by conducting vulnerability assessments of the tourism and fishing communities within the four study site locations through stakeholder participation. The researcher was accountable for conducting a vulnerability assessment of the tourism sector in Nova Scotia, and as such, data collected for this analysis were part of the ParCA project. Therefore, a secondary purpose of this research is to contribute knowledge and insights for the ParCA initiative by assisting researchers and community stakeholders to better plan and adapt to the effects of climate change, a precursor to understanding and evaluating effective learning processes and governance options.

1.4 Thesis Outline

This thesis comprises six chapters. The first chapter contains an introduction and overview of the research, including the problem context, research context, purpose and objectives. Chapter two offers a literature review on the key themes germane to this research. Chapter three presents the methodology used to necessitate the research objectives, followed by Chapter four, which provides the study site context. Chapter five captures the results section, which highlights key findings of the vulnerability assessment in order to examine governance implications. Chapter six concludes with a summary and recommendations on strategies to enhance water security for the rural coastal communities of Shelburne and Queens, Nova Scotia.

Chapter 2
Literature Review

2.1 Introduction

Chapter 2 provides a literature review and synthesis on three key themes significant to this research: climate change vulnerability, water governance and water security. Most broadly, climate change vulnerabilities indicate the exposures to, and sensitivities of people in relation to water resources due to both climatic and non-climatic conditions. The water governance literature considers the tools and approaches available to address these vulnerabilities in order to enhance water security. Water security narratives focus on water related risks that continue to support human health, livelihoods, security and ecosystems.

2.2 Climate Change Vulnerability

Climate change is not only an ensuing environmental problem, but also a socio-economic and political crisis that challenges the global community due to anthropogenic greenhouse gases that abnormally increase the earth's temperature. There are two responses to climate change: mitigation and adaptation (Fussel, 2007b). Mitigation has traditionally governed the climate change discourse, which seeks to minimize impacts by enhancing carbon sinks and reducing greenhouse gas emissions. However, there has been little progress in reducing greenhouse gas emissions (Murdiyarso, 2012). Even with immediate, extensive reductions, mitigation efforts will not be enough to stop the impacts of climate change (Chen & Graham, 2010; Saavedra & Budd, 2009; O'Brien et al., 2007), particularly for coastal communities who are one of the most vulnerable groups (Moreno & Becken, 2009; Torresan et al., 2008). As a result, attention has shifted towards adaptation (Malone and Engle, 2011; Fussel, 2007b; Fussel & Klein, 2006). However, in order to determine what adaptation entails for a community, the vulnerabilities first need to be identified and assessed. As a result, there is increased attention on adaptation, which has in turn, positioned vulnerability as a fundamental concept in climate change research (Hinkel, 2011; Malone & Engle, 2011; Polsky et al. 2007; Kelly & Adger, 2000).

However, as Timmermann (1981 as cited in Fussel, 2007a) astutely pointed out almost four decades ago, "vulnerability is a term of such broad use as to be almost useless for careful description

at the present, except as a rhetorical indicator of areas of greatest concern". Despite much effort put into defining and understanding both, the meaning and utility of vulnerability, multiple, abstract and ambiguous definitions remain (Malone & Engle, 2011; O'Brien et al., 2007; Fussel & Klein, 2006; Gallopın, 2006; Kelly & Adger, 2000). Part of the ambiguity and confusion with defining vulnerability can be attributed to the term's uptake by many disciplines (Fussel & Klein, 2006). For instance, social scientists refer to vulnerability in terms of socio-economic factors, whereas climate scientists use vulnerability to express climate impacts and frequency on systems (e.g. communities) (Brooks, 2003). Inevitably, this has resulted in different conceptualizations and interpretations by researchers. However, vulnerability narratives suggest that these misunderstandings can be avoided if well-defined and transparent definitions are provided, regardless of the conceptual framework applied (Fussel, 2007a; Fussel & Klein, 2006; Kelly & Adger, 2000).

Numerous definitions also exist for climate change vulnerability. For example, Kelly and Adger (2000) define climate change vulnerability as the ability (or inability) of actors to respond to (i.e. cope, recover, adapt) external threats placed on human livelihoods and wellbeing. Fussel and Klein (2006) define vulnerability as the adverse effects of climate change on any exposed system, while the United Nations Environment Programme (2002) considers climate change vulnerability as the interface in which the exposure to physical risks to human welfare, and the capacity for communities to cope with those risks. The leading body on climate change assessment, the Intergovernmental Panel on Climate Change (IPCC) has also provided varying definitions of climate change vulnerability[1] and other key concepts within its own publications (Brooks, 2003). However, the most widely accepted and applied definition of climate change vulnerability does come from the IPCC (2001), defining it as a function of exposure, sensitivity and adaptive capacity, which is the definition adopted by this paper.

Within a climate change context, sensitivity is characterized as the degree to which a system (e.g. community) could be affected (negatively or positively) by climatic variation (Smit et al., 1999) and

[1] "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity." (IPCC, 2001, p. 995) (IPCC Def. 1) and "[vulnerability is the]degree to which a system is susceptible to injury, damage, or harm (one part - the problematic or detrimental part - of sensitivity)" (IPCC Def. 2). (IPCC, 2001, p. 894).

is generally characterized by prevailing social conditions that can be made better or worse by coping and adaptive mechanisms (Calgaro & Lloyd, 2008). For example, communities that are reliant on rain-fed agriculture for their main source of livelihood are more sensitive to droughts than ones dependent on hard rock mining. Exposure refers to the extent or rate to which a community is exposed to climate variation (Smit & Pilifosova, 2001), which is usually characterized by the physical geography as well as built and natural environments (Calgaro & Lloyd, 2008). For instance, coastal communities are more exposed to sea level rise and storms than inland communities. According to the IPCC (2007), sensitivity can largely be minimized by adaptation, and exposure can be eased through mitigation. With this, some communities can be sensitive to climatic variations while others are vulnerable, as sensitivity does not take into consideration adaptation efforts, whereas vulnerability refers to the impacts that are remaining *after* adaptation has occurred (Torresan et al., 2008).

Adaptive capacity is the third dimension of climate change vulnerability, which describes a community's ability to cope with and recover from stress (Smit & Wandel, 2006) such as implementing early warning systems. Climate change vulnerability is intrinsically linked to the process of adaptation (see also Section 2.4.4) whereby a community's adaptation is facilitated by reducing its vulnerability (Kelly & Adger, 2000). In other words, climate change vulnerability is determined by a community's exposure and sensitivity to hazards, and its ability to cope, adapt, or recover from these hazard impacts (Smit & Wandel, 2006). Therefore, the greater the exposure or sensitivity, the greater the vulnerability. However, adaptive capacity is inversely related to vulnerability, signifying the greater the adaptive capacity, the lower the vulnerability.

There are also several framings for climate change vulnerability. For instance, Kelly and Adger (2000) suggest that researchers generally approach climate change vulnerability in one of three ways. The first is referred to as *end point*, which describes vulnerability in terms of the adverse residual impacts that remain after adaptation has occurred. The second approach is referred to as *focal point* where vulnerability is directly linked to specific exposures and hazards, as well as the ability to cope with the impacts of these hazards. As a result, vulnerability and exposure are inseparable, making vulnerability the overarching or focal point. The third approach is characterized as *starting point* where probable sensitivities are identified through the potential to adapt and respond to exposures, thus a starting point is established for further analysis. Similarly, O'Brien et al. (2007) frame vulnerability in two ways: outcome and contextual. *Outcome* vulnerability is linked to a scientific

framing where vulnerability is viewed as the residual impacts (or outcomes) of climate change, which can be minimized through mitigation or adaptation. *Contextual vulnerability* is linked to a human-security framing that determines vulnerability by current socio-economic, political and biophysical drivers, and aims to reduce vulnerability by modifying contextual conditions so communities are better able to adapt. There are clear similarities between these two framings, whereby *starting point* and *contextual vulnerability* are analogous and likewise with *end point* and *outcome vulnerability*. This thesis adopts the starting point/contextual vulnerability framing.

2.2.1 Climate Change Vulnerability and Water Vulnerability

The quality and quantity of water resources can be significantly impacted due to the effects of climate change, such as increased variability in precipitation (Doll, 2009; Biswas 2004; Ziervogel, 2000). Flooding is one of the most anticipated effects of climate change due to an increase in intense weather events such as hurricanes and heavy rainstorms, as well as warmer temperatures resulting in faster melting of ice caps and glaciers (Doll, 2009). For example, warmer winter temperatures and alternating cold and warm periods could result in rainfall over top of snow, which may then affect soil water absorption rates, leading to flooding. On the other hand, less precipitation can result in drought conditions, diminishing water reserves not just for drinking, but also food production and security. Water shortages can even be expected with adequate precipitation. For example, with hotter days anticipated, there is a potential for higher evaporation (Vasseur et al., 2007). More intense storms may also lead to greater erosion rates, decreasing soil water absorption, which in turn affects aquifer replenishment rates, ultimately lowering water tables, resulting in water shortages (NSDE, 2011).

Both flooding and drought conditions also have the potential to adversely impact water quality due to bacterial and saltwater contamination. For instance, flood events may cause sewers to overflow as well as contaminants such as oil, road salt, wildlife carcasses and waste to seep into drinking water supplies. This increases the risk of water-borne pathogens into drinking sources in both ground and surface waters that can impact municipal and private water supplies. Groundwater resources in coastal zones are particularly vulnerable as they are highly susceptible to sea level rise, inundation, and erosion, and thus, vulnerable to saltwater intrusion (Yashura et al., 2012; Moser et al., 2012; Kebede et al., 2012). For instance, if water tables decrease and sea levels increase, groundwater sources may be contaminated with saltwater, therefore making it undrinkable. Additionally, warmer

temperatures may promote greater growth of bacteria and pathogens that can enter into drinking water supplies, a particular concern for shallow wells.

Vörösmarty et al. (2000) suggest that while climate change impacts on water resources are critical, so are other anthropogenic influences on the hydrological cycle, especially in regards to demand and supply within a global context, from population growth to economic development. Pollution and misuse also play key roles in both the quality and quantity of water resources, which have the potential to worsen due to increased population. As a result, Ferguson and Gleeson (2012) suggest that population growth will have a more significant impact on water resources than climate change.

2.2.1.1 Population Growth

Population growth is expected to increase to 8.3 billion people by 2030, and 9.1 billion by 2050 (WWAP, 2012). This can impact water resources in many ways. A greater number of people suggests more water for drinking and other domestic purposes (e.g. cooking, laundry, and bathing). Therefore, global water consumption is anticipated to increase by 19 percent in order to support the growing numbers. Population growth also translates to greater food production, as demand is expected to increase 50 percent by 2030, and 70 percent by 2050 (WWAP, 2012). This includes water use to support agriculture such as crop irrigation, livestock consumption, the feed produced for livestock, loss from transpiration and evaporation (e.g. through irrigation and soil moisture loss), making agriculture the highest water user of any sector, accounting for 70 percent of water usage globally (WWAP, 2012).

Population growth also suggests more land-use changes, such as converting forested and wetland areas into agriculture or urban landscapes to support the growing number of people. Land-use changes deeply impact ecosystem services. For example, deep tree roots that once absorbed and stored a great deal of water and nutrients, and held soil together are being replaced by crops that neither have the depth nor density of tree roots. This can lead to a reduction in evapotranspiration, affecting water movement, and the balance of the hydrological cycle (Bullard, 1996). Instead, these landscapes are now more susceptible to erosion, flooding, and runoff as tree canopies and roots are no longer there to capture precipitation.

2.2.1.2 Pollution

Pollution also has the capacity to affect water resources. Pollution is often categorized into two main groups: point source and non-point source pollution. Point source pollution is when the point of pollution is known, making it easier to identify, monitor and regulate. However, most contamination is from non-point sources whereby the source of pollution is not known or cannot be accurately identified. The main sources of pollution are often from agricultural activities, residential practices, commercial and industrial processes, and from the built and natural environments (Environment Canada, 2010).

Agriculture, which includes livestock and fish farms, is a key source of pollution due to effluence, runoff, pesticides, antibiotics, fertilizers and nitrogen use that can make its way back into water supplies. For example, nutrient surplus such as nitrogen that is not absorbed, leaches into the soil and eventually enter into water systems, which can lead to eutrophication (Basu et al., 2012). Bacteria and pathogens from animal waste can also make their way into water systems, which can be further exacerbated by flood and drought conditions.

Residential practices such as applying lawn fertilizers, dumping chemical solvents down the drain, use of phosphorous rich products (e.g. laundry detergents), pet waste, poorly maintained septic systems, and even the use of birth control pills can find their way back into water systems, polluting supplies. Commercial and industrial processes can also contaminate waterways due to improper handling and disposal of waste. This can include heavy metal contamination that can leach carcinogens into drinking water supplies. Acid rain is another source of pollution, and although there are natural causes that contribute such as vegetation decay, seawater and volcanic activity, the major driver is human activities such as car emissions, coal power plants and base-metal smelting, which eventually enter back into drinking water systems via the hydrological cycle (EPA, 2007).

Contamination from the built environment such as road traffic, spills, brownfields, corrosion, and the expansion of impervious surfaces also impact water quality. For example, road salt, oil and other contaminants can be carried into waterways through runoff from impermeable surfaces, or chemical contaminants from brownfields can leach into groundwater supplies. Finally, processes from the natural environment that interact with anthropogenic processes and structures also affect water resources, such as sediment deposits, snowmelt, soil erosion, runoff, and wildlife effluence.

2.2.1.3 Overuse and Misuse

There is also misuse, mismanagement and overuse of water resources that affect supplies. For instance, Vörösmarty et al. (2000) argue that engineering efforts have led to over exploitation and mismanagement of water resources in many regions as well as the overuse and misuse of water from agriculture due to inefficient water practices (FAO, 2002). This can be considered even more odious given that one third of the food produced for human consumption is wasted according to the FAO (2011a). Furthermore, with mounting cases of water scarcity around the globe, practices such as watering lawns and washing cars, driveways and sidewalks are becoming more widely scrutinized as water wasting activities, and are starting to have hefty fines attached to them in efforts for municipalities to conserve water (Winter, 2014).

Increases in population, pollution, overuse and misuse of water resources not only have the capacity to undermine the quality and quantity of water, but as of consequence also increase exposure and sensitivity. This is because degraded water quality and quantity not only affects the physical environment, but various socio-economic conditions, such as health and nutrition. Moreover, poor water quality and quantity also impede economic activities that underpin livelihoods around the world, such as agriculture and manufacturing. Moreover, exposures and sensitivities are not static, rather they vary by spatial and temporal scales (Smit & Pilifosova, 2001). Therefore, adaptive capacity is integral to managing stressors on water resources.

2.2.2 Climate Change Vulnerability Assessments

A number of tools exist to assess climate change vulnerability, which in turn highlights various interpretations for the purpose of climate change vulnerability assessments. For instance, Preston et al. (2011) suggest that the aim for climate change vulnerability assessments is to provide a common tool for characterizing potential climate change threats within a system, whereas Kelly and Adger (2000) describe vulnerability assessments as a starting point for facilitating mitigation, coping and adaptation strategies to climate change impacts. Fussel and Klein (2006) suggest that vulnerability assessments combine physical and social sciences to assist in developing policy options that reduce climate change exposures. Patt et al. (2005) and Heltberg et al. (2008) propose that climate change vulnerability assessments are meant to identify no-regret solutions geared towards increasing adaptive capacity. Malone and Engle (2011) suggest, under participatory approaches, climate change vulnerability should be discovered by the community rather than being imposed, whereas Moss et al.

(2001 as cited in Hinkel, 2011) argue that climate change vulnerability cannot even be measured, which is consistent with Kelly and Adger's (2000) framing of *starting point* and O'Brien et al.'s (2007) *contextual vulnerability*.

Climate change vulnerability assessments have been criticized for a variety of reasons. For one, the utility of climate change vulnerability assessments in terms of policy making and relevance have strongly come into question for their scientific credibility (Hinkel, 2011; Naess et al., 2007). Polsky et al. (2007) and Adger (2006) suggest there is little consistency or standardization on how to carry out climate change vulnerability assessments, which limits the ability not only to compare results, but to make generalizations about them. The lack of both clarity and consistent purpose can be attributed to the fact that researchers from various disciplines use their own conceptual methods, resulting in varying contexts and terminology, as well as different definitions for the same terms (Brooks, 2003).

Even when the focus is limited explicitly on water vulnerability, there is little agreement on the approaches. For instance, Plummer et al. (2012) reviewed 50 vulnerability assessment tools for water resources, which included an analysis of 710 indicators, and found significant variations, inconsistencies and overlap among the tools. They concluded that water vulnerability assessments should be holistic in their approach and serve as instruments for policymakers, but also acknowledged that the assessment helped to identify and appreciate the complexities innate to managing and monitoring water resources.

According to Schroter et al. (2005), the issues of complexity, divergence and multiplicity arise because there is more focus on the techniques rather than the overarching methodological framework to guide the process. As a result, they suggest five criteria for climate change vulnerability assessments, that they: 1) be drawn from various disciplines and stakeholder input; 2) be place-specific; 3) take into consideration that there are multiple, interacting global climate change stressors; 4) allow for differential adaptive capacity; 5) be forward-thinking, but also take historical analysis into consideration. Additionally, climate change vulnerability assessments should strive for credibility and transparency so stakeholders can make use of the final product, which then requires that there be appropriate communication channels with stakeholders throughout the process, including the results (Polsky et al., 2007).

Despite the criticisms, climate change vulnerability assessments have come a long way. Firstly, they recognize that non-climatic drivers such as socio-economic, cultural, political and technological

factors play a significant role in how communities and individuals are vulnerable (Smit & Wandel, 2006). Fussel and Klein (2006) characterize the evolution of climate change vulnerability assessments into four distinct stages. The first are *impact assessments,* which provide estimates on the potential impacts of climate change by using future climate scenarios that are applied to a static framework. However, impact assessments do not directly deal with adaptation. The second and third phases are referred to as *first and second generation vulnerability assessments,* which are extensions of impact assessments but also take into consideration relevant non-climatic drivers, and the role that adaptation plays in reducing impacts. They also help to advance research, as well as mitigation and adaptation measures in reducing impacts. Where first and second generation climate change vulnerability assessments differ, is that the latter incorporates adaptive capacity, which then focuses on feasible adaptation options rather than potential. The fourth stage in the evolution of climate change vulnerability assessments are adaptation policy assessments, which are concerned with influencing policy-making decisions through adaptation recommendations. Fussel and Klein (p.324) suggest this fourth phase is a "fundamental shift in the assessment purpose". Based on the research objectives outlined in Section 1.3, this research embraces the fourth phase.

2.3 Water Governance

Freshwater resources are not only finite but highly variable in both spatial and temporal dimensions, in that they are neither constant nor consistent in time, place or scale, highlighting the fact that water issues are heterogeneous (Biswas, 2004). Additionally, water issues are not exclusively related to the question of availability, but also the various processes that factor into how water is managed and used. These are influenced by varying environmental, socio-economic and political constructs that often determine a region's or institution's capacity to plan, develop and adapt. Some of these conditions include legal frameworks, availability of funds, perceptions and research, all of which emphasize that water issues are interconnected by many influences and disciplines, and therefore, too complex to deal in isolation or by water experts and governments alone (Biswas, 2004; Biswas, 2001). This is at the core of where water governance narratives stem from.

Water governance is a derivative of a broader term, environmental governance, which refers to the negotiation, coordination and collaborative processes among governments, civil society and non-governmental organizations (NGOs) in efforts to resolve environmental problems (Kallis et al., 2009). Even though the concept of water governance has been around for over 5,000 years, significant

amounts of resources continue to be devoted to help guide the various management, conceptual and ethical approaches in determining how water resources can be managed most effectively (Pahl-Wostl et al., 2008). Scott et al. (2012) characterize water governance as the reconciliation of the various demands on water that are contextualized by the biophysical and anthropogenic drivers of scarcity and vulnerability as discussed in Sections 2.2 and 2.4. Thus, water governance can be viewed as a suite of collective actions that incorporate both formal and informal arrangements (e.g. legislations, policies, social norms and etiquette) intended to achieve a shared goal among diverse actors (Schneider & Homewood, 2013; Wiek & Larson, 2012). Simply put, water governance is the means in which societal decisions are made that impact water (de Loë et al., 2007). However, governance is often mistaken for being synonymous with management despite the distinction. Management refers to the operational approaches and decisions (e.g. "on-the ground activity") used to reach environmental goals, such as water regulations, whereas governance speaks to the overarching processes and institutions that guide how decisions are made, as well as who makes them (Armitage et al., 2012; Nowlan & Bakker, 2010). In other words, governance describes the decision-making process whereas management is the application of those decisions.

Water resources continue to be threatened both in terms of quality and quantity, and while novel approaches are being sought to address these issues through technology, Simms and de Loë (2010) contend that because these threats are largely a result of human activity, solutions to these threats are inevitably rooted in human behaviour and governance. This is of particular importance as scholars suggest the leading paradigm in the Western world is that nature should be dominated, exploited and controlled for human use and that any consequences and risks to sustainability can be managed through engineered solutions (Steyaert & Jiggins, 2007; Crist, 2007). However, more sophisticated insights recognize that engineered or technology-based solutions alone are insufficient for water sustainability (Michaels & de Loë, 2010), and that effective governance is more critical than the technological issues related to managing the resource (Pahl-Wostl, 2002). Moreover, Vörösmarty et al. (2010) illustrate that when water security is enhanced through technology (often based on affluence), the threats to human water security and biodiversity are also increased. This is because engineered solutions, such as building dams to divert river flow, also affects the quality and quantity of water for human consumption as well as the livelihood and habitat of dependent aquatic and wildlife species.

Edelenbos and Teisman (2011) suggest there are widely accepted perceptions that water governance is only needed in regions where water is threatened or scarce, but argue water governance is just as crucial when water is sufficient. Despite the perceived notions of water abundance in Canada, the quality and quantity of Canadian water resources remain under threat due to human activity (de Loë et al., 2007). However, Nowlan and Bakker (2012) suggest there have been three significant water governance movements in Canada: 1) the recognition of collaborative governance models and the value of incorporating them into the decision-making process; 2) the implementation of policy reforms that promote more stringent drinking water standards; and 3) the advancement of the decision-making processes that promotes greater opportunities for civil society engagement in managing water resources. However, Michaels and de Loë (2010) argue that Canada still needs to improve how water resources are governed with more innovative approaches, particularly for issues of allocation, supply, trans-boundary management, and protection of aquatic ecosystems. Edelenbos and Teisman (2011) also highlight water governance is challenged by fragmented responsibilities, as well as short-sighted and self-serving strategies. Moreover, Gizelis and Wooden (2010) contend that GDP is often used to evaluate the effectiveness of governance, which they argue is inadequate, as GDP is not an accurate measure of governance.

Additionally, Gizelis and Wooden (2010) suggest that while good water governance may help to solve issues of supply, demand and distribution, it does not equate to a democratic process. Therefore, any discussions on water governance ultimately deal with issues of justice and rights (Edelenbos & Teisman, 2011). As a result, scholars emphasize that water governance should not be limited to governments, nor should governments be the primary decision-making authority, instead it should include the participation of various actors (Armitage et al., 2012; Simms & de Loë, 2010; de Loë et al, 2007; Biswas, 2004). This is particularly pertinent for well owners as they are generally responsible for monitoring and maintaining their own drinking water. Thus, novel and more comprehensive forms of water governance call for hybrid approaches.

Hybrid governance of resources can be described as a blend of approaches that includes, but is not limited to, private-government partnerships, private-social partnerships, market-based, community-based, hierarchies, co-management, adaptive management, and private property rights (Lemos & Agrawal, 2006). While environmental governance is highly contextual, Armitage et al. (2012) and Folke and Berkes (2004) reveal that hybrid forms of governance can be more effective in addressing

environmental issues as they promote adaptability, collaboration and learning. For example, collaborative governance approaches emphasize the inclusion of relevant stakeholders so their feedback can be incorporated into the decision-making process, and to hold decision-makers accountable for the management and distribution of water resources (Bakker & Morinville, 2013; Nowlan & Bakker, 2010).

2.3.1 Collaborative Governance

Collaborative forms of governance allow for the inclusion of various actors, including individuals from communities who bring different ideas, objectives, knowledge, experience and expertise to the table (Dietz et al., 2003). Diverse participation is important as traditional views of communities are often portrayed as small spatial units with homogenous social structures that share norms, understandings and identities (Agrawal & Gibson, 1999), or that they are uniform in their goals and priorities (Mehta, 2007). However, these characterizations rarely exist, as the capacity of individuals to adapt is seldom homogenous (Schroter et al., 2005; Agrawal & Gibson, 1999). Allowing for different voices to be heard that otherwise may not have the opportunity, is important. It offers greater opportunities to foster relationships intended to build mutual respect, trust and cooperation more effectively. Moreover, collaborative governance allows individuals from various disciplines and backgrounds, such as experts, all levels of government and community members, to form collaborative relationships and networks to co-produce knowledge (Folke et al. 2005).

Community inclusion in environmental governance, including water governance, is also significant not only because their input is valuable (Wolfe et al. 2007), but it has the potential to deter citizens from evading prescribed rules as well as identifying issues that otherwise may have been missed (Dietz et al., 2003). While it may appear that divergent interests and beliefs are likely to create more conflict, they can actually result in positive outcomes if they are facilitated in an effective and constructive manner, such as engendering learning and change. As a result, collaborative governance systems are also more likely to be perceived as effective, accountable and legitimate forms of authority, a key feature in avoiding or minimizing resistance and evasion of rules (Deitz et al. 2003). Additionally, increased stakeholder engagement is likely to encourage a greater sense of community, ownership and empowerment that may influence conformity. This could result in more valuable, positive, timely and successful outcomes, rather than maintaining status quo. According to Wiek and Larson (2012), the relevant actors in water governance is everyone who is affected, which

de Loë et al. (2007, p.2) suggest needs to be "characterized by transparency, equity, accountability, coherence, responsiveness, ethical choices, and integration".

2.3.2 Key Water Governance Themes

This section offers a discussion on several key water governance themes that are significant to this research, which are heavily borrowed from Simms and de Loë (2010). These concepts are summarized in Table 1 and offer valuable insights in examining and understanding the factors that support or hinder drinking water management and governance that are presented in Chapter 5. These governance concepts also help frame the recommendations offered in Chapter 6, which advocate for strategies to enhance water security.

The first of these governance themes is *leadership,* which speaks to the various stakeholders from government and civil society that are required to champion water governance and management initiatives (Simms & de Loë, 2010). In Canada, the responsibility of water resources is fragmented between all three levels of governments. The federal government's jurisdiction with respect to water governance is limited to navigation, fisheries, federal lands, and international relations. Provincial governments are responsible for defining policy and standards on allocation, use, pollution and quality. The responsibility of providing drinking water are generally delegated to municipal governments. However, as municipalities are the creations of provinces, municipal services such as water utilities are ultimately the responsibility of the province (Kreutzwiser & de Loë, 2007). Therefore, it is generally presumed leadership will come from provincial governments.

Water utilities in rural communities often operate with fewer resources (e.g. financial, human, technological, informational, skills) and may face different challenges than larger water utilities in urban centres, highlighting the need for adequate *resources and capacity* to accomplish set objectives (Simms & de Loë, 2010). This can be particularly challenging for rural areas where there may not be sufficient resources and capacity, such as competent and skilled operators, advanced technology and of course money, which can be exacerbated by environmental, economic and political constructs such as climate change, budget cuts or decentralization.

Even with adequate leadership and resources, there needs to be buy-in, both in the process and the actors involved to ensure *legitimacy* and *trust* (Simms & de Loë, 2010). If trust and legitimacy of traditional actors have eroded, it can diminish the roles of leaderships as well as resource capacity.

However, gaining legitimacy for non-traditional actors (e.g. NGOs) under new collaborative governance regimes may also be challenging, as it may be perceived as a risk to democracy. Therefore, building legitimacy is often a long and cumulative process, particularly with change, such as new leaders and policies, or where there is a lack of community cohesion.

This in turn introduces the need for *accountability*, which refers to ensuring objectives and commitments are being met in a timely fashion (Simms & de Loë, 2010). Accountability also involves transparent and regular communication, and responsiveness. As a result, horizontal and vertical checks and balances are essential at all scales. However, traditional accountability measures that are applicable to governments may not be suitable with collaborative governance approaches, as it involves non-governmental actors. Therefore, accountability measures for new governance approaches demand that roles and responsibilities are clearly defined. In addition, Simms and de Loë (2010) suggest that there needs to be consequences for actors that do not meet the deliverables they are responsible for, which can be through formal (e.g. legal) and/or informal (e.g. reputation) arrangements. This in turn highlights the need to clearly define *roles and responsibilities*, particularly as roles and responsibilities are often fragmented and as such, *fragmentation* is also a key water governance concept (Edelenbos & Teisman, 2011).

Hybrid governance approaches, such as collaborative water governance also require new ways of *learning*, in which actors need to be both aware and open to learning opportunities. Such learning opportunities can happen at different scales (e.g. organizational, experiential, behavioural, emotional, etc.) and is also context dependent, and influenced by many factors (e.g. geography and history) (Bos et al., 2013), which are important to identify, as it assists in understanding the structures in which knowledge is distributed and managed (Reed et al., 2011). Wenger (2000) further suggests that learning or knowing is characterized by competencies defined by societal norms as well as the individual's ongoing experience as a world member. However, in order for knowledge to be considered legitimate, accurate and extensive, it must be derived from multiple sources (e.g. community members, academia, scientists, governments, industry), as well as from multiple disciplines (e.g. economics, natural sciences, sociology, geography) and from various scales (e.g. local, national, international) (Reed et al., 2011).

There are also different types of *knowledge* and different ways of extracting knowledge. Explicit knowledge is most familiar because it has been communicated in written or verbal form (Reed et al.,

2011). It is the knowledge that society gives most legitimacy because it is often derived from facts and science. While, explicit knowledge is important as it is supported by evidence that is often the basis for further action or research, it is not the only relevant form of knowledge. There is often knowledge among actors that has materialized through experience and reflection, but has not been made explicit (i.e. expressed in written or spoken form), but can be (Reed et al., 2011). This is referred to as implicit knowledge. Tacit knowledge refers to having intimate understanding of something, but not being consciously aware of having that knowledge. While tacit and implicit knowledge may be more difficult to acknowledge or grasp, implementing learning strategies to tap into these types of knowledge may be necessary in order to draw the most complete landscape. Therefore, knowledge can also be drawn from non-experts who may or may not have formal qualifications. This suggests that engaging actors from various disciplines that have different sources and types of knowledge is essential to acquiring the most objective, comprehensive and accurate knowledge possible. Local and implicit knowledge is particularly critical for rural communities as locals are likely to be most familiar with their surroundings, and better able to observe and notice changes in their environment than traditional forms of knowledge (e.g. scientific monitoring), which may be feasible particularly if resources are lacking.

The treatment of uncertainty and complexity are inherent when dealing with almost any environmental issue, making *adaptation* crucial to the process. Adaptation involves not only continuously monitoring change, but also using the newly acquired information and knowledge in order to advance decisions and plans, as well as to learn from previous methods. This could mean well owners observing and tracking changes in water quality and then using that information to make decisions and changes such as getting their water tested more frequently. However, Simms and de Loë (2010) suggest adaptation can be hindered due to resource constraints, or even a lack of desire to adapt and learn new ways of doing things.

Adaptation also underscores the importance of *evaluation*, which Simms and de Loë (2010) identify as the most significant requirement for successful governance, as it can draw attention to both successes and shortcomings. However, evaluation in the context of water governance is challenging given the associated complexity, making it difficult to know what and how to measure, particularly with data acquired from collaborative participatory approaches, which introduces the concept of integrating institutions.

Integrating institutions is an ideal for water governance according to Simms and de Loë (2010), in that institutions are able to effectively integrate linkages and activities related to water resources at various spatial and temporal scales with respect to the biophysical environment. An example of this could be integrating local knowledge collected by residents (e.g. observed changes in their local environment) so that the knowledge can help shape policies or adaptation strategies.

"[P]erception may very well become more important than reality ... especially when it comes to the quality of drinking water" (Sheat, 1992, p.3 as cited in Doria, 2010). Accordingly, *perceptions* around water play a key role in how water is governed (or not) for both municipal and well sources and thus, another critical theme within water governance. While Canter et al. (1993) suggest there is little research on how public perceptions are used by policymakers, Spence and Walter (2012) and Jones et al. (2006) contend public perceptions do influence water education, programs and policies. Canter et al. (1993) further suggest that perceptions are formed by a multitude of factors such as visible pollution, proximity to perceived problem, education level, age, trust in public officials, and level of involvement. Various studies indicate that perceptions of safe water are often based on smell and taste of water, which is of concern when it comes to contaminants such as arsenic and uranium, where there is no discernible taste or odour (Chappells et al., 2014; Kreutzwiser et al., 2011; Jones et al., 2006). Chappells et al. (2014) also suggest that individuals shape their perceptions not only based on their own experiences and knowledge, but also their social networks rather than through formal channels such as government sources. Shaw et al. (2005) further substantiate this notion as they not only found that individuals' perception of risk is often inconsistent with the quality of their water, but perception of risk is often based on personal influences and experiences that generally cannot be observed (i.e. tacit knowledge) and thus conclude that perceptions drive behaviour such as choosing whether or not to get water tested and treated.

Additionally, Gupta et al. (2013) suggest academic framings are central to the discussions of perceptions, as scholars often take abstract approaches to water governance that are rooted in academic theories and methodologies that are generally not connected or relevant to the real-life problems faced by policymakers, NGOs and governments. In other words, individuals' perceptions are based on implicit or tacit knowledge influenced by their networks. Yet, scholars fail to grasp this important discovery and attempt to address water governance issues in ways that disconnect the very groups they are trying to engage. These gaps not only reflect the different perceptions about water,

but the various ways actors learn and acquire knowledge that leads to the development of these views. More importantly, the countless, conflicting and divergent perceptions on water security and governance narratives emphasize the need for collaborative governance approaches to help reconcile these differences.

Complacency is often linked with water governance (Chappells et al, 2014; Kreutzwiser et al., 2010; Imgrund et al., 2010). According to Rizak & Hrudey (2008), complacency is one of the most important contributors for drinking water becoming insecure. For example, if your water tastes, smells and appears to be fine, then there is no problem type of attitude, which is rather inappropriate when it comes to contaminants such as arsenic and uranium whose characteristics are colourless, odourless and tasteless. According to Kawall (2006), complacency is a form of neglect that is related to vices such as apathy and resignation, where one may overestimate a positive status coupled with a lack of desire or need to improve or maintain that status. While complacency on water safety is lessening because of the countless waterborne outbreaks occurring, complacency remains a prevalent issue within water governance (Rizak & Hrudey, 2008).

Table 1: Key Water Governance Themes

Challenge	Description
Leadership	People and organizations that sustainably champion a project or plan with ongoing dedication to its successful implementation
Resources & Capacity	The capabilities and resources that are required to accomplish goals and objectives
Legitimacy & Trust	The genuine approval of institutions or actors by those subject to its actions
Accountability	The acknowledgement and assumption of responsibility
Roles & Responsibilities	The people who are involved, their responsibilities and the qualities and characteristics of their interactions
Fragmentation	Fragmentation of roles and responsibilities that often lead to issues of confusion and inconsistencies
Learning	The acknowledgement that participants must engage in processes of self, social and organizational learning in order to participate effectively in governance
Knowledge	Different ways of knowing and interpreting the environment
Adaptation	Consistently monitoring change and using new information and knowledge to improve plans and decisions
Evaluation	Learning from previous approaches and evaluating success
Integrating Institutions	Achieving coordination among different policy tools at different scales
Perceptions	Individuals' water perceptions are based on implicit/tacit knowledge, guided by social networks, which are often inconsistent with the quality of their water
Complacency	A form of neglect that leads overestimation of water tied with a lack of desire or need to improve or maintain water status.

2.4 Water Security

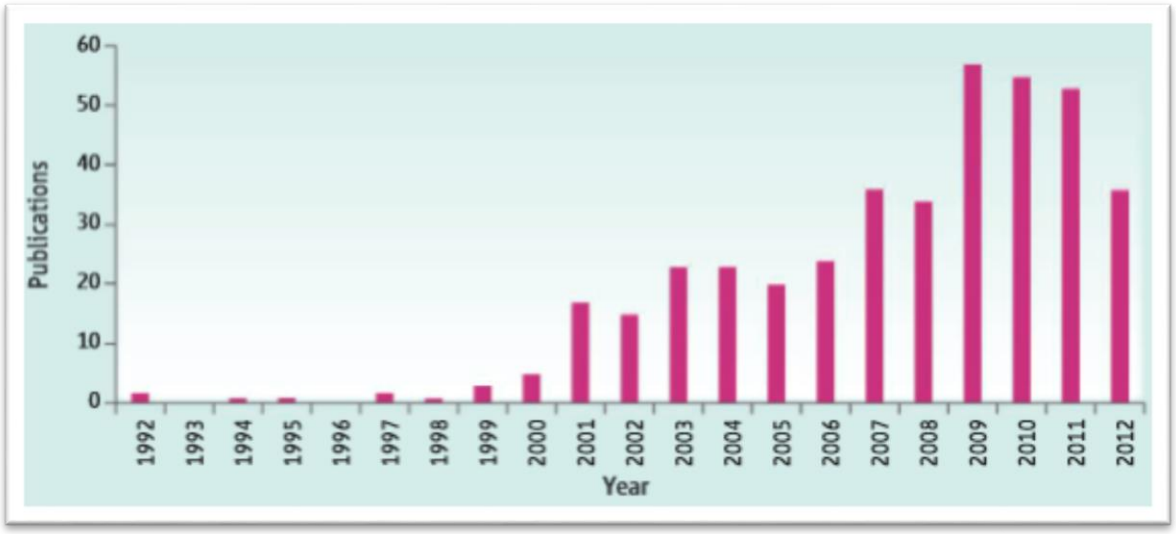
According to Bakker and Morinville (2013), there are three central concepts with respect to managing water resources: water security, water governance and integrated water resource management (IWRM). Despite being the dominant narrative in water management for the last six decades, IWRM has had various definitions to the point where not only do individual views of what IWRM represents widely vary but, "no one has a clear idea of what it means" (Biswas, 2004, p. 224). The most common definition of IWRM comes from Global Water Partnership (GWP) (2000), describing it as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". Biswas (2004) argues this definition leaves much room for interpretation due to the ambiguity of key concepts. For example, it is not clear who would be promoting IWRM and through what mechanisms. Moreover, the terms *economic* and *social welfare* are contentious within their originating disciplines of economics and sociology, where even experts cannot agree on the meaning, yet they are used in a definition for water management. Mitchell (2005) expresses similar concerns such as the lack of clarity on "related resources" as they could refer to forestry or agriculture, which are all governed separately from water. As a result, Biswas (2004) asserts that IWRM has largely been ineffective and unusable despite being the dominant paradigm in water management. Moreover, Cervoni et al. (2008) suggest IWRM has not been sufficiently achieved in Canada (e.g. Ontario and Nova Scotia) because a national IWRM framework (a necessity to fully realize IWRM) does not exist, and because the federal government has failed to prioritize sustainable water resource management in Canada.

As a result, some of these deficiencies have led to the development of water security narratives over the last few years, which seek to incorporate and extend key features of IWRM (Bakker, 2012). Water security remains a nascent concept – for example, 50 percent of existing publications from the Web of Science database have only been written in the last seven years as portrayed in Figure 1. Figure 2 illustrates the wide ranging disciplines adopting this emergent concept. However, social sciences and humanities are not expansively covered in the Web of Science database and thus may not be accurately represented (Cook & Bakker, 2012).

Water security has been characterized as the "single most important factor regarding the future sustainability of our planet" (Biggs et al., 2013, p.388). Yet, despite its significance, water security

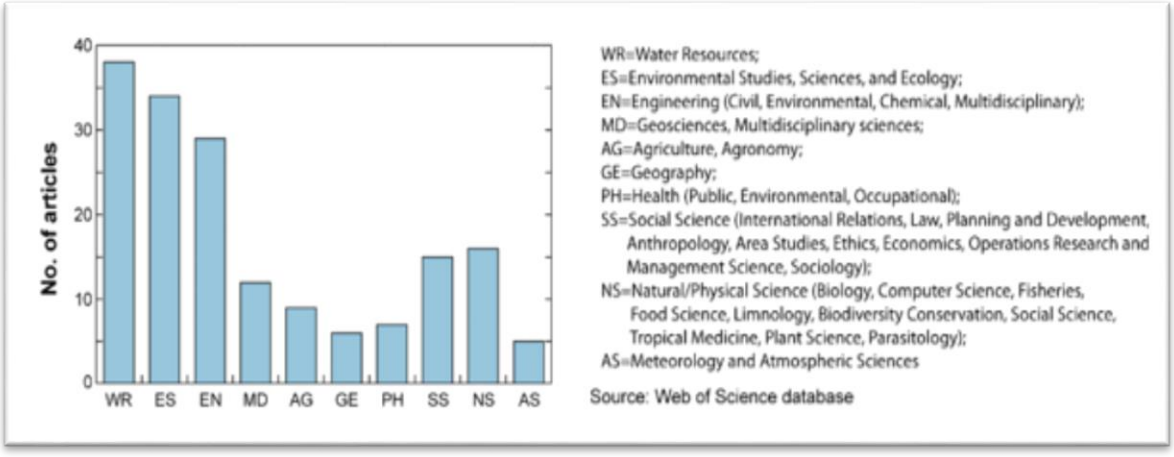
also has various definitions assigned to it by scholars and policymakers alike. This is also attributed to the fact that various disciplines that have taken up the term. As a result, policymakers and scholars offer their own narrow framings to support their subject areas (Cook & Bakker, 2012). For instance, GWP (2010) describes water security as every individual having enough access to safe water from household to global scales at an affordable cost in order to "lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced". The United Nations (UN) (2013) similarly defines water security as an adequate amount of water of acceptable quality for both human and environmental use. de Loë et al. (2007) build upon these definitions by explicitly outlining the need for adequate water for social, economic and cultural uses. Grey and Sadoff (2007) continue to add to the discussion by including terms such as health, livelihoods, production and risk, to not just people but also the environment and economy, and Bakker and Morinville (2013) also take into account risk and national security. Finally, Boelens and Seemann (2014) describe water security more as a political issue that is intended to secure sustainable water access for both people and ecosystems that incorporate fair distribution water use, shared decision-making power and protection against water threats. This paper chooses to adopt Bakker and Morinville's (2013) definition.

Figure 1: Water Security Publications from 1992-2012



Source: Cook & Bakker (2012)

Figure 2: Disciplinary groupings of articles containing the phrase "water security"



Source: Cook & Bakker (2012)

Table 2 captures these descriptions, highlighting the variations and vagueness. For example, the UN's (2013) definition speaks to the "capacity of a population to safeguard" but this raises many questions such as what is the context for capacity. Is it financial resources, technical knowledge, technology or something else? What scale does population refer to (e.g. national, regional, watershed or the community level)? What constitutes safeguarding and are there spatial and temporal dimensions to this safeguarding? How will the sustainability of livelihoods be measured and by whose standards? What benchmarks will be used as a reference point? Interestingly, many definitions do not explicitly account for ecological or ecosystem dimensions.

Table 2: Definitions of Water Security

Author	Definition
Witter and Whiteford, (1999 as cited in Cook & Bakker, 2012)	Water security is a condition where there is a sufficient quantity of water at a quality necessary, at an affordable price, to meet both the short-term and long-term needs to protect the health, safety, welfare and productive capacity of position (households, communities, neighborhoods [sic], or nation).
Global Water Partnership (2000)	Water security at any level from the household to the global means that every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced.
United Nations (2013)	Access to adequate quantities of water, of acceptable quality, for human and environmental uses.
De Loë et al. (2007)	Sufficient water of good quality is available for social, economic and cultural uses while, at the same time, adequate water is available to sustain and enhance important ecosystem functions.
Grey & Sadoff (2007)	The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies.
Bakker & Morinville (2013)	An acceptable level of water-related risks to humans and ecosystems, coupled with the availability of water of sufficient quantity and quality to support livelihoods, national security, human health and ecosystem services.
Boelens & Seemann (2014)	In general terms, water security refers to people's and ecosystems' secure, sustainable access to water, including equitable distribution of advantages/disadvantages related to water use, safeguarding against water-based threats, and ways of sharing decision-making power in water governance.
Norman et al. (2010)	Reliable access, on a watershed basis, to adequate quantities of acceptable quality water to ensure human and ecosystem health.

2.4.1 Scale

A common feature in all the definitions offered in Table 2 is that they contain phrases such as "acceptable levels", "adequate quantities" or "sufficient quantities" of water, also leaving room for much interpretation as it does not address many critical questions such as: How are acceptable levels quantified and measured, and by whom? What is considered "good quality" or "acceptable quantity"? How is it determined and by whose standards? Many of these answers are largely dependent on the researcher's specialty, particularly as various disciplines undertake water security research at different scales (Bakker, 2012). For example, Cook and Bakker (2012) suggest that development studies often use national scales whereas as hydrologists generally work at a watershed

scale and social scientists at the community scale. Vörösmarty et al. (2010) contend that the concept of scale is instrumental in evaluating water security due to hydrological variability. Hydrological variability speaks to water availability in its absolute terms, bound by inter- and intra-annual unpredictability as well uneven spatial and temporal distribution (Gray & Sadoff, 2007). However, examining water security at local scales is just as imperative, as water security is also a social issue whereby the impacts are experienced locally (e.g. regional, community, household, and individual). Moreover, as drinking water is often managed locally (e.g. municipal), so are adaptation efforts (e.g. conservation, by-laws and education). Therefore, examining water security at multiple scales (national, provincial, municipal, watershed and household) is necessary. Finally, discussions on scale, quality, quantity and access also underscore the importance of recognizing both the physical and human dimensions of water.

2.4.2 Physical Dimensions

As identified above, the definitions provided in Table 2 underscore the importance of quantity and quality to the concept of water security. However, there are a number of methods proposed and applied to measure water availability but there is no definitive approach or standard in analyzing or measuring water security (Kummu, 2010). This highlights the potential for epistemic uncertainty, which describes the limitations in acquiring knowledge that can be a result of measurement errors, systematic errors, natural variation, inherent randomness, model uncertainty and subjective judgments (Regan et al., 2002). Epistemic uncertainty also makes it difficult to accurately quantify the demand and supply of water and what future supplies may look like. This in turn creates uncertainties regarding how water security and vulnerability are framed and defined, and by whom. In this way, different vocabulary, context, experience and disciplinary lenses applied to the topic lend itself not only to epistemic uncertainty but also to linguistic uncertainty.

Linguistic uncertainty refers to the vagueness, context dependency, ambiguity, indeterminacy, and under specificity in our natural language (Regan et al., 2002). Linguistic uncertainty is of particular concern in environmental narratives because it often creates confusion, opposition or mis-understandings that potentially limit the seriousness of, or response to a problem. Water narratives are no exception as ambiguous or inaccurate vocabulary is often used to express the problem. It may be to generate or communicate the urgency of the problem but in many cases, it is due to a lack of standardized and consistent vocabulary. For example, Mehta (2006) argues water scarcity and

shortages are often used interchangeably even though they are not synonymous. Water shortages are of natural consequences due to the physical amount of water available whereas scarcity is of human-induced consequences related to social and political constructs. However, Rijsberman (2005) also proposes there are two types of scarcities characterized by physical and economic dimensions. Physical water scarcity refers to insufficient water supplies to meet all demands as consumption rates exceed the replenishment rates, causing water deficits. With economic water scarcity there is sufficient water supply but limited financial, human or institutional capital to access water reserves due to poor infrastructure. In essence, both Mehta (2006) and Rijsberman (2005) are communicating the same message, but using different terminology.

In this way, both epistemic and linguistic uncertainties are important in their own right, and both pose challenges for planning and sustainability. By the same token, they both can be reduced. In the case of linguistic uncertainty, while many of the sources overlap or are perhaps redundant, in practicality they could be substantially reduced or even eliminated. For example, if relevant actors in a specific community (e.g. researchers, institutions, governments) collaborated and cooperated in developing a mutually agreed upon set of terminology that is clearly defined, the problems of under specificity, ambiguity, vagueness and contextual dependency can be minimized. Reducing epistemic uncertainty on the other hand can be achieved through greater understanding, but is likely to be more challenging in that the understanding of key system components may be difficult or perhaps impossible (e.g. how much precipitation will be received in a given period).

Moving beyond the definitional challenges, water availability for a region is generally measured based on the number of users accessing the source (Kummu, 2010). The Falkenmark Water Stress Indicator is the most commonly used method to indicate the onset of water stress and scarcity on a national scale (Brown & Matlock, 2011). Falkenmark et al. (1989) estimate 100 litres of water per person per day is the minimum amount required for basic human needs and further suggest that five to twenty times this amount is further needed to meet the demands for agricultural, industrial, and energy production. According to Gray and Sadoff (2007), if water resources are sufficient, attaining basic level of water security is relatively simple as it can be achieved without high levels of skills or investments. As a result, growth and development can occur without strain on water supplies in contrast to areas where there are issues of water shortages such as arid regions where precipitation is sparse or variable. At the same time, Gray and Sadoff (2007) also suggest future changes in the

environment, including climate change impacts, and responses to those impacts can shape water security, introducing the human elements of water security.

2.4.3 Human Dimensions

Biggs et al. (2013) argue that water security is not just bound to hydrological issues but also the lack of accessibility, which describes a problem from a human perspective. Examining the human dimensions of water security is extensive in scope as it can touch upon varying social, economic and political conditions such as health, safety, sustainability, accessibility, affordability, rights, conflicts, threats and governance. For instance, an area can have adequate water supply but still be water insecure due to various drivers and stressors at play such as climate change, uncertainties, population growth, power imbalances (e.g. race, class, political), as well as the state of water infrastructure (Smith & Patrick, 2011). In this way, issues of water access are generally related to socio-economic conditions even if water availability is sufficient. Regions that face water shortages will not only need greater infrastructure to access water, but also stronger governance (Gray & Sadoff, 2007). At the same time, it is important to recognize that water protection, development and management as well as the delivery of water services, are all different activities, and not necessarily the mandate of water security, but rather the challenges of water security (Sadoff & Muller, 2009).

A key component of accessibility is the affordability. However, most definitions of water security do not explicitly account for economic and institutional limitations, which is a significant issue in many regions. However, according to Witter and Whiteford (1999, p. 2 as cited in Cook & Bakker, 2012), ‘‘water security is a condition where there is a sufficient quantity of water at a quality necessary, at an affordable price, to meet both the short-term and long-term needs to protect the health, safety, welfare and productive capacity of position (households, communities, neighborhoods [sic], or nation)’’. This again raises questions such as who determines what is affordable and how is that decided.

Boelens and Seemann (2014) argue that issues of water security tend to get “naturalized” because distribution and security are constructed through scientific, economic or legal framings, rather than acknowledging the issues largely emerge from the interplay between human interest, intervention and power dynamics. As a result, this leads to false assumptions, especially by financial institutions and policymakers, that water rights can increase water security. Boelens and Seemann (2014) further argue that once water security is institutionalized (e.g. incorporated into policies), that “techno-

rationalized" and management solutions are used to address water security, even though it is fundamentally an issue with unequal power structures (e.g. one actor or policy defines water security). As a result, it excludes tacit values and interests of others.

Another human aspect involves conflict over water resources. Scholars are predicting the depletion and pollution of fresh water to be one of the six environmental problems that are likely to cause violent conflicts (Klare, 2001a, b as cited in Crank, 2003; Homer-Dixon, 1994). In fact, water scarcity is regarded as one of the most pressing issues that humankind will face in the 21st century (Ohlsson, 1995; Postel, 1994 as cited in Mehta, 2001), a subject that has been richly developed by many scholars (e.g. Padowski & Jawitz, 2009; Lall et al., 2008; Mehta, 2006; Rijsberman, 2005; Crank, 2003; Homer-Dixon, 1994) who show the relationship between water scarcity and conflict. Thus, as the water security narratives mature, the definitions become more elaborate and inclusive. For instance, recent definitions have begun to incorporate the concept of managing and protecting against risks and threats. Yet interestingly, water conflict scholars have not adopted the term water security, even though one might expect it to be pivotal to the discussion (Cook & Bakker, 2012).

2.4.4 Climate Change Adaptation and Water Security

Adaptation is a concept used in many disciplines, which in the broadest sense refers to the process of organisms adjusting to their environmental surroundings through biological and cultural changes (Heyd & Brooks, 2009; Smit & Wandel, 2006). Defining adaptation within the human dimensions of climate change can be described as ecological-socio-economic adjustments made in response to real or anticipated climatic impacts (Smit & Wandel, 2006), and may reduce unavoidable, negative impacts of climate change for vulnerable systems (Fussel & Klein, 2006).

Exposure, sensitivity and adaptive capacity are the functions of climate change vulnerability (as discussed in Section 2.2) and is also related to the concept of climate change adaptation (Smit & Wandel, 2006). Climate change adaptation refers to the adaptive capacity of a community, which can be long-term strategies to manage with the impact of climate change, or to coping, which are short-term responses (e.g. providing first-aid) (Berkes & Armitage, 2010; Malone & Brenkert, 2008). Adaptive capacity also differs from coping, as adaptive capacity is largely contingent on socio-economic and political conditions (Keskitalo, 2009). For example, communities may be able to cope with moderate climatic changes, but extreme changes may exceed the coping range or adaptive capacity (Smit & Wandel, 2006). However, coping mechanisms can also become adaptive responses

that may increase a community's coping range by building its adaptive capacity (Berkes & Armitage, 2010). Yet, this does not suggest that adaptive capacity will always translate to adaptation (Berrang - Ford et al., 2010). According to Malone and Brenkert (2008), adaptive capacity is typically fostered through human resources, economic potential and environmental capacity. Furthermore, adaptive capacity is viewed as the first step in evaluating and understanding what adaptation measures ought to be implemented. However, this process is often hindered by financial and knowledge limitations as well as rules and regulations (Rudberg et al., 2012).

Climate change adaptation within the context of water security is complex, as achieving water security is a significant undertaking in its own right, due to the natural variability (as discussed in Section 2.2.1). Tacking on the challenges of climate change impacts only adds to the intricacy. As Section 2.2.1 describes, climate change has the capacity to negatively impact water resources, in that it can reduce quantity, quality and access to water, which ultimately would diminish water security. However, making water security the priority for climate change adaptation can in turn enhance adaptive capacity and thus water security. Therefore, Sadoff and Muller (2009, p. 4) suggest placing emphasis on water security would be a "sound early adaptation strategy", and that a water security framing can lend itself as a framework for developing adaptation strategies. However, in order to achieve water security, investments and resources (institutions, infrastructure, etc.) are required to support and sustain the treatment, transportation, storage as well as the reuse of water, which inevitably would support climate change adaptation mandates. As a result, Sadoff and Muller (2009, p. 58) contend that "[w]ater security therefore lies at the heart of adaptation to climate change" and that present day investments in water security should be viewed as part of broader, long-term climate change adaptation strategies.

However, it is not enough to achieve water security, but also to be able to maintain it. Thus, communities who have not already achieved water security, dealing with the impacts of climate change will be even more challenging, and even those who enjoy water security, may find it difficult to sustain (Sadoff & Muller, 2009). This reveals that water insecurity is not only an environmental issue but also a social, economic and political one. Therefore, Ludi (2009) argues, adaptation activities should not be approached in isolation from these other factors. This also suggests the need to mainstream climate change adaptation into development agendas (Murdiyarso, 2012; Berrang-Ford et al., 2010). Mainstreaming refers to integrating climate change responses into broader

development, economic and planning initiatives, and making better use of human and financial resources (Klein et al., 2007). Moreover, highlighting these water linkages is critical to understanding the impact of climate change on water resources and security, particularly at community and household scales.

Central to the discussion of water security, is the appreciation that uncertainty, particularly in the face of climate change, is inherent and limits our ability to fully understand and control water systems. As a result, focus is placed on identifying and prioritizing thresholds and acceptable levels of risks (Bakker & Morinville, 2013). The attainability of water security is also dependent on the decisions made by stakeholders according to de Loë et al (2007), including individual water users, as well as governments, which ultimately underscores that human water security is innately a political issue (Borgardi et al., 2011). This involves recognizing and anticipating when a system's resilience, whether social or ecological, is at risk, and thus our ability to respond to such vulnerabilities through governance tools and approaches. This in turn highlights that water governance is central to the water security discussion, as well as for sustaining freshwater systems (Bakker & Morinville, 2013). Yet, Cook and Bakker (2012) argue that water governance is often a neglected feature in water security narratives due to both broad and narrow framings of the discourse.

2.5 Summary

Chapter 2 provides a literature review and synthesis on the three areas that are significant to this research: climate change vulnerability, water governance and water security. While these disciplines have been criticized for having multiple, inconsistent and ambiguous definitions, their importance is central to the understanding and management of water resources and issues.

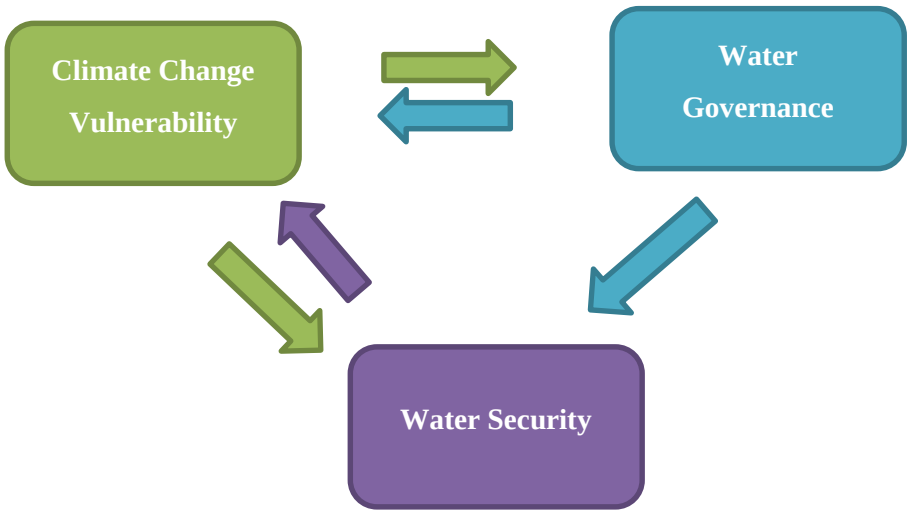
The climate change vulnerability narrative speaks to the sensitivities and exposures of a system and the capacity of that system to adapt to those sensitivities and exposures. The literature synthesis connects the vulnerabilities associated with water resources and its implications. Assessing water vulnerability includes not just examining the physical resource, but also the various associated threads, such as the capacity of existing and future water infrastructure, as well as the relationship between water and health (Plummer et al., 2012). This signifies a complex relationship in that water vulnerability is multifaceted issue operating at varying scales, and though biophysical conditions are quintessential determinants of vulnerability, socio-economic factors are just as critical (Plummer et

al., 2012; Vörösmarty et al., 2000). Thus, a human security lens is applied when looking at vulnerability as it speaks to social drivers of vulnerability to environmental changes, such as social, political and economic constructs (O'Brien and Barnett, 2013).

The water governance discourse contributes to the discussion by drawing attention to how actors can respond to these vulnerabilities, such as the tools, skills and knowledge required. In other words, the ways in which society makes decisions that impact water (de Loë et al., 2007). Water governance is significant to water security narratives, as governance largely influences, and often determines security (de Loë et al., 2007). Bakker and Morinville (2013) contend that not only is water governance paramount to water security, but also for sustaining freshwater systems for the long-term.

Finally, the water security literature deals with acceptable levels of water related risks that will continue to support human health, security, livelihoods and ecosystems. Water security embodies the physical dimensions (e.g. quality and quantity) as well as the human dimensions of water (e.g. accessibility, sustainability, affordability, health, rights, conflicts, threats and governance). Security of water is regarded as one of the most important factors for "future sustainability of our planet" (Biggs et al., 2013), and as such, Sadoff and Muller (2009) suggest placing emphasis on water security would provide for good adaptation strategies. The ways in which these themes intersect and influence one another in the context of this research, are also described by Figure 3.

Figure 3: Conceptual overview of how research themes relate and affect one another



Chapter 3
Methodology

3.1 Introduction

The literature review offered in Chapter 2 discusses how water resource management has traditionally been overseen by water experts and governments. However, Biswas (2004) suggests that water problems cannot be adequately addressed by conventional top-down approaches, indicating that more participatory approaches are necessary to sufficiently evaluate existing and potential vulnerabilities (Smit & Wandel, 2006). One of the key purposes of this research is to incorporate stakeholder knowledge and perspectives in order to identify the vulnerabilities associated with drinking water and the implications for water governance and water security. Participatory or stakeholder approaches seek to improve community engagement through its participation and is essential in situations where much of what is significant is only accessible through verbal communication rather than written form (Schroter et al., 2005).

Sections 3.2 and 3.3 review the research approach and methods employed to help identify the vulnerabilities associated with water security. Section 3.4 provides a discussion on the case selection, proceeded by Section 3.5, which reviews the data analysis and interpretation process. Section 3.6 examines some of the limitations and challenges of the research methods. The chapter concludes with the researcher's positionality statement in Section.3.7

3.2 Research Approach

This research uses a qualitative, case study approach in concert with a community-based vulnerability assessment framework developed by Smit and Wandel (2006).

3.2.1 Qualitative Case Study

The case study approach aims to understand not only how certain behaviours and processes are influenced by context, but how those behaviours and processes influence context (Cassell & Symon, 2004). Case studies are often used for exploratory research that examines contemporary issues within real world conditions, and perspectives that accommodate both quantitative and qualitative approaches (Yin, 2003). This research is largely exploratory as it seeks to answer questions such as: What are the human vulnerabilities associated with water security? Who is affected, in what ways

and why is that important? What can be learned from this? Finally, it is qualitative as the research questions are open-ended and exploratory in order to acquire the necessary data.

The case study methodology is a powerful catalyst for data gathering as it allows for in-depth analysis of the key issues within its current context (Cassell & Symon, 2004). Case studies are also flexible in terms of allowing the investigator to not only probe and adapt the planned areas of research, but also to examine emergent topics (Cassell & Symon, 2004). Case studies also support inductive theory building whereby the data gathered can be pieced together to formulate hypotheses (Cassell & Symon, 2004). However, it is important to take into consideration that theory building is both an ambitious and taxing process, as it requires ongoing comparison and refinement of data and theory that is developed gradually over time (Dooley, 2002). While qualitative case studies can be generalized theoretically, this is not always the case (Yin, 2003). Instead, case studies often aspire to "expand and generalize theories" (Yin, 2003, p. 10) as they have the capacity to demonstrate that individuals can experience the same events and places differently (Winchester, 2005; Dooley, 2002).

Conversely, case studies have been critiqued for being lengthy, time consuming processes that generate vast quantities of data that are not easily grasped (Yin, 2003; Dooley, 2002). Yet, Yin (2003) argues that case studies need not be drawn-out nor produce lengthy documents if proper considerations are taken. For instance, taking into account the target audience and then structuring, formatting and orienting the research, and end report accordingly, can help reduce its length. Finally, as with other research approaches, case studies can be challenging given that they require certain skills and aptitude from the researcher (e.g. adaptability, good judgment and focus). However, it is often difficult to assess the abilities of the researcher in advance, which can potentially affect the research quality (Yin, 2003).

According to Winchester (2005), quantitative research has traditionally been viewed (and taught) as a more legitimate, objective, fact-based, and value-free approach, despite the fact that qualitative research allows for multi-interpretations and meanings rather than promoting conventional or dominant narratives. For qualitative research to be useful and useable, it needs to be analyzed and deciphered, which is generally based on the researcher's own interpretations and biases. This is important to acknowledge because biases not only influences one's values and beliefs, but also how research is constructed and conducted, which may affect the authenticity of the data gathered (Winchester, 2005). This also presents challenges for coding as "coding is not a precise science; it's

primarily an interpretive act" (Saldana, 2009, p. 4). However, these issues can be largely circumnavigated by revealing the investigator's assumptions and positionality in order to frame the research within its appropriate context.

3.2.2 Conceptual Framework

The Community-based Vulnerability Assessment (CBVA) framework is a three-phased approach developed by Smit and Wandel (2006), which seeks to incorporate scientific and local knowledge by collaborating with community members and partners in discovering a community's vulnerability rather than assuming it. In addition to environmental factors, the CBVA also takes into consideration the political, social, economic, cultural, institutional and technological influences.

The objective of phase one is to collect baseline and background data on the community, which is marked by two research tasks. The first is to identify and document the current exposures and sensitivities (see Section 2.2) by examining what drivers or processes impact the livelihoods of communities. This is to be supported by evidence that explains why these are risks and their underlying trends. The second research task is to identify and evaluate what current adaptive strategies are being sought by stakeholders in response to the conditions identified in task one. This information is collected through a review of secondary data such as reports, climate records, population census, etc., as well as the acquisition of primary data through qualitative methods, such as semi-structured interviews. With regard to my research, I collected and analyzed the current and projected vulnerabilities for Nova Scotia's South Shore's tourism community (my first research objective), thus followed the first phase of the CBVA, which is presented in Chapter 5. This was achieved by using the research methods of literature and documentation review, semi-structured interviews and participant observation (see also Section 3.3).

The second phase of the CBVA involves collecting data to provide estimates of future exposures and sensitivities, as well as identifying future adaptive capacity options. Future exposures and sensitivities are established in two ways. The first way is to review the current exposures and sensitivities that were discovered in phase one, in order to determine the probability of change in these conditions. The second way is to document possible changes in conditions even if they were not identified by the community members themselves. Future adaptive capacity is established by examining future exposures and sensitivities, which includes the use of quantitative methods, such as scenario building, remote sensing, coastal erosion, hydrological modelling and GIS analysis. My

research contributed to phase two by: 1) providing the baseline and background data required by ParCA researchers to estimate future exposures and sensitivities, and 2) documenting possible changes in conditions that were not identified by stakeholders.

The third phase looks at the governance structure and how policies and institutions support or hinder adaptation (my third research objective). This process is also intended to position communities to "mainstream" and "scale-up" their adaptation efforts into broader policy, development and planning initiatives instead of being an independent goal onto itself. My research complements phase three by generating insights for policy and practice in support of adaptation strategies to enhance water security (my fifth research objective).

3.3 Research Methods

This research makes use of triangulation, as multiple research methods are applied in efforts to produce the most accurate and unbiased data possible. Triangulation in social sciences refers to the use of multiple data gathering technologies to evaluate a single theory or construct (Berg, 2001). Denzin (1978 as cited in Berg, 2001) maintains that triangulation can also include multiple theories, researchers, and methodologies, or a combination of these. Triangulation methods used for this research include literature and documentation review and synthesis, semi-structured interviews and participant observation.

3.3.1 Literature and Documentation Review and Synthesis

Before the start of the field season, a literature and documentation review was performed to understand the broader themes associated with the problem context. The review also helped shape the research design, acquire descriptions of the study sites, offer initial understandings of water issues within the study site, identify emerging issues, and develop stakeholder profiles. Literature and documentation reviews were also conducted during and post fieldwork to help supplement data that was not possible to collect through semi-structured interviews and participant observation. Sources consulted include academic and peer-reviewed journals, books, newspaper articles, government publications, relevant websites, as well as documentation provided by participants and other appropriate sources such as brochures, planning documents and maps.

3.3.2 Semi-Structured Interviews

Semi-structured interviews are useful for in-depth analysis of issues in addition, to offering flexibility and adaptability, particularly when new or unknown issues arise. For instance, semi-structured interviews (rather than structured interviews) allow for the incorporation of new, pertinent questions that may only become evident during the interview process (Berg, 2001). Moreover, in-person methods also allow the researcher to observe body language, tone of voice and facial expressions (Kawuitch, 2005), which is described in more detail in Section 3.3.3. The semi-structured interviews were designed to support research objectives one to three by identifying and documenting: 1) the current vulnerabilities associated with water security; 2) knowledge, values and assumptions around water and water use to assess the barriers and enabling factors for drinking water governance and management; and 3) current and future adaptation strategies.

Between May and July 2013, 64 semi-structured interviews were conducted. As referenced in Section 1.3, this research is part of the ParCA project, which has a specific focus on the tourism and fishing communities, as they are key economic sectors for the region. As such, 12 of these interviews were with tourism agencies and associations that were specifically relevant to the ParCA project, but not applicable to this research. Therefore, the data elicited from this group is only represented where relevant. Forty-two of the participants are licensed tourism operators that have a tourism based business situated in either Shelburne or Queens County, generally within one kilometer of the coastline (Section 3.4 provides a classification of tourism businesses). Eight semi-structured interviews were completed with water resource managers. Participants from this group may be water utility operators, town employees, water managers for a tourism operator or they may work for an NGO. Eight interviews were conducted with community members and leaders that include town councillors and employees, emergency measures officers and journalists. Table 3 offers a listing of the interview groupings.

The number of interviews to be conducted were not known in advance and concluded by point of saturation. The length of time for interviews ranged from thirty minutes to three hours. The variance in time is based on several factors, such as the amount of time available to participants (discussed further in Section 3.6.1), the personalities of interviewees (e.g. some were more talkative than others or sometimes dialogs went off topic). Experiences and frustrations encountered by respondents also influenced the length of interviews and what they wanted to discuss.

Table 3: Interview Groupings

Participant Groups	Number of Interviews
Tourism operators	42
Tourism agencies and departments	8
Water resource managers & experts	6
Business, community & political leaders	8
Total	**64**

An interview guide (see Appendix A) was developed as an illustrative tool to loosely frame key questions and themes in efforts to guide the process, promote continuity and flow of dialogue, and ensure my research objectives were met. The interviews were dynamic in that they were adjusted and customized for each individual interview based on prior discussions with the respondent, as well as how the dialogue naturally progressed during the formal interview. This involved spontaneous and probing questions to elicit further detail, or for clarification. The interview guide was designed to help individuals (including the researcher) understand the nature of water issues in the study area. Asking direct and indirect questions gave perspective on areas such as existing water practices, observed environmental and climatic changes, water issues experienced, and the state of their current water knowledge.

3.3.3 Participant Observation

Participant observation is a popular and well-established qualitative research method in social science disciplines. It can be described as a reflection of events, behaviours, discussions and demeanour, as witnessed by the researcher (Kawuitch, 2005). It is more than being a passive observer according to Yin (2003), as it may involve participating in the events being observed and in some cases, is the only method available for eliciting the data needed. Therefore, participant observation can be passive or pro-active depending on the research context (Winchester, 2005). This notion is further supported by Kawuitch's (2005) extensive literature synthesis, which reveals that successful and authentic participant observation embraces establishing a rapport with community members in a way that the researcher is able to blend in and be part of the community. This enables participants to behave and talk naturally rather than feeling they are being studied or observed, making for a more authentic experience. This requires the researcher to have a neutral, non-judgmental and open attitude, as well as being open and interested in learning about the community

beyond the use of scheduled events and formal data gathering techniques, such as interviews. In this way, it allows the researcher to be both an insider and an outsider (Winchester, 2005).

Observational methods can be effective in many ways, as they lend themselves to verifying findings from unspoken words and tacit knowledge that comes from a deeper and more intimate connection with the population sample, as well as accounting for non-verbal communication (e.g. facial expression and body language) (Kawuitch, 2005). Participant observation can assist in providing insights on how respondents grasp or understand information or situations, or how they communicate with others. However, participant observation also has its drawbacks, as it is open to interpretation, and therefore, is highly subjective. This process is often guided by the researcher's attitude, views, assumptions, biases and upbringing (i.e. positionality). For example, two researchers, observing the same situation form differing accounts based on what they perceived (Winchester, 2005). Furthermore, the researcher's ability to elicit information may also be limited due to the researcher's skills, but also how the researcher is perceived by the community (e.g. taking into account cultural differences, appearance, gender, race, class, sexuality). This underscores the importance of the researcher's ability to observe, adapt, interpret and document, as it is critical to the outcome of this approach (Kawuitch, 2005).

In regard to my research, participant observation involved me taking note of facial expressions, body language, tone of voice, and other non-verbal forms of communication (e.g. hesitation), during formal interviews. Participant observation also included informal conversations in social settings with non-participants. Additionally, living in the community for three months, participating in every day events such as joining fitness classes, going to the farmer's market, grocery store, festivals, frequenting cafes and restaurants, helped me gain not only familiarity with stakeholders and residents, but also to foster positive and welcoming relationships. Establishing these connections proved to be highly advantageous when I returned for a second field visit a year later. I was able to follow-up with several participants and gain even deeper insights based on the trust and relationships already established (Section 5.3.1.2 offers an example of this).

3.4 Case Selection

As identified in Chapter 1.2, this research is part of the ParCA initiative, which has a focus on tourism due to the strong economic reliance the province (in particular the South Shore) has on the

industry. With the influx of seasonal residents and visitors, there are added pressures on potable drinking water sources for the area, particularly during the summer months which often experience drought like conditions, and as such, suggests a particular vulnerability for the tourism sector. Therefore, the sampling strategy for assessing the vulnerabilities associated with water security, is limited to the tourism community, however, the sampling strategy also includes water resource managers, many of whom are also residents of the area.

The tourism community was mainly identified through documentation review, snowball, convenience and saturation sampling, and further supplemented through ParCA gatekeepers who helped to recommend and assist in connecting the field researcher with the appropriate people to interview. The tourism community consists of tourism based establishments and merchants, which include all types of accommodations, restaurants, shops, rental companies, and tour companies and outfitters. Participant criteria for the tourism community was limited to those: 1) whose operations are or may be impacted by climatic drivers; 2) over the age of 18; and 3) who have a tourism establishment situated within the study site boundaries of Port Clyde and East Port Medway in the counties of Shelburne and Queens, Nova Scotia, generally within one kilometer of the coastline.

3.5 Data Analysis and Interpretation

According to Berg (2011), there are a number of approaches to analyze data, with the three principle ones being interpretative, social anthropological and collaborative techniques. This paper applies an interpretative approach, which involves treating human and social actions (e.g. participant responses and reactions) as text (Berg, 2001). In other words, activities can be expressed in symbols or codes that are later transcribed and analyzed. The following section discusses how the data were examined and interpreted for the methods outlined in Chapter 3.3.

3.5.1 Documentation and Literature Review

The knowledge and data acquired from secondary sources such as journals, government publications, news articles and websites were stored and organized electronically for easy access and referencing, using Doc Fetcher software. The data were used as the foundation for getting acquainted with the study area, as well as for designing the interview guide. The document and literature reviews were also used as a starting basis for: interview questions, to probe specific/key issues, gain further insights, and to confirm, support (or potentially refute) findings, assumptions and projections from

literature. Finally, based on this process, initial themes were established (e.g. "quantity issues", "quality issues", "water testing", and "well knowledge") and used to organize the flow of the interviews.

3.5.2 Semi-Structured Interviews

The qualitative data acquired from semi-structured interviews were audio recorded using a tape recorder with the consent of the participant, then transcribed using Microsoft Word, and later coded and analyzed using NVivo software. Adopting a similar position to Saldana (2009), coding is viewed as "essence capturing" that contributes to the telling of an emerging story. During the interview process, initial coding was applied based on "first impression" phrases (Saldana, 2009) reflected through written notes that helped to later organize the coding process, as well as aid in formulating the relevant questions needed.

"Coding and analysis are not synonymous, though coding is a crucial aspect of analysis" (Basit, 2003, p.145 as cited in Saldana, 2009). Post-data collection, responses were first decoded (a process of reflection and interpretation of the core meaning of the data), a practice that lent itself in producing a more sophisticated and comprehensive coding system. The data were then encoded (a treatment for determining and applying the appropriate codes) (Saldana, 2009). More than just coding and labelling, the process involved linking and connecting fragmented pieces of data and ideas through an iterative process in order to refine information (Saldana, 2009). However, with coding there is a potential that data are summarized or condensed as opposed to reduced (Saldana, 2009). Therefore, careful consideration was taken to avoid this. Moreover, rather than taking purely static views of the data, the coding and analysis process took into account the various patterns that emerged using Hatch's (2002 as cited in Saldana, 2009) approach. Hatch's method takes into consideration the similarities, differences, frequency, sequence, correspondence and causation, of and, between, the various accounts told, actions taken, and perceptions formed.

3.5.3 Participant Observation

As mentioned in Section 3.3.3, participant observation in the context of this research involved taking written notes of facial expressions, body language, tone of voice, and other non-verbal forms of communication during formal interviews. These notes were recorded in a notebook and captured within the transcribed interviews that were eventually coded and analyzed in NVivo. For participant

observation data that were elicited from informal conversations (e.g. social settings with non-participants), a mental note was made and later captured in the same notebook, which was ultimately coded and analyzed in NVivo.

3.6 Limitations and Challenges

As with any approach, there are challenges and limitations that are important to recognize, particularly if they can influence the outcome of the research. Four key challenges were experienced during the data elicitation phase: timing, omissions, presence of a tape recorder, and shared understandings.

3.6.1 Timing

Scheduling time with participants proved to be difficult in some instances for a few reasons. Firstly, interviews took place between May and July. This is the start of peak tourism season, and thus, one of the busiest time for tourism operators. Secondly, many participants operate their business without additional staff, and therefore, operators have long and inconsistent work days. As a result, interviews were usually conducted during hours of operation, which often resulted in frequent interruptions, fragmenting the conversation, as well as disrupting the flow and thought process for the participant, and at times the researcher.

3.6.2 Omissions

In a couple of situations, data omissions (unintentional and intentional) were discovered during the data elicitation and analysis process. There can be many reasons for this that may not be known to the researcher, but one could postulate. For one, it could be due to the time constraints mentioned in Chapter 3.6.1 as some interviews were rushed or felt rushed. This may have resulted in divided attention, and thus, either unintentionally forgetting details or intentionally not mentioning information to evade further questioning in efforts to move the interview along.

Another factor could be fear. Participants were asked questions regarding the quality of their water, which at times did provoke defensive and guarded responses. Despite being informed that their responses are completely confidential and anonymous, these omissions are likely rooted in fears because they may feel that revealing negative information (e.g. bacterial contamination) may be construed as potentially unsafe conditions by tourists. This could be received as negative publicity

not just for their business, but for the resale value of their business, which often doubles as their home. These factors can affect their livelihood, so hesitation is understandable. Therefore, ensuring participants were being open, honest, forthright and accurate in their responses was a limitation in the data collection process.

Unintentional omissions may have also occurred, such as not remembering past events or not remembering them fully or accurately. This was recognized when information received from other participants either conflicted, or revealed additional information that was not given directly by the interviewee. Data omissions were accounted for in the analysis process by making note of them where possible or known, as they can contribute to the evaluation of water security.

3.6.3 Audio Recorder

When respondents were approached to participate in the interview, they were advised that their interview was anonymous and confidential. Participants were also asked permission if the interview could be audio recorded. All participants consented to the recording. However, the presence of a tape recorder posed as a barrier for a couple of participants in eliciting open and honest information. This barrier was mostly limited to those who were not business owners/operators, but rather employees. The researcher observed on at least two occasions that it was likely out of fear (e.g. getting in trouble with their employer or affecting their employment in some way). In one situation, once the researcher put the recorder away and wrapped things up, the respondent's guarded demeanor, facial expression and tone of voice immediately changed, and he became much more relaxed and responsive.

3.6.4 Shared Understanding

The vulnerability assessments were structured using a climate change lens. However, a majority of participants tended to focus on issues not pertinent to climate change impacts, as cautioned by Van Aalst et al. (2008). This potentially could be due to the fact that participants may have trouble understanding or knowing what climate change means or entails (e.g. what they are experiencing is a result of climate change impacts), while others may not even believe climate change is real (Van Aalst et al., 2008). Alternatively, this finding may mean that environmental or weather related issues are not significant due to other distractions, which takes precedence for them. This could also explain why information was omitted.

3.7 Researcher's Positionality

To begin, only those who wished to participate were interviewed to ensure data was consensual and free from any obligations. Regardless of attempts to be neutral, unbiased and objective, the researcher's positionality (i.e. experiences, upbringing, education, political, economic, cultural and social views and norms) ultimately guide what was heard, seen, experienced and learned. Accordingly, positionality invariably influences what was heard, interpreted and reported, as fieldwork can be "intensely personal" (England, 1994, p. 251). Therefore, sharing the researcher's positionality to the reading audience before presenting the work is important, as biases not only influences one's values and beliefs, but also how research questions and methodologies are constructed (Winchester, 2005). Additionally, knowing the researcher's positionality can give insights to the objectivity, accuracy and consistency of the research.

According to England (1994, p. 242), feminism and post- structuralism has given way so that perspectives of others that are not of "white Western, middle-class, heterosexual men" can be embraced. However, Bauder and Engle-Di Mauro (2008), contend that largely white Eurocentric perspectives persist in what they term as "Anglophone academic geography". This is of note given I am a female of colour, born and raised in Ontario, Canada. While several participants and locals shared comments about prevalent racism in the community to me, I myself did not face or perceive any (outright) racism. However, on a few occasions remarks were made that would otherwise not have been if I were not a person of colour.

My political and social leanings tend to be rooted largely in socialist views. Further, I have a strong background and passion in environmental issues through academia as well as volunteer work. This position may have influenced the way questions were framed and how responses were received and interpreted by me. This is an important consideration as Bauder and Engle-Di Mauro (2008) suggest environmental problems are deeply rooted in issues of social justice.

3.8 Summary

Chapter 3 outlines the research approach (a qualitative case study methodology, complemented by the conceptual Community-based Vulnerability Assessment framework) used to meet the objectives outlined in Section 1.3. The applied research methods were also discussed (literature and documentation review and synthesis, semi-structure interviews and participant observation), as well as the treatment of the data gathered for each of these research methods. The chapter also summarizes how the case study and population sample were selected, as well as some of the limitations and challenges experienced with the data solicitation process. The chapter concludes with a positionality statement from the researcher.

Chapter 4
Study Site Context

4.1 Introduction

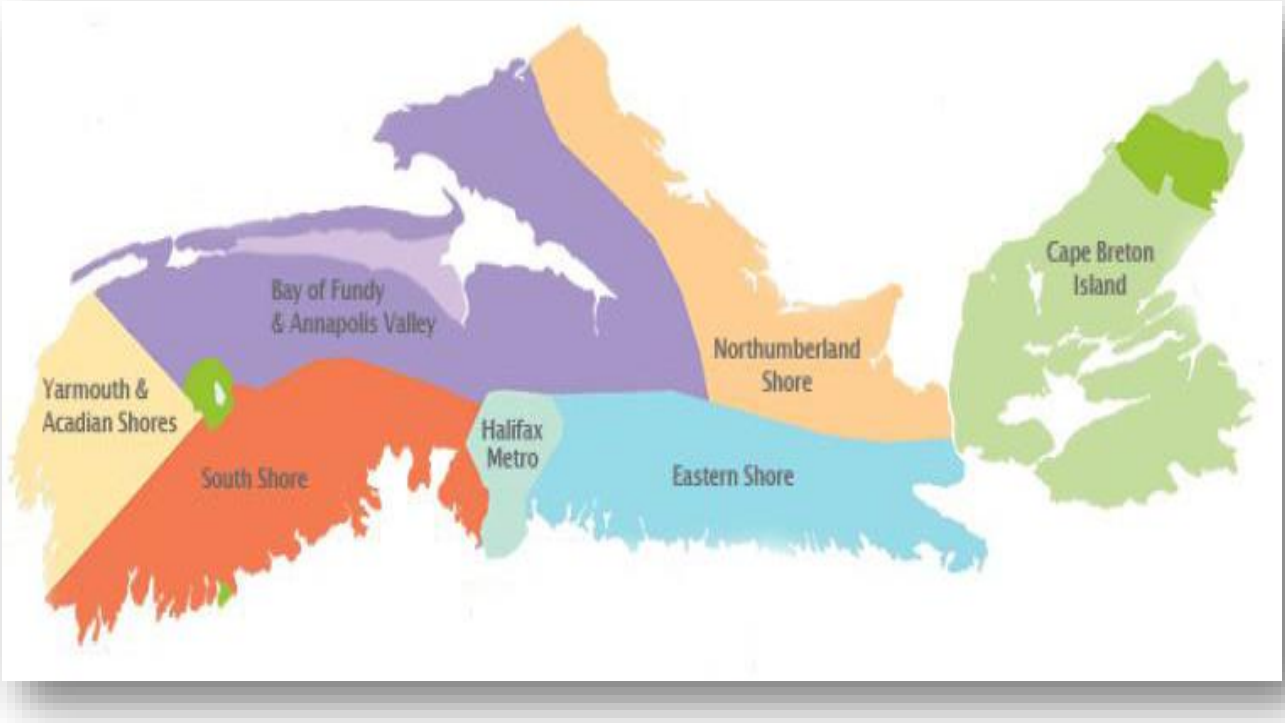
Nova Scotia is located on the south-eastern seaboard with a land mass covering of 55,284 kilometres, a coastline of 7400 kilometres, and would be considered an island if it were not joined to mainland Canada by the Isthmus of Chignecto (GNS, 2006). Nova Scotia is divided into seven regions (Figure 4), 18 counties (Figure 5) and has 51 electoral boundaries (Figure 6). The focus of this research is limited to the coastal villages and towns in Nova Scotia's South Shore, specifically from East Port Medway (Queens County) to Port Clyde (Shelburne County), a distance of 110 kilometres (see Figure 7). This chapter profiles the social, political, economic, biophysical environment and governance landscapes for Shelburne and Queens Counties, as well as the issues and topics pertinent to drinking water resources for the area.

4.2 Social and Demographic Profile

The counties of Shelburne and Queens share similar demography in terms of population, race, income, education and employment levels. This section summarizes key demographic characteristics based on Government of Nova Scotia's (GNS) (2011) most recent community data from 2006 and 2011.

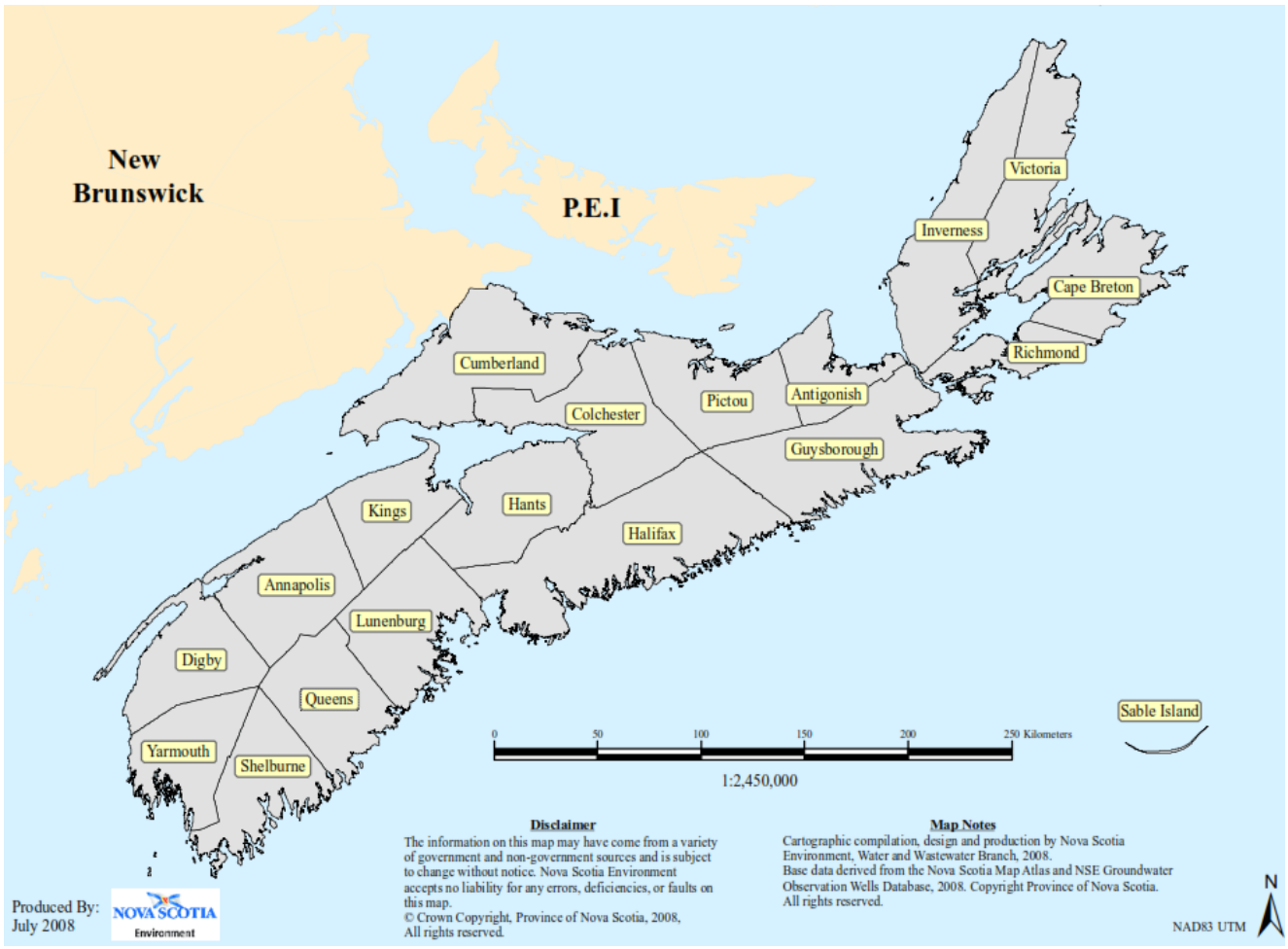
The population of Shelburne County is estimated at 14,495 based on 2011 statistics, 10.75 percent lower than in 2001. Twenty percent of the population is under 20 years of age and 19.5 percent over the age of 65. The primary language spoken at home for 99.3 percent of the population is English. The average household income is roughly $54,017, compared to the provincial average of $66,032, with 9.2 percent of families having low income status. Thirty-eight percent of residents aged 15 and over have a post-secondary education (provincial numbers at 53.8 percent) and 36.4 percent had no post-secondary education. Average value of dwellings is $118,755. The employment rate for residents 15 years and over is 49.1 percent, and the unemployment rate is at 14.3 percent, provincial statistics sit at 56.8 percent and 10 percent respectively.

Figure 4: Nova Scotia Regional Map



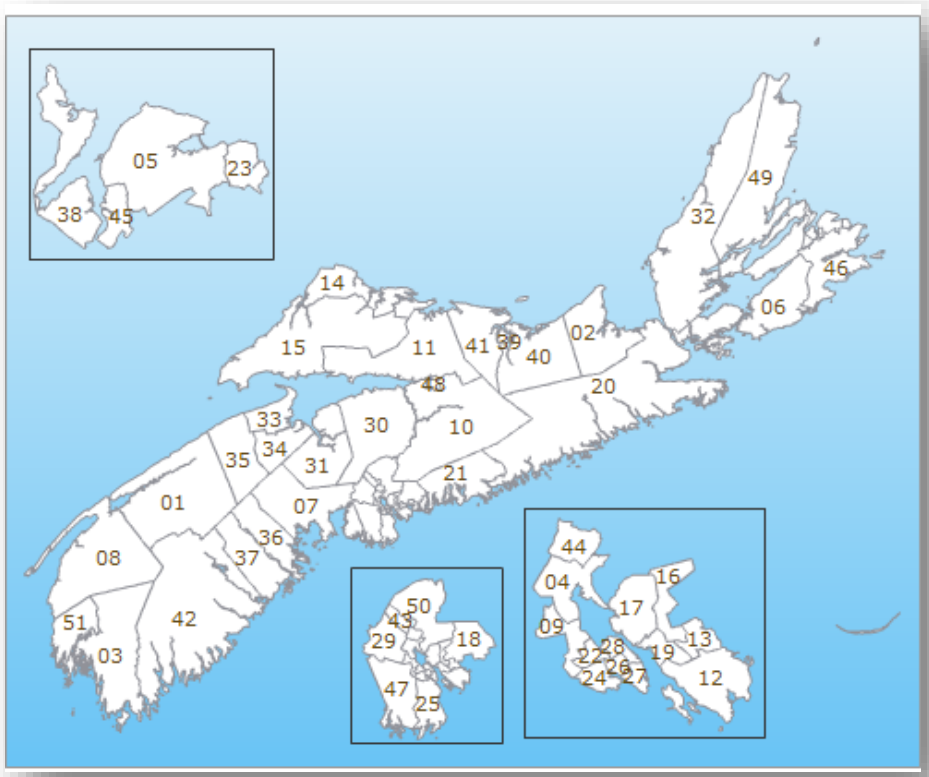
Source: NSBBA (n.d.)

Figure 5: Nova Scotia County Map



Source: NSE (2014e)

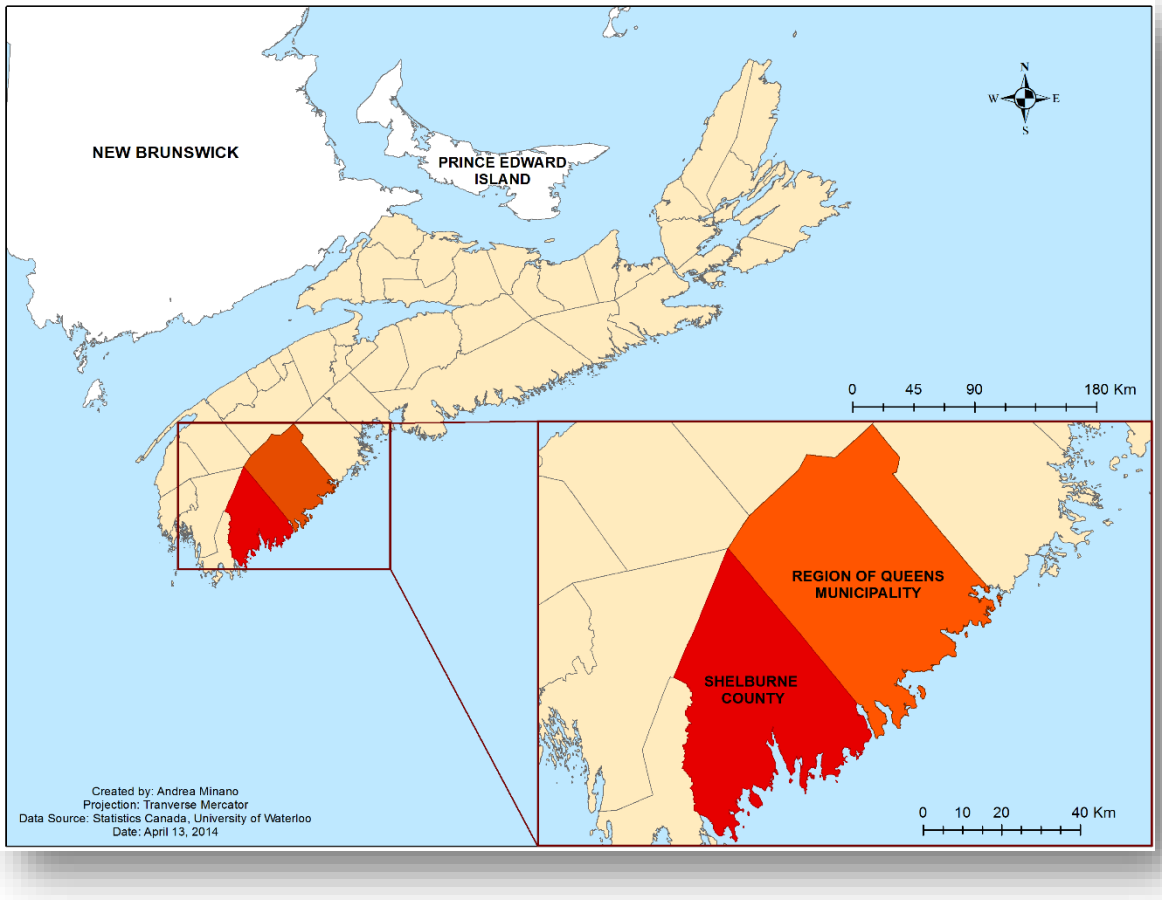
Figure 6: Nova Scotia's Electoral District Map



01 Annapolis
02 Antigonish
03 Argyle-Barrington
04 Bedford
05 Cape Breton Centre
06 Cape Breton-Richmond
07 Chester-St. Margaret's
08 Clare-Digby
09 Clayton Park West
10 Colchester-Musquodoboit Valley
11 Colchester North
12 Cole Harbour-Eastern Passage
13 Cole Harbour-Portland Valley
14 Cumberland North
15 Cumberland South
16 Dartmouth East
17 Dartmouth North
18 Preston-Dartmouth
19 Dartmouth South
20 Guysborough-Eastern Shore-Tracadie
21 Eastern Shore
22 Fairview-Clayton Park
23 Glace Bay
24 Halifax Armdale
25 Halifax Atlantic
26 Halifax Chebucto
27 Halifax Citadel-Sable Island
28 Halifax Needham
29 Hammonds Plains-Lucasville
30 Hants East
31 Hants West
32 Inverness
33 Kings North
34 Kings South
35 Kings West
36 Lunenburg
37 Lunenburg West
38 Northside-Westmount
39 Pictou Centre
40 Pictou East
41 Pictou West
42 Queens-Shelburne
43 Sackville-Beaver Bank
44 Sackville-Cobequid
45 Sydney-Whitney Pier
46 Sydney River-Mira-Louisbourg
47 Timberlea-Prospect
48 Truro-Bible Hill-Millbrook-Salmon River
49 Victoria-The Lakes
50 Waverley-Fall River-Beaver Bank
51 Yarmouth

Source: Elections Nova Scotia (2012)

Figure 7: Study Site Map



Source: Minano (2014)

Queens County is home to approximately 10, 960 residents, 6.5 percent lower than in 2006, and 22.5 percent of the population is over the age of 65. The primary language spoken at home for 99 percent of the population is English. The average household income is $51,471 with 12.4 percent of families having low income status. Forty-four percent of Queens' population aged 15 and over have a post-secondary education whereas 30.9 percent have no post-secondary education. The average value of dwellings is $118,344. The employment rate for residents 15 years and over is 45.9 percent and the unemployment at 11.1 percent.

Despite being a homogenous community in terms of culture, race and language, the community can be described as segregated because of various circumstances. Tourists are characterized by their short stays. However, once that stay lengthens indefinitely, these individuals are placed into another category by Atlantic Canadians (and some North-Eastern states in the US), called "come from away" (CFA) (Baldacchino, 2012). CFA refers to those who are not originally from an Atlantic Canadian community. In some cases, the term CFA also applies to individuals originally from Atlantic Canada that moved away at some point and since returned. While the term is not meant to be malicious or derogatory, it has brought into question feelings of exclusion by some considered a CFA (Baldacchino, 2012). The term CFA was unknown to the researcher and was brought up on several occasions both in formal and informal settings. Interviews were conducted with a mix of locals and non-locals, in which divide amongst these groups was both expressed by participants and observed by the researcher. During interviews, several participants not originally from the area (referred to as non-locals from hereon in) brought up the topic of CFA. This was often to share that they felt they were treated differently (in some cases poorly) because they are seen as an outsider.

Other factors that contribute to community division may be attributed to issues of class, income and education. For instance, tension was observed among community members who had different levels of education and status, in terms of how they were represented (i.e. thought of, spoken about, viewed as) by other community members. An interesting observation is that those viewed as CFAs are perceived to have an higher education and income levels, whereas locals were typified by others as low income, low education folk that were dependent on social assistance. Another feature that strongly contributes to the tension and lack of solidarity (in Shelburne specifically), is the political strife.

4.3 Political Profile

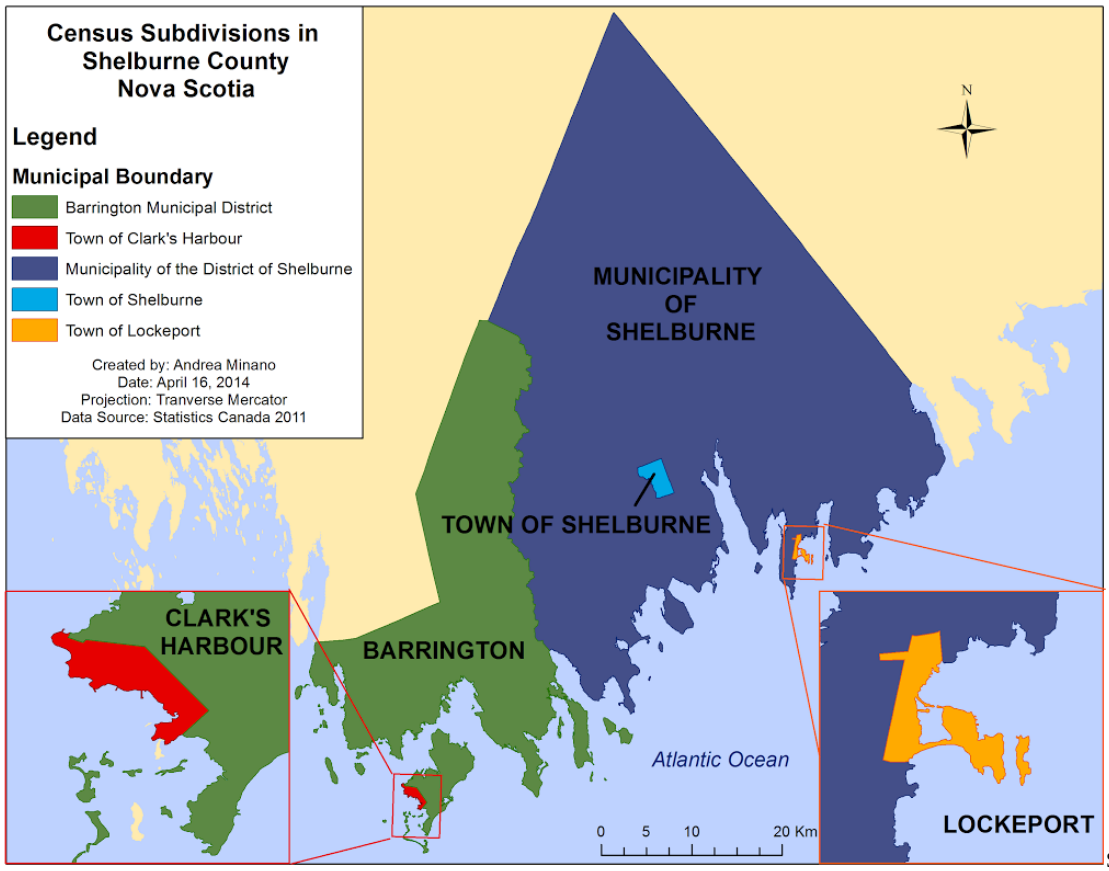
Shelburne County comprises five municipal units: Town of Shelburne, Municipality of the District of Shelburne (from here on in referred to as the Municipality of Shelburne), the Town of Lockeport, Town of Barrington and Village of Clark's Harbour (see Figure 8 for map). Each of these municipal units has its own mayor/warden and council. Within Shelburne County, only the Town of Shelburne, the Municipality of Shelburne and the Town of Lockeport are considered for this research due to resource constraints of the project.

The Town of Shelburne's constitution is made up of a mayor, deputy mayor, chief administrative officer and three councillors. The population of the town varies based on the source, sitting roughly at 1,400 according to the town office. The Municipality of Shelburne has a population of approximately 4,400 residents, which is overseen by a warden, deputy warden and five councillors. The Town of Lockeport is governed by a mayor, deputy mayor and three councillors and has less than 600 year round residents. Segregated by political boundaries, conflict and tension are high among municipal units and counties, often resulting in lack of cooperation, cohesion, communication and collaboration. There have been talks about amalgamating the Town of Lockeport, Town of Shelburne and Municipality of Shelburne over the years however, due to historical and present-day conflicts this had not come to fruition at the time of writing this thesis.

The towns and villages within Queens County voluntarily amalgamated to form the Region of Queens rather than facing a possible provincially imposed amalgamation. As a result, Queens County has one governing body since 1996, which is comprised of a mayor, deputy mayor and six councillors to support their seven electoral districts.

Table 4 illustrates that despite similar demography and land size, Shelburne County has a more complex and inflated political scenery in comparison to Queens County. Shelburne County has roughly 3,500 more people and 73 km² more land but has 22 more municipal staff. To add to the political tension within Shelburne, Queens and Shelburne each had their own electoral riding. However, after a reconfiguration in 2012, Queens and Shelburne are now represented by one electoral district, and the Town of Barrington and Clark's Harbour are now consolidated with Yarmouth County (see Figure 6).

Figure 8: Municipal Units of Shelburne County



Source: Minano (2014)

Table 4: Shelburne & Queens County Comparison

	Shelburne County	Queens County	Difference
Population (2011)	14, 495	10, 960	3,535
Land Area	2,465 km²	2,392 km²	73 km²
No. Municipal employees	30	8	22

4.4 Economic Profile

Nova Scotia's beginnings were founded in good-producing sectors, namely fisheries and forestry that invariably determined human settlement patterns, most notably in coastal regions. However, in recent years, service-producing sectors such as tourism are emerging as economic drivers for the province, but Nova Scotia routinely remains a "have not" province. The "have not" status is determined by provincial gross domestic product (GDP), in which less wealthy provinces receive equalization payments from the federal government. In 2012, Nova Scotia's GDP was $38,397 million, ranking it the seventh lowest out of the ten provinces (Statistics Canada, 2012). Nova Scotia's annual GDP has been on the decline over the last four years, representing approximately two percent of Canada's over all GDP.

For the South Shore, tourism is a prevalent industry, equalling $161 million annually, as it is home to the scenic Lighthouse Route that leads the way to a multitude of pristine, peaceful, picturesque beaches. Nova Scotia's tourism consists of accommodations, food and eating establishments, vehicle and local transportation, shipping, vehicle rental recreation and entertainment, groceries and commercial transportation fares. According to the GNS (n.d.b), accommodations are the main indicators for tourism activity in Nova Scotia, as licensed operators are required to submit monthly occupancy reports in accordance with the *Tourism Accommodations Act*. However, it is recognized that many operators are not licensed due to the higher cost and bureaucracy. Therefore, occupancy reports do not necessarily reflect an accurate portrait of Nova Scotia's tourism.

Nova Scotia's visitor economy is valued at $2 billion and contributes $722 million to the provincial GDP, which accounts for two percent of all provincial economic activity (GNS, 2010). Despite the significance of tourism for the province, it has been on the decline. Statistics show that 86 percent of the tourists are Canadians and 42 percent of those are from Nova Scotia alone, indicating a significant portion of tourism revenues are from within Nova Scotia's borders, as opposed to "new money".

Tourism is anticipated to be impacted by climate change, introducing new vulnerabilities such as beach erosion, drought conditions and floods, with the potential for saltwater and bacterial contamination, all of which can affect the quality and quantity of drinking water. However, climate change also presents new opportunities such as extended tourism seasons and new tourism products. For example, a recent climate study conducted by Colville & Reiger (2013) suggests the South Shore is a prime locale for growing certain crops, such as grapes and berries (discussed further in Section

4.5.1). These goods can create a niche market for agriculture, culinary, and/or wine tourism. Experiential tourism is also a hot commodity, allowing tourists to participate in unique experiences, such as fishing or clamming with local fishermen.

With most of the South Shore's major sectors on the decline (e.g. tourism, fisheries, paper mill and forestry), which has led to outmigration of youth, high unemployment and dependence on social assistance, the region is grappling to find new sources of revenue. For instance, Bowater Mersey Paper Mill operated in Queens County for over 80 years, employing hundreds of residents, and was regarded as the "lifeblood" of the region until it was shut down in 2012 (Bundale, 2012). The South Shore continues to seek new opportunities to bolster its economy through exploring various enterprises, such as aquaculture (which has generated controversy in the community - see Appendix B), gas extraction/exploration, mink farming (see Appendix C) and deep water oil exploration, all of which have the capacity to have adverse social and environmental consequences, including adverse impacts on water resources.

4.5 Biophysical Profile

This section outlines the key biophysical features of the study site, such as the soil and bedrock, water resources, climate as well as climate change impacts and scenario data.

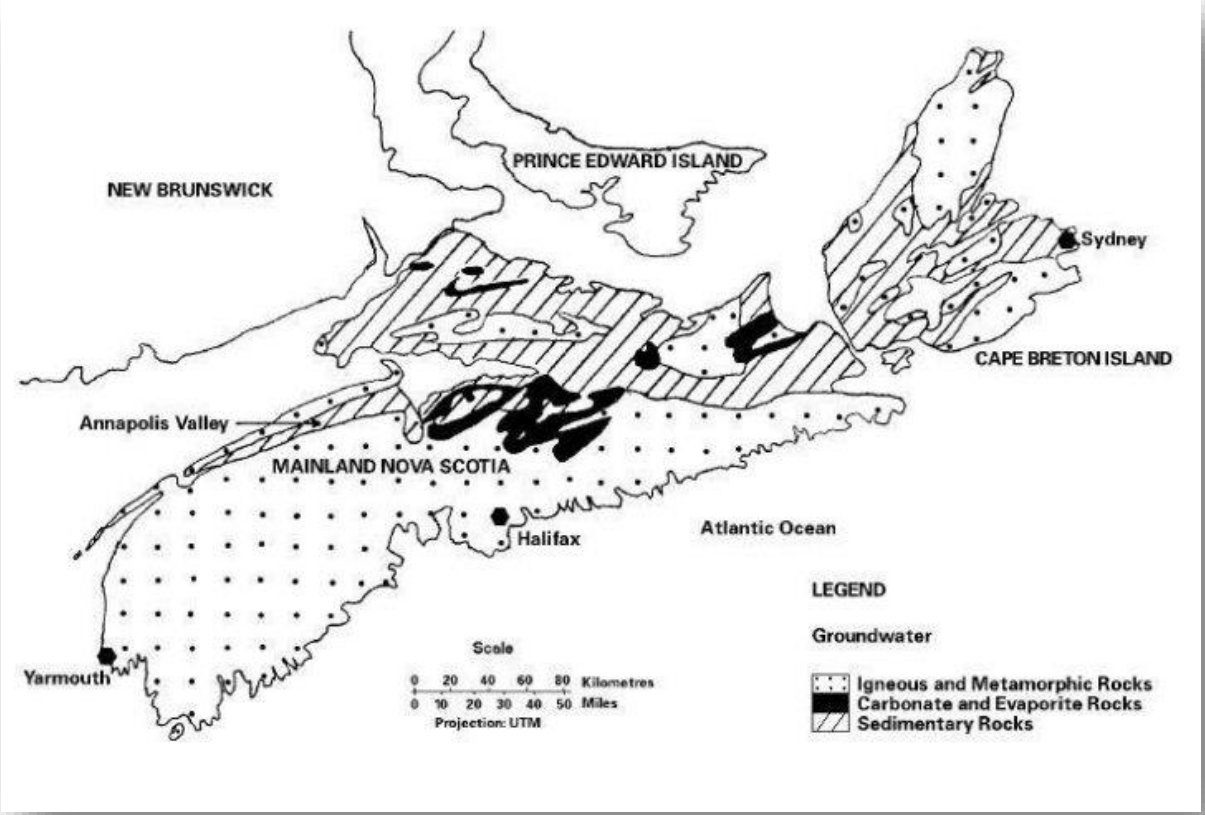
4.5.1 Bedrock and Soil

The bedrock formation in Queens and Shelburne is dominated by metamorphic rocks (see Figure 9), specifically slate, quartzite and granite (NSE, 2014b; Porter, 1982). Metamorphic rocks are generally poor aquifers because they are only permeable if they are disturbed through fracturing, and even then, they may only yield small quantities of water at a time, particularly as there are limitations with how deep they can be drilled. As a result metamorphic rocks can lack the capacity to store and generate sufficient water supplies, and in some cases act as flow barriers (USGS, 2013). A characteristic of granite, alkaline sandstone, and shale bedrock is its capacity to hold high concentrations of uranium. As such, much of the soil and bedrock in Queens and Shelburne (as well as the rest of the province), has naturally occurring arsenic and uranium (NSE, 2014c; NSE, 2014d).

Shelburne and Queens only hold one percent of total cultivable land in Nova Scotia due to the lack of arable soil, the least of any other county in the province (Devanney, 2010). As referenced in Section 4.4, a recent climate study by Colville and Reiger (2013) measured and monitored the

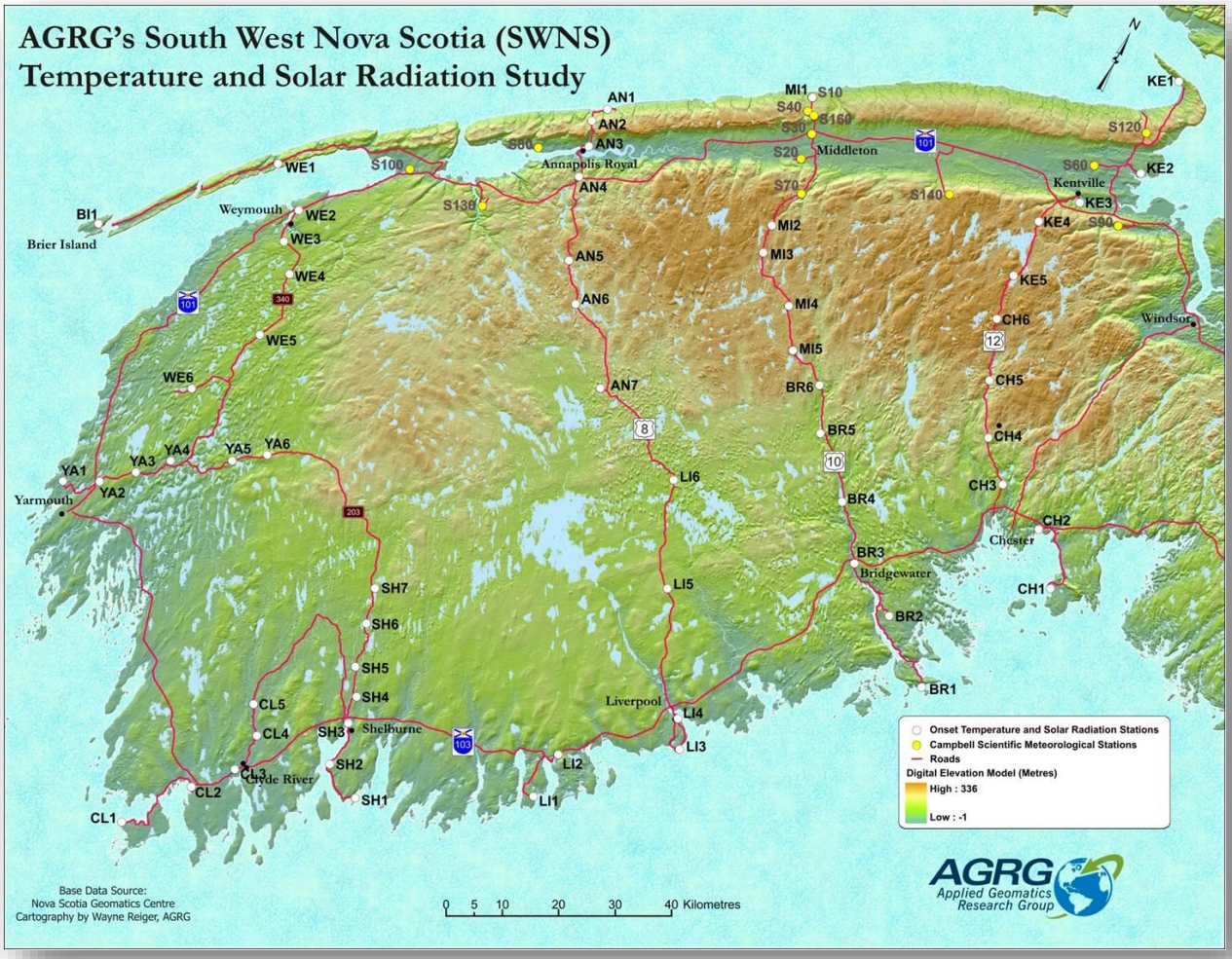
temperature, number of frost free days, and the amount of solar radiation received in 72 sites in the western half of Nova Scotia for 2011, 2012 and 2013 (see Figure 10). Key findings of the study concluded that the South Shore is comparable if not superior to Annapolis County (which is regarded as the gold standard for agriculture in Nova Scotia) for growing certain high value crops such as high-bush blueberries, grapes, and peaches.

Figure 9: Groundwater Regions of Nova Scotia



Source: NSE (2014a)

Figure 10: Nova Scotia Climate Study Sites



Source: Colville & Reiger (2013)

4.5.2 Water Resources

The counties of Shelburne and Queens have many freshwater systems such as lakes, rivers, streams and creeks (NSE, 2014e.). Despite the rich set of water resources, Porter (1982) documented over 30 years ago, the frequent water shortages for the towns and villages in Southwestern Nova Scotia. In terms of water quality, natural characteristics of the surface waters in Nova Scotia tend to be generalized across the province as being soft with "high color, low pH, low alkalinity, low turbidity, low conductivity" (NSE, 2010a, p. 7). NSE (2010a) also suggests that the metal concentrations found within the surface waters are typical of the area of the province. Moreover, many of the lakes have high organic matter such as tannins, which leads to discolouration (NNN, 2006). As a result, these lakes make for poor drinking water sources, as they are more susceptible to bacterial contamination, and thus, require more aggressive treatment. Additionally, the province's lakes generally have high levels of iron and manganese, both of which yield an unpleasant odour and taste (Porter, 1982).

While the province has attempted to inventory and assess its water resources (which can be found on Nova Scotia Environment's website under their "Water Resource Reports and Maps"), much of the data were written in the 1960s and 1970s. Only one report is listed for Shelburne, which examines one small area within the county written in 1982 (NSE, 2014e.). For Queens County, the only information listed is a three page summary report written in 1977, which details the issues with Liverpool's water utility at that time. Recent data on the health of lakes and river systems for the South Shore (and other parts of the province) prove to be scarce. However, related water studies in neighbouring counties and one in Shelburne County were conducted by Nova Scotia Environment (NSE) in recent years, discussed further in Section 4.6.2.2.

Nova Scotia's waterways were once protected by the *Navigable Waters Act*, which since 1906 required that any water body that can float a canoe, needs an environmental assessment conducted before any development projects can be initiated. However, in 2012 the federal government amended Bill C-45, which removed this condition. This translated to 99 percent of Nova Scotia's waterways no longer being protected (CBC, 2012). Critics fear the implications for water systems are that development projects (e.g. pipelines) can occur without public notice or appropriate approval (CBC, 2012).

4.5.3 Climate

With its close proximity to the Atlantic Ocean, Nova Scotia's weather is quite variable, but is moderate compared to other parts of Canada (see Table 5 for the average temperatures by season). Residents often refer to the South Shore as the "banana belt", as it is known to have a temperate climate compared to the rest of the province.

Table 5: Nova Scotia's Average Temperatures by Season

Season	Past Average Temperatures	Current Average Temperatures
Spring (mid-March – mid June)	2° to 9° C	0° to 20° C
Summer (mid June – mid September)	16° to 24° C	20° to 25° C
Fall (mid-September – mid December)	18° C	0° to 20° C
Winter (mid December – mid March)	-3° C	0° to -15° C

Source: GNS (n.d.a) & GNS (2006)

4.5.4 Climate Change Impacts and Scenario Data

Section 4.5.4 (as well as Sections 4.6.2 and 6.2), address the fourth research objective by summarizing the general conditions related to climate change and the impacts on water resources for the study site. Climate Change Nova Scotia (2014) is a division of Nova Scotia Environment that is responsible for creating climate change mitigation and adaptation policies, as well as promoting climate change education and awareness. The province hired a climate consulting firm (Richards Climate Consulting) to prepare climate change scenario data and projections for the province, which examined 22 municipalities (Richards & Daigle, 2011). No communities within Shelburne County were included in this study, however, Liverpool was one of the 22 municipalities examined in the study. Therefore, the data presented in this section is for Liverpool, but can be generalized for Shelburne due to the geographical similarities and proximity.

Based on historical temperature data from the 1980s, Table 6 shows that a temperature increase of almost 1°C by 2020, 2.4°C by 2050 and a 3.6°C increase by 2050. Table 7 reveals that annual precipitation (i.e. snow, rain, drizzle, freezing rain, hail) is expected to increase for Liverpool by 45 millimetres by 2020 (based on 1980s data), 59 millimetres by 2050, and up to 110 millimetres by 2080. However, more precipitation does not necessarily translate to more water, as warmer temperatures will likely lead to greater evaporation rates, which have the capacity to exceed precipitation rates (Vasseur et al., 2007). Appendix D contains the full climate change dataset scenarios for Liverpool.

The greatest climate change impacts projected for the study site are coastal and inland flooding due to storm surges, increased precipitation and sea level rise. Storm surges, which include extreme weather related events such as hurricanes, severe rain and snow storms, have already begun damaging property (e.g. homes, businesses, buildings) and infrastructure (e.g. roads, water lines) in Shelburne and Queens (RoQ, 2014). Temperature rise may also increase conditions for droughts and wildfires (RoQ, 2014; Tipton, 2014). As Section 2.2.1 discusses, both flood and drought conditions also have the capacity to adversely affect drinking water resources (e.g. water shortages, saltwater intrusion and bacterial contamination). Climate change impacts on water resources for Shelburne and Queens is described in Section 4.6.2.

Table 6: Temperature Patterns and Projections for Liverpool, NS

Season	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Winter	-3.2°C	-1.9°C	-0.5°C	1°C
Spring	5.3°C	6.4°C	7.5°C	8.6°C
Summer	18°C	19.1°C	20.3°C	21.4°C
Autumn	9.4°C	10.5°C	11.7°C	13°C
Annual	7.4°C	8.5°C	9.8°C	11°C

Source: Richards Climate Consulting, 2011

Table 7: Precipitation Patterns and Projections for Liverpool, NS

Season	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Winter	502.3 mm	526.7 mm	539.3 mm	568.7 mm
Spring	424.1 mm	438.2 mm	444.5 mm	461.9 mm
Summer	287.2 mm	292 mm	291.1 mm	291.5 mm
Autumn	433 mm	438.3 mm	437.6 mm	447.5 mm
Annual	1646.7 mm	1691.9 mm	1705.9 mm	1756.5 mm

Source: Richards Climate Consulting, 2011

4.6 Drinking Water

This section describes the consumption patterns, drinking water threats, background context with respect to municipal and well water sources, and the governance context for drinking water.

4.6.1 Consumption

A typical Nova Scotian household consumes 700-1,400 litres of water per day, or approximately 328 litres per person per day according to NSE (2014a). This is on par with the national average. Furthermore, residents can extract up to 23,000 litres per day without requiring a permit. In Shelburne and Queens, drinking water is supplied both from municipal and private well sources.

4.6.2 Threats

4.6.2.1 Climate-Related Threats

Climate change is recognized by Government of Nova Scotia as a key issue and has identified coastal regions and fresh water resources as two areas of concern that will be significantly affected by climate change impacts (NSE, 2011). Freshwater is already being impacted by saltwater intrusion due to erosion, flooding and drought conditions, leading to shortages (NSDE, 2011). Coastal zones are susceptible to saltwater intrusion if water tables decrease and sea level rises, contaminating water sources with saltwater, and therefore, making it undrinkable. Section 2.2 offers greater context on the impacts climate change can have in coastal areas.

Contrary to NSE's projections, Ferguson and Beebe (2012) suggest that while climate change impacts have the potential to cause saltwater contamination in coastal aquifers, precipitation variability and sea level rise are not likely to have major impacts on water quality. However, they do suggest groundwater extraction is likely to cause saltwater intrusion. Yet, in a separate study, Beebe (2011) reveals that significant saltwater intrusion will likely not be an issue even with intensified groundwater extraction. It is notable to point out Ferguson and Beebe's study is specific to Pugwash and Wolfville, located in the north-central part of the province. These findings may not be reflective of Shelburne and Queens, as several respondents have already reported issues with saltwater intrusion. Regardless, there is a lack of empirical research to assess the situation, and as Ferguson and Beebe (2012) conclude, most regions in the province do not have adequate groundwater management plans. Therefore, they suggest greater emphasis should be placed on geological and groundwater resource mapping to necessitate assessments and inventories of available resources.

Flooding is another issue of concern given that frequent and intense weather events, such as hurricanes and heavy rainstorms are expected to increase (Doll, 2009). Flooding will not just be restricted to summer months, but will likely extend to winter seasons (NSDE, 2011). For instance, warmer winters are being experienced with less snowfall and received snowfall is not likely to remain or accumulate on the ground due to warmer temperatures. Moreover, flooding is particularly problematic for groundwater users, and even more so for wells in close proximity to agriculture lands and septic tanks, as effluence can lead to contamination. While projected climate models for the region indicate higher precipitation rates, hotter days are also anticipated, leading to higher evaporation rates (Vasseur et al., 2007). Furthermore, intense storms are anticipated, which will not

only cause erosion, but can also decrease soil water absorption, affecting aquifer replenishment rates. As a result, lowered water tables are likely to result in water shortages (NSDE, 2011). Water shortages have the potential to have detrimental effects in all sectors such as tourism, agriculture as well as having social and health implications as water is a necessity. One response to climate change in Nova Scotia was the province mandating that municipalities prepare Municipal Climate Change Action Plans (MCCAPs). MCCAPs were required to be submitted by December 31, 2013, which asked municipalities to outline their adaptation plans (CNSIS, 2012). The government provided a variety of tools to assist municipalities in preparing the MCCAPs (e.g. guidebook, risk assessment spreadsheet and workshops). Further discussion on MCCAPs is also offered in Section 5.4.3.

In reviewing the MCCAPs for the four municipalities within the study site, it did not appear that a standard template or format was required to be used. Therefore, each municipality presented their findings in different ways. Table 8 attempts to summarize the risk of climate change impacts on drinking water sources based on the information provided in the MCCAPs. Bacterial contamination is listed as a potential climate change impact in Table 8, because as Section 2.2.1 mentions, warmer temperatures are likely to increase conditions for bacterial growth. The Town of Shelburne (2014) used a flood hazard impact matrix, and ranked the impacts of flooding on drinking as high. Queens has identified a medium risk for drought conditions to affect potable drinking water, low risk for saltwater intrusion and a medium risk for forest fires to contaminate water sources (note - increase of forest fires is ranked as high) (RoQ, 2014). The Municipality of Shelburne did not elaborate on private or public drinking water as it states it is "not responsible" for drinking water (Tipton, 2014). Lockeport's acknowledges the climate change impacts to drinking water, but did not provide a ranking. However, given the findings of this research and existing documentation and data (including the MCCAP) the impacts to drinking water is estimated as a high risk.

Table 8: Summary Climate Change Impacts on Drinking Water for Study Site

Location	Bacterial Contamination	Saltwater Contamination	Drought/Shortages
Lockeport	Significant potential but not ranked – estimated as High	Significant potential but not ranked - estimated as High	Significant potential but not ranked – estimated as High
Queens	Medium (due to forest fires, forest fire is high risk)	Low	Medium
Town of Shelburne	High (due to flooding)	High (due to flooding)	
Municipality of Shelburne	Not evaluated – estimated as Medium to High	Not evaluated – estimated as high for wells in close proximity to coastlines	Not evaluated – estimated as High for dug wells

4.6.2.2 Non-Climatic Threats

There are also a number of non-climatic threats that have the potential to reduce water security for the area. These include oil contamination (e.g. from leaking gas stations and vehicle accidents - discussed further in Section 5.3), as well as mink and fish farming, which in some cases are already a cause for concern. Mink and fish farming are out of scope for this analysis, however, Appendix B and Appendix C offer a more in-depth profile on these activities within the context of the study site.

4.6.3 Municipal Water

4.6.3.1 Region of Queens Water Utility

The municipal water source for the Region of Queens' (RoQ) is Town Lake, which is located in the town of Milton and managed by RoQ. The RoQ serves 1,100 households and businesses in Liverpool and Brooklyn areas (RoQ, n.d.), however, not all residents and businesses are on municipal supply. The original water utility was built in 1899. Surveys conducted in the 1960s and 1970s describe the water quality as "extremely poor" (Cameron, 1977). Additionally, the town engineer in 1967 revealed "the town of Liverpool has been experiencing a water supply and quality problem which has become particularly acute within the last year or so", but a response or follow-up study was not conducted until 1974, seven years later (Cameron, 1977, p. 2). In response, the local engineer constructed a public town well in 1973, funded by a government grant (see Figure 11). While problems with the water utility were known since the 1960s, the utility was not replaced until 2008. The cost of the new water utility was $7 million, which was equally split by all three levels of government. Despite the new facility, the town is forced to keep the public well in operation (which can be accessed by anyone free of charge) due to residents' perceptions and preferences (discussed in more detail in Section 5.4.2.5). The public town well yields 65,000 gallons annually, and costs the RoQ $2000/year to operate and maintain (personal communication with RoQ Engineering Department, 2014).

Figure 11: Queens' Public Town Well

Source: Saveena Patara (2014)

4.6.3.2 Town of Shelburne Water Utility

The Town of Shelburne's water utility is sourced from George Lake. The water utility was originally constructed in the early 1970s to support a naval base. Initially, the utility was managed by the province, but after talks about building malls in the area a decision was made to devolve the facility to the town, which occurred by the mid-1970s. Since then the town has owned and operated the water utility, which currently supports 312 customers. However, the number of town residents and businesses on municipal water is minimal, as the utility's infrastructure only extends a few blocks within the town limits. The majority of the customers are from the Municipality of Shelburne (e.g. high school, hospital, retirement home, as well as other residents and businesses). Yet, the infrastructure, operating and maintenance costs are all assumed by the Town of Shelburne.

In 2009, town council proposed to the Nova Scotia Utility Review Board (NSURB) a new water line extension. Approval was granted on the basis the town would supply water for an additional 86 homes and 33 commercial customers, at a cost of $1,179,098, of which $393,032 was the utility's

responsibility (NSURB, 2014). However, in April 2010, additional funding was requested by the town in the amount of $1,015,046, to be funded by debt. The project completed in the Fall of 2010 at a total cost of $1,999,830, of which $378,325 was federal monies, $543,890 provincial, $1,007,091 utility debenture and $70,524 in cash (NSURB, 2014). In the end, the utility only received 19 new residential customers and two commercial customers. The utility also lost a major customer during this time (a fish processing plant that closed down). Figure 12 shows the businesses and residents on municipal water. As a result, the town is in debt to the amount of $750,813 and without a rate increase to customers, the town anticipates the utility will continue to accumulate an operating deficit. The request for a rate increase was submitted to NSURB and approved in 2015.

4.6.3.3 Lockeport Water Utility

The Town of Lockeport is an island surrounded by the Atlantic Ocean and is attached to mainland Nova Scotia via 12 foot gravel road. The town's water utility is located on the mainland with underwater pipes to the island. The source water is supplied by Hayden Lake. The water utility was initially established by the provincial government to boost Lockeport's economy, namely to support the fish processing industry. The utility is still owned by the province and is currently operated by the department of Transportation and Infrastructure Renewal (TIR). The facility was never intended to support a residential drinking water system, but over the years the high school, post-office and various other businesses and residents have connected to the water utility. It is not clear as to why other businesses and residents were able to connect to the source. At present, the Lockeport facility supports roughly18 customers, most of which are businesses. The province has been attempting to devolve all water utilities operated by the province to their respective towns. This has been met with resistance by the town of Lockeport given the cost, human resources, knowledge, experience and expertise required for maintaining and operating a water plant. Additionally, the facility is experiencing a number of problems such as source water quality and supporting infrastructure, discussed in depth in Chapter 5.

Figure 12: Shelburne businesses & residents on municipal water

Source: Saveena Patara (2014) – taken at town office

4.6.4 Well Water

Many rural communities get their primary source of drinking water from their own private wells (dug, drilled or artesian), which is generally fed by groundwater. Therefore, groundwater is particularly vital in rural areas (Doll, 2009). Dug wells are shallow holes that historically were mined by hand with a shovel until the water table was intercepted. As digging below the water table is difficult, the depth of a typical dug well is generally no more than 30 feet. Wells are lined with casing to prevent collapse and are covered with a cap of some sort, usually made from concrete, stone or wood material. Given the shallow depths, dug wells are susceptible to contamination, as well as depletion during dry conditions (GNB, n.d.).

Drilled wells are constructed by drilling a hole with machinery through impervious layers until it intersects with bedrock fractures that contain groundwater. The upper part of the well is lined with casing to prevent the well from collapsing and to prevent surface and subsurface contaminants from entering. The casing also serves as a home for the pumping mechanism. Artesian wells are also deep, drilled wells except that water is received from higher altitude so there is pressure to force water flow upwards. Figure 13 provides a pictorial illustration of both shallow and deep wells. Most modern day wells (dug or drilled) have water automatically pumped out of the ground with the use of a water pump, which operates on electricity.

As with most Canadian jurisdictions, private well owners are responsible for managing, maintaining, monitoring and testing their own water supplies. According to the province's well logs (NSE, 2014f accessed October 2014), there are 2,114 wells in Shelburne County and 2,492 for Queens County, which includes both inactive and active wells. It is also up to owners to research, purchase, install and maintain some sort of water treatment system. Common filtration systems include UV filters, water softener, and reverse osmosis. The responsibility of getting water tested for bacterial and chemical contaminants also rests with well owners. Water quality issues are generally characterized by bacterial and chemical features.

Bacterial contamination can pose serious health threats including death. Coliforms are the most present form of bacterial contamination, which are bacteria that are naturally present in the intestines of warm-blooded animals, including humans as well as in soil and plant material (EPA, n.d.). Water can be contaminated with coliform due to pollution (e.g. livestock, wildlife or pet effluence that makes its way into water systems). Most coliform is not deadly but a particular strain of it can have

serious health issues. Most basic water tests scan for total coliform bacteria, and anything above a zero count for 100 millilitres is considered unsafe to drink by Nova Scotia Environment's (2014g) standards. Collection and handling of the water sample can affect the accuracy of the test results if proper procedures to avoid sample contamination are not followed.

With respect to chemical contamination, some substances such as iron and manganese, can be easily detected due to odour and taste, whereas other elements such as arsenic and uranium are only detectable through testing. Figure 14 reveals that most of Nova Scotia's groundwater supplies are naturally high in arsenic, in some cases approximately 100 times above the water quality guidelines (Gibbons & Gagon, 2010). There is also naturally occurring uranium found in Nova Scotia's groundwater (see Figure 15). Minerals containing uranium and arsenic can be dissolved by groundwater, which then can leach into drinking water supplies. Drilled and artesian wells are more susceptible to uranium and arsenic contamination than shallow wells or surface waters because it penetrates deeper into the earth's surface (NSE, 2014d). Uranium and arsenic are both known to have health effects (e.g. nausea and diarrhea) and in some cases severe implications (e.g. cancer), even at low levels, but is dependent on other factors such as length of exposure and amount consumed. There are a number of methods to treat water with elevated levels of arsenic and uranium, such as reverse osmosis and distillation (NSE, 2014c; NSE, 2014d).

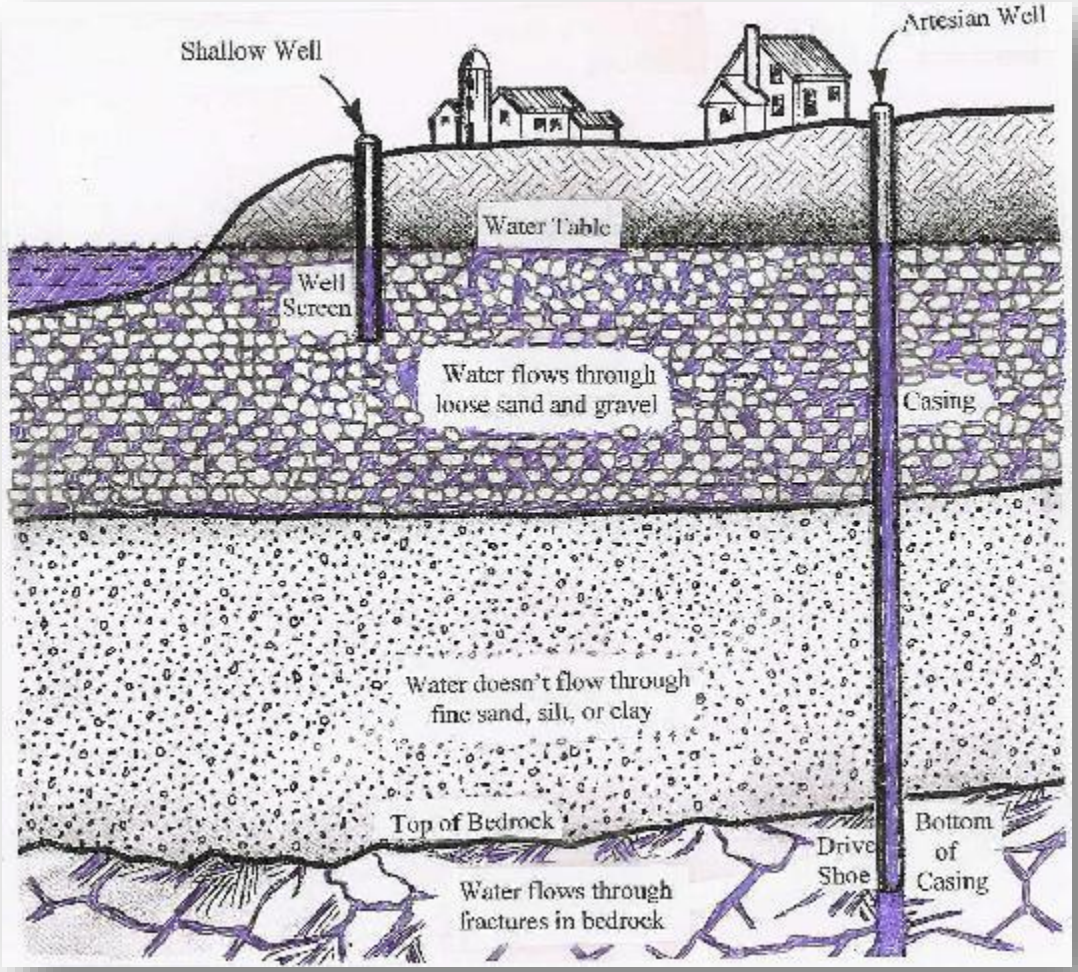
Other natural occurring substances that impact water quality for the area include, chloride, hardness, iron, manganese, radionuclides, radon and sulphate, which is often a direct reflection of the bedrock of where the well is drilled. While not harmful, but more noticeable due to strong taste and odour, are iron and manganese, both of which are prevalent in Nova Scotia's groundwater sources (Porter, 1982). Chloride issues may also be common in wells that are in close proximity to the ocean (NSE, 2014a). Table 9 provides a comprehensive list of common water quality problems in Nova Scotia and their causes.

Table 9: Common Water Quality Substances, Causes and Problems

Substance/Cause	Problem
Coliform bacteria	Health problems
Hardness	Hard scaly deposits in kettles and piping, bathtub ring, soap scum, high soap consumption
Iron	Red or orange stains on laundry or fixtures, metallic taste, rust particles after water sits
Manganese	Black stains on laundry or fixtures, metallic/bitter taste in coffee and tea
Iron bacteria	Red to brown slime in toilet tank, iron staining, unpleasant taste or odour
Low alkalinity	May cause corrosion of piping (green stains due to copper corrosion)
Hydrogen sulphide and/or sulphate-reducing bacteria	Rotten egg odour and flavour, silverware may turn black, worse in hot water
Turbidity	Cloudy, dirty or muddy appearance
Sodium	High blood pressure
Chloride	Salty taste, corrosive
Sulphate	Laxative effects
Arsenic	Health problems
Uranium	Health problems
Gasoline and/or oil	Oily smell or film on water
Nitrate	'Blue babies' in formula-fed infants under 6 months

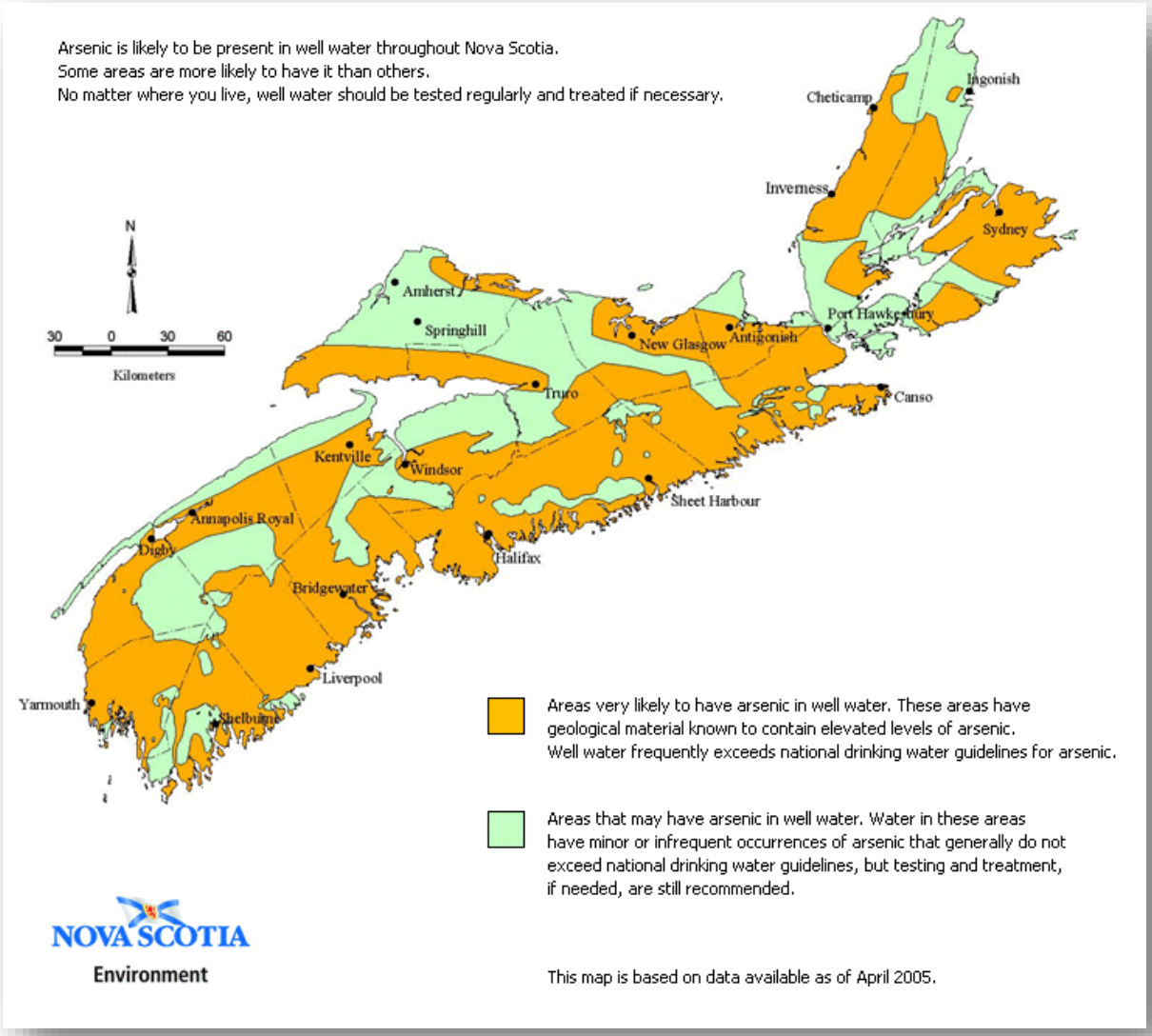
Source: NSE (2014b)

Figure 13: Deep and shallow well illustration



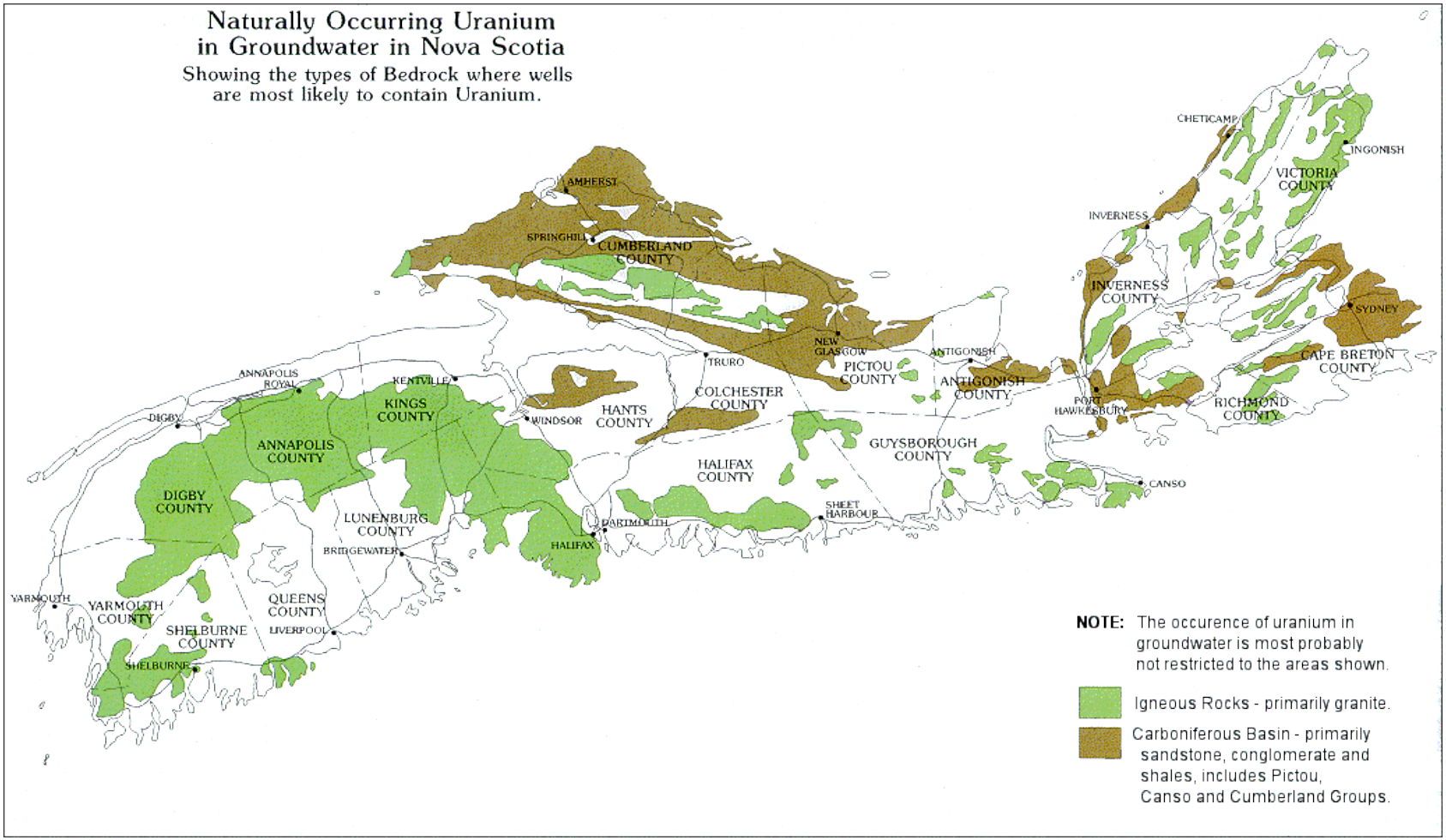
Source: Well Water Connections (2014)

Figure 14: Naturally occurring arsenic in Nova Scotia groundwater



Source: NSE (2014a)

Figure 15: Naturally occurring uranium in Nova Scotia groundwater



Source: NSE (2014a)

4.6.5 Drinking Water Governance

According to Cervoni et al. (2008), there is little research when it comes to examining local capacity building for water management in Atlantic Canada. Moreover, Nova Scotia's lack of capacity to manage water resources is producing unfavourable socio-economic and ecological impacts, as there is no integrated approach (Timmer et al., 2007; Willcocks-Musselman, 2005 as cited in Cervoni et al., 2008). For instance, Nova Scotia's public water resources are fragmented, as they are managed at municipal, provincial and federal levels, to which even the GNS (2010) agrees creates complexity and redundancy.

One of Nova Scotia's first pieces of water legislation was passed in 1919 with the *Water Act.* The act guarantees that water is a public resource and allows the province to address emerging issues with respect to water requirements for municipal and industrial purposes (NSE, 2010b). In 1963, the Water Authority was established, which was later replaced by the Water Resources Commission in 1968. During this time, these establishments made efforts to manage water pollution, institute wastewater standards and begin focussing on standards for wells. In 1973, the *Environmental Protection Act* was passed that also led to the development of the Nova Scotia Environment (NSE) department, which replaced the Water Resources Commission as the new authority on water management in Nova Scotia.

The next major water act was not passed until 1995 with the *Environment Act*, replacing the *Water Act.* The *Environment Act* granted NSE as the primary authority for water resources in the province. NSE is responsible for the management and allocation of water resources, as well as charging money for water use. In 2000, the *Water Resource Protection Act* was passed to prohibit the removal of bulk water and in 2002, *A Drinking Water Strategy for Nova Scotia* was established to help improve municipal and public drinking water protection.

In 2007, a commitment was made to have a comprehensive water strategy by 2010 under the *Environmental Goals and Sustainable Prosperity Act.* This water strategy was led by NSE through an interdepartmental water management committee, which involved public engagement and consultation with various stakeholders. The final product from this three-year engagement was the *Water for Life: Nova Scotia's Water Resource Management Strategy*, a ten year roadmap for water management in Nova Scotia, which advocates for change in four areas (NSE, 2010b). The first objective is to adopt an Integrated Water Resource Management (IWRM) approach to managing water resources by capturing human activities and their impact to watersheds and ecosystems, as well

as to ensure sustainability. The second area of focus is to gain a better understanding of both the quality and quantity of water. The third objective is to enhance the protection of water quality and quantity. The fourth and last goal of this strategy is to ensure citizens are engaged in water and water related issues. There is also a commitment to publish annual progress reports.

According to the NSE, it has taken many initiatives to both understand the impacts of climate change, as well as identify and implement strategies to adapt to the anticipated effects. The following is a sampling of these initiatives: funding research (e.g. Climate Change Nova Scotia); publishing information for well owners (e.g. "A Guide for Private Well Owners"); providing water testing guidelines; establishing programs (e.g. "Become a Water Steward in your Community"); and assisting with conservation efforts such as wetland restoration.

Governance initiatives such as engendering and promoting learning and awareness on various environmental issues have also occurred through NGOs. In particular, the Ecology Action Centre (EAC) based out of Halifax since the 1970s, has been instrumental to this goal, as it aims to hold industry and governments accountable through monitoring and evaluation initiatives. For instance, in response to NSE's 2013 annual progress report, the EAC (2014) highlights key objectives not being met by NSE, such as prevalent blue-green algal blooms and lack of zoning by-laws for new development.

4.6.5.1 Water Utilities

There are currently 60 water utilities in the province of Nova Scotia, which are governed by the Nova Scotia's Utility Review Board (NSURB) and Nova Scotia Environment (NSE). The province has adopted the *Guidelines for Canadian Drinking Water Quality* to be a legally binding standard for regulating public drinking water facilities (NSE, 2014k). Water utilities are typically owned and operated by municipalities or an independent Commission. NSE is responsible for monitoring and regulating water facilities. The NSURB is responsible for "setting of rates, tolls and charges, regulations, fire protection charges, rates and regulations for the provision of service and approval of capital expenditures in excess of $250,000" (NSRUB, n.d.a). NSURB (n.d.a) is also accountable for addressing complaints or any other matters that it deems necessary in order to fulfill its mandate.

Rates are typically determined by each individual utility, but must be in accordance the *Public Utilities Act* and must be approved by NSURB. NSURB has published a *Water Utility Accounting*

and Reporting Handbook to assist water utilities with setting rates. Any rate reviews must first be presented and approved to municipal council before it is submitted to NSURB, along with other required documents justifying the rate increase. Before NSURB can make any decisions, it must elicit stakeholder feedback by arranging a public hearing, which is generally within 8-10 weeks. The water utility is required to advertise the public hearing notice in local newspapers and incurs all associated costs. A decision by NSURB is typically made at the public hearing (NSRUB, n.d.b.).

4.6.5.2 Well Water

Almost half of Nova Scotians get their water supplies through private wells, which well owners are responsible for protecting and treating (NSE, 2014h). NSE's (2014i) role with respect to private wells is to: 1) provide information on groundwater quality and quantity in Nova Scotia; 2) regulate the construction and maintenance of water wells; and 3) regulate groundwater withdrawals exceeding 23,000 litres/day.

Water testing guidelines are provided for homeowners. However, it is not required, regulated or monitored by the government; it is only a guideline. Public drinking water supplies on the other hand, are legally required to get their water tested regularly in accordance with the *Water and Wastewater Facilities and Public Drinking Water Supplies Regulations* and the *Guidelines for Monitoring Public Drinking Water Supplies*. A public drinking water supply is defined by the NSE (2014l, para. 1) as:

> A water supply system, including any source, intake, treatment, storage, transmission or distribution, that is intended to provide the public with potable, piped water and that:
>
> i. has at least 15 service connections,
> ii. regularly serves 25 or more persons per day for at least 60 days of the year, or
> iii. serves any of the following for at least 60 days of the year:
>
> A. a day care facility licensed in accordance with the Day Care Act,
> B. a permanent food establishment licensed in accordance with the Health Protection Act,
> C. a commercial property for the accommodation of the travelling or vacationing public comprising land used for camping or for overnight parking of recreational vehicles or containing a separate building or buildings containing at least 1 room to be used as an alternate form of accommodation in a campground,
> D. a commercial property for the accommodation of the travelling or vacationing public containing more than 4 rental units, including cottages or cabins.

Parts iii B, C and D are applicable to the research's sample population. Regulations require that bacterial testing be done every three months (or four times a year), which requires submitting a sample to an authorized laboratory (generally a local hospital). A chemical test is also required every two years. At the time of writing, the only facility that is equipped to perform chemical testing in Nova Scotia is a laboratory located in Halifax. To ensure public supplies are complying with this regulation, they are audited every three years by NSE, in which owners are required to produce their water test reports for the past three years. Failure to do so may result in a $693.95 fine pursuant to *Schedule 9 and 9a of the Summary Offence Tickets Regulations*, and multiple offences can result in other forms of prosecution (NSDJ, 2014). Such compliance monitoring only occurs for registered businesses, even though there are many unlicensed accommodations operating within the province.

Additionally, in 1965, the province implemented the Nova Scotia Groundwater Observation Well Network, which is a provincial monitoring system that observes groundwater levels and chemistry through a series of wells throughout the province. The system is used to monitor groundwater quantity and quality, assess the effects of human activities on groundwater, and to gauge long-term patterns such as climate change (NSE, 2014j). There is only one observational well in Shelburne, established in 1988, and none in Queens. This monitoring program mainly serves as an information system rather than for regulation.

4.7 Summary

Chapter 4 provides a study site characterization. The social and demographic profiles reveal that the study site has a declining and aging population with low or fixed income, and post-secondary education is not prevalent. The political landscape reveals an inflated municipal government for Shelburne County that is characterized by a history of conflict and tension among municipal units. From an economic perspective, fisheries and tourism are two of the dominant sectors within the region, both of which are in decline and contributing to increasing unemployment and poverty rates. The environmental landscape of the area reveals an abundance of freshwater systems, but largely uncultivable land. However, climatic changes, such as warmer winters with less frost free days has made the South Shore an attractive option for growing various high value crops. Finally, the sources of drinking water, how they are managed and governed are also described.

Chapter 5
Results

5.1 Introduction

This chapter presents the key findings that emerged from the data collection and analysis process described in Chapter 3. Section 5.2 offers a summary of the participants interviewed, as well as some of the changes and challenges they have experienced. Section 5.3 provides the findings for well owners. Section 5.4 offers the results for tourism operators on municipal water and the water utilities who supply municipal water. Sections 5.3.1 and 5.4.1 deal with the first research objective by presenting the current and projected vulnerabilities associated with well water. Sections 5.3.2 and 5.4.2 focus on research objective two by examining the barriers and enabling factors for well owners in managing their drinking water. Sections 5.3.3 and 5.4.3 discuss the adaptation strategies to address these vulnerabilities in support of research objective three. The findings presented in Chapter 5 also support research objective four, to summarize the general conditions related to climate change impacts and water resources for the area. Additionally, many of the findings (i.e. barriers, enabling factors and adaptation strategies) can be traced back to the water governance themes presented in Table 1, therefore, these linkages are also highlighted.

Table 10 summarizes the drinking water sources for the 42 tourism operators interviewed, and their location within the study site. To maintain confidentiality, each interview is represented by an "I" followed by a unique number assigned to that interview. In cases where the interviewee is easily identifiable, this unique identifier is omitted to maintain anonymity.

Table 10: Primary Drinking Water Source for Tourism Operators

Source	Location/Type	Number
Water Utility		**12**
	Town of Shelburne	9
	Town of Lockeport	2
	Town of Liverpool	1
Private Wells		**30**
	Dug	4
	Drilled	20
	Artesian	5
	Dug & Drilled	1

5.2 Participant Profile

This thesis explores drinking water security for the tourism community, and focuses on the data collected from tourism operators, water managers, municipal employees and NGOs. Tourism agencies were also interviewed for the ParCA project, but they are not particularly relevant to this research. Therefore, their input is only represented where applicable.

Twenty-six participants are from the study site area, seven are from the Maritimes (including other parts of Nova Scotia), and 16 are from outside of the Maritimes (justification for distinguishing between Maritimes and non-Maritimes is provided in Section 4.2). Of the 64 participants interviewed, 42 are tourism operators (see Table 3). Of the 42 tourism operators:

- 20 are open year round
- 15 are seasonal
- 10 are retired
- 3 are volunteers
- 17 receive their main source of income from their tourism enterprise
- 11 had other sources of income
- 15 use their place of business as their primary place of residence

Each participant was asked about environmental changes they have observed over time. Many reported similar observations such as: higher tides (10), erosion (14), drier grounds/soil (3), increased humidity (6), less snow (12), lower water levels (3), greater seasonal variability (5), more frequent and violent storms (9), warmer winters (9), warmer summers (4), colder and wetter springs (6), more acidic lakes (4), and warmer water temperatures (3). In 23 of the interviews, hurricanes were mentioned at least once.

Participants were also asked about what (if any) major challenges they have had to deal with. Thirteen complained about high power rates, five mentioned challenges with power outages (often weather related), and 12 brought up high commercial taxation as significant obstacles. During this exploration, multiple tensions among various actors surfaced, both explicit and implicit, particularly for Shelburne. One of the major findings is the lack of collaboration, cooperation, trust and, cohesiveness among actors at varying levels (e.g. provincial and municipal governments, tourism operators and residents). Much of this tension appears to have a historical and cultural context that

cannot easily be understood by an outsider, but can certainly be observed by an outsider. Another connecting topic of contention that also emerged was the possibility of amalgamation (forced or voluntary) among the three municipal units within Shelburne County. When probed about the general cause of this tension, a common response suggested that each municipal unit views itself as a unique, self-sufficient entity, and that the possibility of amalgamating or even working together, may cause them to lose their identity. This is despite the fact that other towns and villages in the province have amalgamated (including neighbouring Queens County almost two decades ago). However, the tension did not only exist among municipal units, but also between the province, town employees, as well as other counties, residents, and tourism operators. For instance, the following passage is from a tourism operator talking about other businesses in the area:

> You don't owe me anything. We have to work together. We have to build what's going. I've had businesses here in town promoting one business but not promoting everybody but they do stuff for us. Do you not think I promote your business on a regular basis? I don't need to promote your business anymore, and I don't. It's like you guys look after each other if you're a clique and that, I'm not looking for a clique (I2).

The following are a collection of quotes from some of the participants regarding their views on government:

> The biggest single [challenge] is the provincial government. ... I used to go to meetings and meet the government and say hey listen what you're doing, this is the end results, you're going to create unemployment, you're going drive people out of business and all you get from the government is thanks for coming, the only reason we're here is because it's due process and we really don't give a crap what you say because we're going to do what we're going to do anyways. I do not see the government…in this province, I don't know what it's like in the rest of Canada but I've never seen a government care less about small business ... increase in taxes, and increase in power bills, government intervening in business (I3).

> The left foot doesn't know what the right foot doing…any government they don't know the left foot from the right foot. ... government is putting obstacles in our way ... there's a lot of red tape to get going (I11).

> They don't have any vision of the future. Instead of taking that money and investing it in like green technologies, green energy. We could be leaders in that area, they're taking the money and they're investing it in trying to keep the status quo. It's just asinine really. I can't …I don't know…I just didn't think people that were that stupid (I15).

> Our plan is at the municipal government level – we're orders of government away. There's no direct connection between municipal government and federal government to set priorities as to what you deal with first (I53).

These excerpts suggest that there are views by many participants that the government is not competent, or not a source of support. Participants also reported that government regulations have hindered them rather than supported them, such as prohibiting the sale of propane, restricting whom you can purchase food from, and limiting new business ventures and innovations (I11; I25; I29). In addition, respondents also reported that government legislation makes it more difficult to be marketable through outdated attitudes and procedures (e.g. Nova Scotia Approved, an accommodation ranking system) (I25; I10; I22; I29; I9; I24; I7; I3). Interviewees also complained where legislation ought to be enforced and monitored, it is not. For example, businesses that operate without a license, or the lack of zoning by-laws restricting development in vulnerable areas (I51; I1; I9; I18; I11). In another example, one participant divulged:

> I34: My sister used to have a B&B next door. They're on artesian well and her husband ... put in a geothermal heating system and he figured he had 25gallons/minute flow from the artesian well so he figured there's lots of water right ... but instead of putting the well water back in the well he just lets it go into the waste out into the ground rather than putting it back into the well. ... But then they noticed the water was getting salty. ... all the freshwater coming out was being replaced by ocean water so he said they couldn't drink it because it was getting salty they had to get it tested
>
> SP: They basically were overusing the water and the saltwater was intruding?
>
> I34: Yeah! And what about all the neighbours! It's going to affect the whole aquifer here!
>
> SP: Were you affected?

> I34: Yeah but we're just surface water but they're taking water from 300ft down and the other people have drilled well too down to the same depth. I'm surprised the Department of the Environment lets people install a system that isn't inspected because they would never approve … The Department of the Environment should get their act together. He could screw up the aquifer for all the people along the road here.

The importance of relating some of these quotes is to give insights on how disillusioned residents have become with the service and support they are receiving from their government. It also reveals how the government is perceived as a barrier or source of the problem, and not necessarily as a support mechanism. Moreover, this key finding offers important insights when examining some of the vulnerabilities associated with water security that are presented in Sections 5.3 and 5.4, particularly when it comes to governance issues.

5.3 Well Water

Of the 42 tourism operators, 30 are serviced by well water for their main drinking water source. Specifically 20 operators have drilled wells, five have artesian wells, four are on dug wells, and one participant has both a drilled, and dug well (see Table 10 for a summary and Section 4.5.3 for an explanation of different well types). The results presented in this section are mainly based on these 30 participants.

5.3.1 Current and Projected Vulnerabilities

The biophysical vulnerabilities for well owners can be broadly categorized by issues of quantity, quality and access (see Section 2.4.2), and as such, are presented in this fashion. As Section 2.2 explains, exposure, sensitivity and adaptive capacity are key determinants of vulnerability. The findings offered in this section showcase the ways in which exposure (the extent or rate to which a community is exposed to climate variation), and sensitivity (the degree a system can be affected by climatic variation) are affecting these communities.

5.3.1.1 Quantity

Several participants reported issues with quantity, especially during summer months when there is generally less precipitation. For example, nine interviewees reported having either their well water run completely dry, or have come very close to it. This type of exposure is more common for dug

wells, but was also reported by participants with drilled and artesian wells. For example, "it was a real issue for us…because we have sometimes faced empty wells" (I41). Another respondent shares:

> When we have a full house we turn on the taps and you don't have water ... hot weather like in July August and that's our busiest time, it's very dry it's like drought situation ... we have run out of water in the summer. ... We have been in times where we've been so low that we watch what we do. We go into conservation mode. We bring in bottled water to support the potable side (I37).

At least four interviewees mentioned that the community (e.g. neighbours), regularly run out of water. One of the respondents explained that it is common for local residents to use his Laundromat when their wells do not have sufficient quantity (I36). At least two people reported that limited water has negatively impacted their tourism enterprise, and another two mentioned that it has the potential to. Some of the negative implications include, not being able to prepare food, wash dishes or do laundry. Moreover, guests are unable to wash their hands, take showers, flush toilets, etc. One participant disclosed:

> Then there's the water issues. …there's not a lot of water here ... when the tourists come or even people in general, they want to come in and use the washroom. Well I'm at their mercy. ... 90 percent of them are non-customers, they just come in off the street and come use the washroom and they don't buy anything. So we also serve as a public washroom as well as a restaurant [laughs] and that's frustrating. We have to be very, very careful with our water here. We're on a limited water supply. ... We've got a note on the door (I25).

5.3.1.2 Quality

The government of Nova Scotia is not only anticipating greater demand and competition for freshwater, but also anticipates greater risks to freshwater, due to saltwater and bacterial contamination from warmer temperatures and flood events (NSE, 2011). Section 2.2.1 explains how climate change impacts can affect the quality and quantity of water. Some of the key findings from this analysis reveal these implications are already an issue for many participants.

Nine respondents reported issues of bacterial contamination, specifically coliform, and at least ten participants admitted to having their water test fail at least once. Another five interviewees reported being under a boil advisory on at least one occasion, however, none of the respondents reported any

health issues arising from this. Positive results for bacterial contamination have also occurred due to improper collection and handling of water samples, suggesting knowledge gaps (discussed further in Section 5.3.2.2). Positive results for bacterial contamination can also be due to other issues. For example, one participant shared that a dead rodent in the pipe was the cause of their water test failing (I17). At least one respondent reported discolouration of their water due to high organic matter (I41). Another five participants have experienced saltwater contamination, which is one of the major anticipated challenges of climate change for coastal aquifers. One interviewee shares "saltwater came out of the showers and you could not drink the water … and the iron was horrible, the showers were brown" (I12). According to another respondent, saltwater has a real potential to affect Lockeport:

> I have been told that there will...there might be already a degree of saltwater intrusion and as the years progress, there will be more saltwater intrusion. ... I've been told that eventually there will be saltwater intrusion to the point we won't be able to use what we've been using for our natural wells….So immediately I have to think well…you can't buy a house unless you have your water tested …you can't sell your house if your water is not fine. ... Some people in Lockeport already have issues with their water. Some get bottled water, some get filtration system some use both and some don't. …if anyone wants to sell their home they can't say our water is good. Right there you have a huge barrier. …if the water quality is going to affect the retail value of homes, that's going to affect the economy, that's a given....If you don't have a good source of water you can never encourage any small industries to come in (I52).

Many respondents reported issues with poor taste and smell due to high levels of iron and manganese, a common feature in the region's bedrock (as explained in Section 4.5.1). In addition to the smell and taste, at least two participants also reported the iron from the water routinely causes unsightly discolouration on their fixtures, such as toilets and sinks. This can impact their tourism business, for example, "after a while it's red and rusty and it's terrible, it really messes up everything. It gets between the ... tiles. ... We had to get water at the community centre [town well]" (I29).

While no tourism operators brought up arsenic or uranium (most likely because they are both odourless, colourless and tasteless), they are known to be significantly high in the area (see Figure 14 and Figure 15) with the potential to have harmful health effects. Nova Scotia Environment (2014d) warns residents against high levels of arsenic in drinking water, which may coincide with the high cancer rates in the province (Saint-Jacques et al., 2014). Additionally, signs are posted around

tourism centres to warn about consuming water due to chemical contamination (see Figure 16). During a second field trip to the study site in June 2014 (one year later), one respondent shared the results from a recent water test, which showed high levels of uranium. This forced them to purchase a new water system that cost several thousands of dollars, but yet the taste of their water still remained poor. While the participant did have concerns revealing this information in front of customers, for fear it may affect their business, the participant trusted the researcher, and felt comfortable bringing it up.

Figure 16: Signs Posted Around Tourism Centres

Source: Saveena Patara (2013)

Oil and petroleum contamination were also mentioned. For instance, "there are pockets of petroleum underneath Lockeport from leaking gas stations over the years" (I43). One respondent shared:

> Everyday a super tanker makes a turn out here at the end of Nova Scotia going to Saint John, NB to the Irving Oil refinery. If that tanker was to cut the turn a little too sharp there are ledges that run for miles off the end of Nova Scotia - if one spills its load then our entire economy is gone. ... We don't know how to respond to that. How do you deal with that? ... One of the biggest problems we have is the response to the oil spill ... I won't dwell on oil spills but the perpetrator of the oil spill is responsible for the mitigation for it. Well if you don't know who the perpetrator is, it just appears on shore one day, and that happens all the time because they pump their bilges ... in the middle of the night, nobody sees them – boom, boom, next thing you know you got a big mess of oil coming (I53).

Another potential source of contamination brought forward, is groundwater contamination due to a poorly maintained landfill that is still in operation (see Figure 17). This information was revealed during an informal conversation with a town employee and long-term resident. The participant felt the landfill may be potentially contaminating groundwater sources. The individual also shared that the landfill is located in the poorer part of town, predominately inhabited by the town's black population. Additionally, this person also mentioned higher cancer rates in the area, which they felt may be linked to the landfill. Although the only dumping permitted in the landfill is for brush and metal, there is no monitoring. Moreover, people are able to leave behind what they want in the landfill, and when they want, as there are no effective barriers (e.g. fencing) preventing individuals from entering and dumping (personal communication, 2015).

An additional complaint regarding the water quality was the hardness of the water due to the high mineral content, making it difficult to do laundry (I45). Two participants made reference that geographically the South Shore is a poor area for drinking water, because of high mineral content in groundwater, and high organic matter in surface waters (I5 and I43). Additionally, several tourism operators shared that they have had questions or concerns by guests about the quality of water during their stay (I34; I17; I45). In fact, one participant reported their primary drinking water source (home and business) was bottled water, which is also what is offered to guests (I2). Table 11 offers a summary of water issues brought up by participants.

Table 11: Well Water Quality Issues Reported

Issue	Number of Participants
Bacterial contamination	9
Discolouration	1
High levels of iron	6
High levels of manganese	2
Saltwater contamination	5
Acidic taste	2
Hard water	1
Poor odour	3
Experienced boil advisory	5
Petroleum contamination	2

Figure 17: Operational Landfill Site

Source: Saveena Patara (2014)

5.3.1.3 Access

While some of the reported issues related to access are from equipment failure, most of them are due to power outages. As Section 4.6.4 explains, wells have water pumped out of the ground through a water pump, requiring electricity to operate. Therefore, a power outage means no access to water from the taps, and toilets also cannot be flushed. At least six participants reported experiencing more frequent power outages than in previous years. Some participants also expressed that given the remoteness of the area, the timeliness in resolving power outages may be slower compared to more urban areas. For example, respondents have reported multi-day power outages, the "longest it was out was a few days once" (I38), or "occasionally days, after a bad storm" (I42). Other issues associated to access are related to infrastructure or equipment failure, such as broken water pumps or aging pipes (I26; I38). In one instance, lightning struck the well and shorted the water pump (I5).

5.3.2 Barriers and Enabling Factors

This section deals with research objective two by discussing some of the barriers and enablers to managing and governing drinking water for well owners, which is framed by the overarching governance concepts presented in Section 2.3.2 and Table 1.

5.3.2.1 Complacency and Perceptions

A key theme that emerged from this research with respect to well water and stewardship, are issues of perceptions and complacency. There are widely held perceptions by many participants that *their* water is pristine and of abundance. This was something that was expressed verbally, and observed by the researcher. For example, participants used words like "perfect" and "fabulous" to describe the quality of water (I42; I59). In some cases, participants seemed defensive and guarded when asked about their water, while others appeared somewhat bewildered that a researcher was even bringing up the topic since the water is "perfect". As an illustration, despite the issues reported in Section 5.3.1, one participant who has lived in the area for 40 years, shared, "I've never ever heard of anybody having that kind of problem. Our well water here is fabulous" (I27). And when asked if they thought if most people get their water tested, their response was "no because I've never ever heard of anybody ever having a problem with the drinking water ever". Other participants also shared similar sentiments. For example, "it's in a natural spring and it'll never run out, it's right into the cliff…it's a continual water flow" (I10), or "we have the best water you can have" (I41).

Perceptions and complacency can be rooted in how natural resources are perceived and valued. For example, for individuals who have traditionally enjoyed water resources that are of sufficient quality and quantity, and are easily accessible, water is probably not something that they think of, and perhaps is even taken for granted (Sadoff & Muller, 2009). As a result, water may not be of interest or priority. In fact, a couple of participants mentioned they feel residents do not value or respect their environment. For example, "they have no respect for the environment" (I15) and, "I can't believe the ignorance of the people that they didn't respect their environment" (I59). This notion was also supported by numerous anti-littering signs (see Figure 18). Another participant also shares:

> They have never had to worry about the environment, now it's time. The garbage along…kids, young kids will be driving around their cars…my house is…my husband always said it's a medium coffee away from Tim Horton's because our driveway is full sometimes with Tim Horton's cups and the same thing with McDonalds (I57).

Figure 18: Anti-littering Sign in Shelburne County

Source: Coast Guard (2012)

5.3.2.2 Knowledge

Simms & de Loë (2010) have identified knowledge as being a core theme and challenge in water governance. This is also evident in this analysis, along with a lack of shared understanding (discussed in Section 3.6.4). For example, the researcher asked well owners basic questions regarding their wells, in order to evaluate their knowledge on areas such as age, capacity and depth (see Appendix A). Only 12 respondents knew how old their well was, eight knew the depth, and only four knew the capacity. The value in having basic well knowledge can help well owners be better aware of their water situation. As of consequence, this can better position them to anticipate and prepare for future water challenges. Furthermore, demonstrated knowledge of their wells may also provide insights into their level of engagement and pro-activeness, whereas the lack of knowledge may indicate low value, priority and complacency.

As alluded to in Section 5.3.1.2, another knowledge gap discovered is around the water testing process. In Nova Scotia, businesses on well water that serve the public are required to get their water tested on a regular basis (see Section 4.6.5.2). Some respondents only tested for chemical, or only for bacteria, not both, indicating they may not be entirely clear on the requirements. At least two participants admitted to not knowing about the water testing obligations. For instance, "I took a drink of my water and I was like…this water tastes gross …apparently we have to [get the water tested] because after that we learned we were supposed to [laughs] (I38), or:

SP: do you get your water tested?

I8: no

SP: is there particular reason why you don't get your water tested or you never thought about it?

I8: just really never thought about it. I mean we had it tested when we moved here

SP: and it was fine?

I8: they said it's fine you can drink it, you can …I mean there was no restriction on it and I figured nothing's really changed on the property in the time we were [paused the recorder here]

SP: when you say they never told us, who do you mean?

I8: the province

SP: any particular department?

I8: tourism, the regulators

Several participants reported having their water test results return positive for bacterial contamination. When probed further, it was discovered that many positive tests were due to improper collection and handling of water samples (I5; I12; I47). This wastes time and money for well owners, and also suggests there are knowledge gaps, or at least a lack of understanding in the water testing procedures. For instance, the "[false result] was the fault of the way the bottles were stored. The day the water samples was [sic] taken, the guys also took the waste water sample" (I45), "the method that was used to collect the water, I think was the issue" (I12), or:

> Usually the biggest problem with doing the water test you don't wash around the tap. So you what you got to do is a take a Q-tip and go around the tap. Take the tap apart so there's no filters on it and then clean it with the Q-tip with Javex and then run the tap for about 20mins (I5).

Additional knowledge gaps around climate change also surfaced. This could be due to the fact that climate change is still a topic of continued controversy and confusion. Moreover, climate change may mean different things to different people, resulting in a reduced understanding (see also Section 3.6.4). It could also be partially attributed to gaps in knowledge distribution and dissemination. For instance, not knowing the impacts of climate change, and what they look like at community and household scales, or not associating their experiences to weather related events. This was evident in

some of the discussions the researcher had with respondents. For example, when one participant was asked if any flooding occurred on the property, they answered no. However, later on in the interview they reported having to put in a concrete floor on their property, because the ground was oversaturated due to flooding (I28). In another instance, a tourism operator was also asked if any weather related events impacted their property, they answered no (I26). However, during an interview with another participant, the following story was recounted that occurred on I26's property:

> ... beach for example, it's a very popular tourist area. A lot of the young people like to go camping there on weekends and they're in their camps and tents and sleeping bags. Unfortunately, high tide …what we call a full moon tide, a high tide that whole beach goes under water. We've been there and actually observed it happen when there's 2ft sea water going over the entire camping area. Imagine it would be midnight and you're in your sleeping and you're trying to get out of your sleeping bag with 2ft of sea water roaring through the area. There's going to be fatalities (I53).

Another dimension of shared understanding is the expectation of shared responsibility for water and water stewardship. In the study site, there is an expectation (and trust) by regulators that motorists report any chemical or oil spills (I43) (e.g. ?
Figure 19). However, an anecdote shared in Section 5.3.1.2, discloses that individuals are not necessarily reporting spills (and sometimes are intentionally discharging oil e.g. from their bilge pumps in waterways). Therefore, it cannot be assumed mutual understandings and expectations exist among actors (e.g. motorists). Did they even see the sign? If they did, did they understand the implications? What about out-of-town drivers and tourists, do they have the same awareness?

Figure 19: Watershed Protection Sign

Source: Saveena Patara (2013)

5.3.2.3 Evaluation

With respect to water testing, one participant mentioned not receiving immediate notification of the results (I11). Others did not know how to read the findings of the water tests, or what the numbers meant (I25; I38). One participant even questioned the usefulness of water testing, because there could be contamination in between test periods:

> It's kind of crazy because I mean I tested right in the early spring maybe March ... I bet you if you test it in the summer it might be different ... but the health people get a bit concerned and the guests ask us and I say well here's the test but I'm sure that test is probably only good until a month because the water is being used right? And what replaces it? But it's prohibitive because you can't have it tested every month, it would be too expensive (I34).

This last comment, is particularly relevant with seasonal variations and shifts being experienced. For instance, if snowmelt and runoff (which is generally when there is a higher concentration of pathogens flowing into waterways, see Chapter 1) is happening later (which may coincide with the tourism season), it places a greater emphasis on both water testing and education. Therefore, the significance of evaluating current policies and processes to ensure they remain effective, relevant, and accessible is key.

5.3.2.4 Resources and Capacity

As discussed in Section 4.6.5.2, in Nova Scotia, water testing is optional for homeowners, the government only offers guidelines on what to test for and how often. For businesses that serve the public, it is not a recommendation but a requirement. Pursuant to the *Water and Wastewater Facilities and Public Drinking Water Supplies Regulations* and the *Guidelines for Monitoring Public Drinking Water Supplies* Acts, bacterial testing is required every three months, and chemical testing every two years. The average cost for getting the bacterial test done by a lab is roughly $20-30 ($100/year), and for a chemical test, it is approximately $200 ($100/year). Individuals are required to collect samples as per the instructions provided, and deliver them to a water testing facility. Bacterial tests can now be dropped off at participating hospitals (the closest ones are in the Municipality of Shelburne and Bridgewater). For chemical tests, there is only one facility in the province that is equipped to perform them, which is located in Halifax, a 2.5 hour drive for some in the study site. Participants expressed frustration in getting their water tested with respect to the time and distance

driving to the lab and back, having to take time off work, the cost of fuel, wear and tear on the vehicle, as well as the cost of the tests. For example, "we have to drive to Bridgewater so that's an hour away. So it takes from our business; that someone has to leave. So there's an hour down, $30 to have the test" (I11) or "getting the water isn't a problem, taking it absolutely, that means I go to take a day off, I got to drive to Halifax with this water" (I25).

5.3.2.5 Enabling Factors

In support of the second research objective, this section identifies the factors that promote stronger water governance and management for well owners. As identified in Section 4.6.5.2, the province provides extensive information that is aimed at empowering and supporting well owners to ensure the integrity and quality of their drinking water and wells, are maintained. This is achieved through various publications (websites, pamphlets, posters, etc.) in efforts to increase and advocate water education and stewardship. The government also informs the water testing procedures, and offers guidelines and information on groundwater quality and quantity in the province. The province also has regulations on well construction and maintenance, as well as daily withdrawal limits to prevent over exploitation. Additionally, the government has also implemented the *Nova Scotia Groundwater Observation Well Network*, a provincial monitoring system to observe groundwater levels and chemistry through a series of wells throughout the province. However, the literature presented in Section 2.3.2 reveals that knowledge and perceptions are largely shaped by personal experiences and social networks rather than formal channels (e.g. governments). This is substantiated by the findings presented in Section 5.3.2, which uncovers that knowledge gaps persist despite the information available. This may suggest a number of circumstances, such as: stakeholders are not aware of the information available; it is not understood; or perhaps, it is not trusted or viewed as legitimate.

NGOs such as the Ecology Action Centre (EAC) also serve to promote and engender learning and awareness through various initiatives within the province. This includes a team dedicated specifically for water related issues and topics. EAC's mandate includes working at various scales (e.g. regional, community, government and industry) in efforts to provide awareness, education, support and resources. As a side note, to demonstrate EAC's role and influence in communities, a participant from this research reached out and received resources (e.g. expertise, tools) with regards to problems that the community was facing due to beach erosion (I51).

5.3.3 Adaptation Strategies

This section details the different approaches and measures respondents are taking to deal with the vulnerabilities described in Section 5.3.1, which include long-term adaptation strategies, as well as short-term coping mechanisms (see Section 2.4.4 for greater detail on climate change adaptation).

5.3.3.1 Quantity

Participants encountering water shortages have reported reducing their water consumption. Some stakeholders have also installed water efficient appliances (I13; I34; I57). Other respondents have secured backup sources such as purchasing bottled water, or storing water in jugs (I34; I38). Some participants located in Queens County use the town's public well (I22; I34). At least four participants have upgraded their dug well to a drilled well (I24; I12; I36; I 41). Three participants have installed additional wells to keep up with the demand (I13; I16; I37). In some instances, fire departments (as depicted in Figure 20) have also been called upon to deposit water in the wells for a small fee (I47), "there have been issues even in the past summers where the wells have been going dry and they had to get the fire departments to put water in them" (I55) or:

> Quantity there is a number of wells around and that's been an issue for quite some time and our volunteer fire department will graciously for $10 or $15 take a truck load of water and dump in someone's well. Whether that's legal to do with the Department of Environment or not, I'm not sure but they'll hook up to one of the fire hydrants and pump the truck full and take it down (I51).

Subsequently, this raises questions about hygiene and sanitation issues as water from fire hydrants is not intended for drinking consumption. This then, may suggest a case of maladaptation. Maladaptation refers to responses that do not minimize or eliminate harm, but rather exacerbate it, or create other problems (Fazey et al., 2011). Other adaptation strategies include the use of environmental indicators to anticipate water shortages. For instance:

> If the grass is sort of turning brown then you gotta be careful of the …August is the tricky time the well will recover overnight. It goes down to 2ft of water and then I'm getting kind of worried. I don't use the washing machine. The showers and toilets are ok I've got low flush toilets so that's not a big problem and shower they don't use much water and but the washing machine that uses a lot of water (I34).

Figure 20: Fire Department Water Dump

Source: Saveena Patara (2013)

5.3.3.2 Quality

In dealing with issues of poor water quality, participants use a variety of methods, such as: water filters (e.g. UV or sand filters) (10); water softeners (3); or bleach to "shock" the pipes (5). One participant routinely needs to decommission two of their wells when their water supply starts to get contaminated with saltwater (which is generally when the water levels of their start depleting), and on one occasion has had to get water trucked in. The same participant has also discontinued their use of chemical lawn fertilizers in efforts to be more water conscientious (I13). Additionally, even though water testing for public drinking supplies is mandatory (see Section 4.6.5.2), it is also a form of adaptation, as it makes well owners more aware of their current water situation, and then to be able to respond accordingly.

5.3.3.3 Access

As Section 5.3.1.3 reveals, access issues are mostly due to power outages. Stakeholders have responded to access issues by securing backup sources (e.g. purchasing bottled water or storing water in jugs for later use). In one instance, a participant purchased a backup generator because power outages had become that problematic (I42).

5.4 Municipal Water

This section presents findings from 1) participants who receive their primary drinking water from their town's water utility, and 2) from water managers who supply municipal water. Of the 42 tourism operators interviewed, 12 get their water supplied by their town, all of whom were previously on private wells. Nine are from the Town of Shelburne, two from the Town of Lockeport, and one from Liverpool (see Table 10). The two tourism operators in Lockeport requested access to town water because their own private wells were inadequate with respect to quality, quantity, and access. It was indicated by some participants in the Town of Shelburne that they did not have a choice in switching to municipal water when the town completed the first water infrastructure project (approximately six years ago), even if they had no issues with their well water. For instance, "I used to be on a well, I had to go on town water because I'm a food service" (I30), or:

> I35: when we first started we were on our own well and then after probably 5-6 years they told us we had to hookup to town water.
>
> SP: you didn't have a choice?
>
> I35: nope ... the well was fantastic it was an old, old loyalist well, really deep never had any problems with that. Any problems would have been with machinery like pump but no water pumps.

5.4.1 Current and Projected Vulnerabilities

The biophysical vulnerabilities for municipal water can also be broadly categorized by issues of quantity, quality and access.

5.4.1.1 Quantity

No issues were reported in regards to water quantity by any of the tourism operators. Water managers also did not report any issues with respect to quantity. Additionally, future water quantity problems are not anticipated by water managers, as they feel the source lakes are sufficient in supporting drinking water for the community.

5.4.1.2 Quality

Quality issues reported by tourism operators are mostly due to high chlorination levels. For instance, six interviewees reported poor taste and smell due to chlorination in all three towns, and some even used the word "chemical" to describe it. For example, "[tap water is] much cleaner than it was 20 years ago but it's also very heavy chemical but I'm used to it" (I22), or "I think this year I feel

like the water taste stronger – have chemical in it ... this year I think they changed, I think they put more chemicals" (I40). This was also substantiated by water utility operators. For instance, "then I taste [the water], and there might be a slight ammonia tang". Two respondents reported discoloured water from their taps on at least one occasion. However, deeper analysis revealed that many customers in Shelburne experienced brown water from their taps. This incident was reported by news and social media outlets (e.g. CBC, 2012; Gillespie, 2012), as well as the NSURB (2014). The cited reason for the brown water was due to operator error.

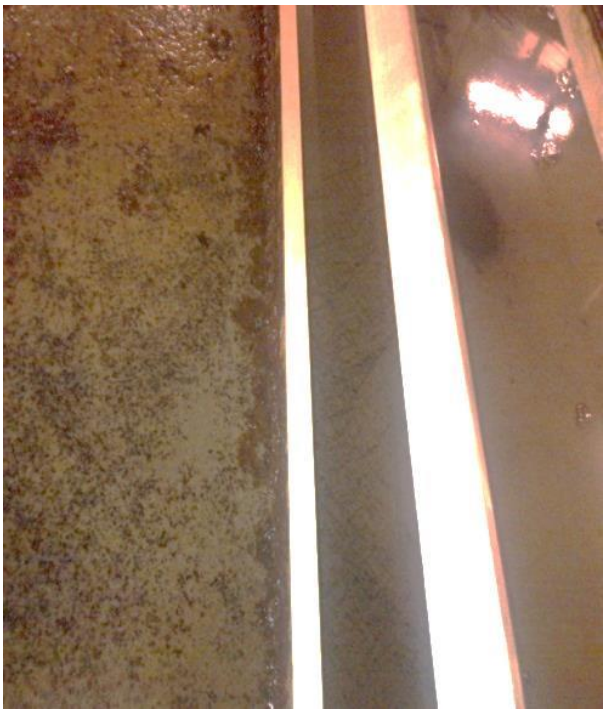
At least two respondents reported not drinking or limiting their tap water consumption due to poor taste, smell and/or perceptions. Another three interviewees admitted to filtering their tap water before consuming it "because the town water for my taste is very chloriney [sic] so we have a filter system to take all that out" (I35). The water utilities in all three towns have also issued boil advisories, often due to maintenance activities, which correspond to the responses given by participants on town water (I6; I20; I32).

From the perspective of water utilities, the majority of the quality issues are due to naturally high levels of organic particulate in the source waters, as discussed in Section 4.5.1 (also see Figure 21), which are characterized by water managers as "poor" and "complex". Water utilities also mention due to the complexity and various factors involved (e.g. time of year, temperature) that it will become even more complex as the impacts of climate change increase. As a result, water treatment in these facilities demand highly skilled and qualified operators (NSURB, 2014). For example, when organic matter such as tannins "react with chlorine, which is a disinfectant that you use in water treatment, [it] creates TCBs [trichlorobenzene]. Those are hazardous. Those are known to be carcinogenic". A water manager shares:

> The main challenge that the water quality faces is the high colour with the water. ... It decreases your filter runs. ... The higher the colour level of course ….the more organic removal you have from the water in turn filters operate on a head loss system so as the filters become dirty from all this colour removal you have to backwash, clean your filters on a more regular basis versus when your colour is much lower during the winter months. It creates a situation where it becomes higher in costs for treating the water because higher dosage rates per chemicals. That's the main challenges with this water utility is that high colour.

Another respondent suggests, because the pipes in most homes are so old that he "would be more concerned about [lead] than chlorine", introducing another vulnerability, but was not pursued, as it is out of scope for this research.

Figure 21: Untreated Water at Treatment Facility



Source: Saveena Patara (2014)

5.4.1.3 Access

For some tourism operators water access has been problematic due to issues with their building's physical infrastructure. For instance, one business owner shared that she did not have access to water because of frozen water pipes, "yeah frozen, can't turn on the water" (I40). It is likely that with more inclement weather events, there is a greater probability of more issues with infrastructure and equipment malfunction. However, most issues are related to the utilities' maintenance activities on aging and damaged infrastructure (e.g. water main breaks). In some cases, this has resulted in outages that have spanned multiple days for at least one town. For example, "I lost business for two days ... and of course [the town] didn't do anything about it" (I23). Another respondent recounted two specific incidents where water was shut off for multiple days:

> Well the 12-18 hours ended up being more than 72, it was over three days so basically they shut it off on Friday morning and didn't get water back until Monday afternoon so basically I had a full house including two ladies from California and so during those three days my neighbor allowed me to hookup his hose and lug water over for flushing toilets and that type of thing. I brought freshwater from home where I got five gallon jugs from the pharmacy and delivered that them to. I made them coffee, whatever I could so during that weekend, I don't know how many thousand gallons I lugged back in my truck.
>
> Every couple of years [the water main breaks] the one on the main street just broke this past year – it took them better part of the day and a half to get it back up and running so we were without water again on a fairly busy weekend. ... This time it happened on a Friday afternoon at 1pm and none of the local contractors wanted to work on a Friday night so they said they'll come on Saturday morning so basically they did nothing for the first 12 hours and finally the next day, they started early on Saturday morning and finally we got water back 10:30 Saturday night. So really it was better than a day and a half. I turned people away, I sent people home and other people I had to discount people that were here for the weekend that decided to stay and let me bring in water for them so instead of charging them for two days, I only charged them for one (I6).

The accumulation of these problems has resulted in I6 advising guests to "buy a couple of gallons of spring water at the local market". Once again, it is anticipated that with more extreme weather events, more water outages are likely to be endured. This can be further exacerbated if water utilities do not have the resources to keep up, or adjust to the changes being experienced.

For water utilities, poorly planned infrastructure that is aging is a big impediment in delivering water services to the community, which is further compounded by weather related events. For instance, in Lockeport, part of the water lines connecting the water utility to the island are buried under ocean water (also see Section 4.6.3.3). According to Lockeport's water manager, the infrastructure is 30-40 years old using cast iron material, and breaks to the water lines are occurring in areas where there is evidence of saltwater corrosion to pipes. These water lines have already been repaired a number of times, often resulting in multi-day water outages. This is projected to increase with climate change. Another respondent also shares:

> it's not corroding from the inside out, it's corroding from the outside in so that saltwater intrusion on those pipes is basically what's doing it…not the water that's running through and rusting it on the inside or the chemicals that are used on the inside the treated water but it's actually the problem the pipes on the outside (I51).

An additional barrier expressed by at least one water manager is that getting parts and supplies in a timely manner is a challenge due to the South Shore being a fairly remote area. Additionally, finding skilled and qualified resources locally, such as water plant operators, is also problematic for some of these water utilities. Consequently, this can have an impact on the ability of a water facility to provide safe, clean water, including delivery and access to water services. As an example, a critical part malfunctioned at one of the water utilities that was needed to continue water delivery for the town. The utility was notified that it would take six weeks for the replacement part to arrive. There was no backup or contingency plan in place. The response was to have employees "at the plant 24 hours/7 days/week doing what that actuator valve would do automatically controlled by the computer, manually". Naturally, this consumed a significant amount of resources (e.g. over-time). Climate change adaptation literature (see Sections 2.2 and 2.4.4) suggests that due diligence, adequate planning and capacity building, can largely minimize or even prevent these types of problems from occurring or becoming larger and ongoing issues (discussed in greater detail in Chapter 6).

5.4.2 Barriers and Enabling Factors

As with well owners, many of the issues related to quality and access can be attributed to the governance issues discussed in Section 2.3.2, which inevitably act as barriers to managing drinking water. This section is dedicated to exploring these issues in greater detail.

As introduced in Section 4.2, the conflict between municipal units is a notable one. The general lack of cohesiveness and cooperation is important to recognize when examining the governance challenges presented in this section, as it can help to understand some of the underlying conditions, and how they may further compound the issues.

5.4.2.1 Resources & Capacity

There are various barriers that are broadly rooted in resources and capacity issues, which are affecting the management and governance of drinking water for utilities. For at least two of the water facilities, financial and human resource constraints are of particular concern.

5.4.2.1.1 Financial

Water utilities, in general, are not in business to make profits, but rather to deliver a service, and are often dependent on government funding. For example, both the towns of Shelburne and Liverpool would not have been able to undertake upgrade and expansion projects to their water facilities had they not received significant funding from the government. In the case of Liverpool, as Section 4.6.3.1 reveals, water quality and quantity problems were identified as early as the 1960s, but the utility was not upgraded until 2008, whereupon two-thirds of the costs were picked up by the federal and provincial governments. The Town of Shelburne also received a sizable contribution from the government (see Section 4.6.3.2), but most likely due to a lack of planning and foresight, the town was not able to attract additional customers to offset the costs, landing itself in considerable debt. The Town of Lockeport's water utility is in a unique situation, as it is owned and operated by the province. Therefore, the costs are absorbed by the province, which the water manager described as "a big chunk of change compared to their whole town's budget".

In addition to limited budgets, the water facilities also reported high operational costs, which are further exacerbated by various factors. The first of these is aging infrastructure (water towers, pipelines, etc.), which requires significant maintenance, and is a problem reported by all three towns:

> Not so great is that the pipes that were put into place to service that area, that have been put in there by D&D [Department of Defense] 70 years ago [… they] burst 3 times so we have to go in and repair [them]. – Town of Shelburne

> You have water mains and water sewer lines that were put in the turn of the century so like 1910. So they're basically now just a compacted hole through the ground so as they dig them, there's nothing so they have sewage flowing in their trenches. It's like a nightmare. It's a huge nightmare. So bringing old infrastructure up to today's standard is a huge challenge. – Town of Liverpool

> Well there are 30 or 40 year old water mains that are cast iron and the cast iron, where we believe the breaks are happening, are in areas where there seems to be a lot of saltwater intrusion, causing corrosion of the pipe. So we have on our books, on our capital list of projects we hope to do a request to begin replacing water pipe. – Town of Lockeport

> Inspection of the elevated tank has revealed that the coating is failing which may compromise the integrity of the structure in the near future. …the structure no longer meets the safety requirement for tower climbing, which needs to be corrected in addition to upgrades to the tower grounding. …Two water towers which require maintenance and one in particular was scheduled for maintenance two years ago, which did not happen (NSURB's transcript regarding Town of Shelburne water utility, 2014).

Since the Walkerton incident, many provinces have implemented more stringent drinking water regulations. This has resulted in higher operational costs for water utilities, which has been described as "very, very demanding" (I43). Moreover, "[the government is] increasing the standards for drinking water and waste water treatments. That's an extremely high cost for municipalities, and a lot of them are just not going to be able to do it, there's just no funding" (I44).

5.4.2.1.2 Human Resources

In line with Kot et al.'s (2011) findings, the study site's water utilities are having difficulty with recruiting and retaining qualified staff to competently operate the water utility. For instance, one participant shared "they would be hard press to know how to run the utilities so they would need training". Another interviewee shared:

> The guy that was in there before was a perfectly good guy but he didn't have the qualification ... there were some violations or that I regard as violations of safety standards. The hose for example, the hoses conducting acid to various parts of the plant for part of the water treatment plant weren't shielded so if they sprung a leak, you don't wear glasses you could walk in there and say oh look at that and get acid right in the eyes, which is, well I'm sure you wouldn't enjoy that very much. ... A lot of the pumps and the little nozzles and stuff had not been properly maintained and cleaned. As [the current operator] goes along and he says oh this nozzle hasn't been cleaned and he cleans it out all of a sudden the set dosages that's [sic] being provided by the computer are way over what's required. So we have to turn it back so every time he cleans a pump I wait for the calls about "my water smells like chlorine". Well yeah it does sorry.

There are a number of factors contributing to low retention rates such as, the inability for smaller municipalities to offer competitive salaries. However, for at least one of the water utilities in the study site, it is due to the infighting, and lack of trust and support among actors. For example, during

the second field visit (June 2014), the researcher discovered one of the water managers had resigned because of constant conflict and infighting, leaving the utility in a vulnerable position:

> with the outgoing operator, the previous operator, there was no period of succession where both operators were there at the same time… unfortunately to date, this utility does not have standard operating practices, or process-control descriptions in place for the plant (NSURB, 2014).

During the second field trip, it was also mentioned to the researcher through informal conversations that another employee within the same facility was encountering issues by some town members. For example, the employee was allegedly followed by a resident when the resident spotted the plant operator driving a town-owned vehicle during non-work hours. Subsequently, the researcher saw a job posting for that employee's position in February 2015. A position that took significant effort to fill the last time around.

Another capacity issue for Shelburne, is difficulty with its accounting, as a number of financial errors were discovered. For example, between 2010 and 2012 a total of $13,000 had to be reimbursed to three customers due to overcharging. This led to the underestimation of the town's debt, and their overall financial portfolio:

> The Utility's financial position has deteriorated since its last rate application in 2010 due to a number of factors, both within and outside the Utility's control. …The Utility's practice of funding capital through revenue when there is ample depreciation funding available has further distorted its financial position (NSURB, 2014).

Additionally, there are also human resources issues with Shelburne's Emergency Management Officer (EMO) position. Each district is required to have an EMO as per the Emergency Management Office, a division of the Municipal Affairs department. In essence, EMOs are responsible for creating planned responses to deal with human-made or natural disasters, and then distributing the plan to the Emergency Management Office. In most jurisdictions the EMO is a paid position. For instance, Queens County has a paid EMO position, which is currently held by a retired RCMP officer. The Town of Barrington and Clarke's Harbour (within Shelburne County) also have a paid EMO position. The Town of Shelburne, Municipality of Shelburne, and Lockeport share one *volunteer* EMO position, who has held this role for the last 30 years. This raises a number of questions such as: Why does the most populous area within the study site have a volunteer EMO,

while neighbouring counties have a paid position? How might this arrangement affect the morale of the volunteer EMO? Further discussion on the EMO position is available in Section 5.4.2.2.2.

5.4.2.2 Leadership, Roles and Responsibilities

As described in several of the previous sections, there is a lack of cooperation, cohesion, and collaboration among actors within the study site, much of which is rooted in historical, political and cultural differences that appears to stem from fragmented, undefined, or unclear roles and responsibilities.

5.4.2.2.1 Fragmentation and Shared Understanding

Fragmentation is a key governance concept (Edelenbos & Teisman, 2011; Simms & Loë, 2012) as indicated in Table 1, which ultimately originates from poorly defined roles, responsibilities, and leadership. Fragmented responsibilities have created confusion and lack of clarity among the various actors in the study site, as to who is responsible for what, often resulting in frustration, hopelessness, as well as a lack of trust and legitimacy for the processes and actors involved. For instance, a respondent disclosed that a section of highway in front of their property serves as a beach entrance for pedestrians, which is owned and managed by the province. That particular stretch of highway also serves as parking for those wishing to access the beach, which is under the jurisdiction of the municipality. This section of highway is in need of repair due to impacts from severe weather events (e.g. huge rocks tossed on the highway during a storm) but "hasn't been fixed because the province … and the regional government are arguing who's going to pay to fix it" (I18). These types of conflicts are also occurring with respect to water services.

In the Town of Lockeport, the water utility is owned and operated by the province's Transportation and Infrastructure Renewal (TIR) department, as a legacy service that the province initially established in order to help boost Lockeport's economy (see Section 4.6.3.3). The water utility was only intended to be use for commercial purposes (specifically the fish processing plant), but now supports drinking water for various commercial and residential uses, "it's only been approximately 10 years ago that it began a municipal drinking supply and that's because of the addition of the school on the system" (I48). Over the last several years, TIR has been divesting all of its water facilities to its respective towns. However, "one [challenge is] to try to persuade the municipalities to take these [water utilities] on because as you know, most municipal water supplies are owned by the

municipality that's sort of a municipality responsibility ... at the end of the day that's not [the province's] business".

Lockeport refuses to take ownership of the water utility that supports the town, given their lack of resources and capacity (i.e. money, staff, expertise), especially with the aging infrastructure that frequently needs to be repaired and maintained, coupled with the ongoing effects of climate change (see Section 4.5.4). This fundamentally is a leadership issue, as well as one with a lack of clearly defined roles and responsibilities. As a result, there are frustrations, confusion and misunderstandings, making it difficult to manage expectations. For instance:

> Do you want to buy a car that's 30 years old? There's going to be questions. Do we want to take on this system that's 30-40 years old? I mean there's going to be huge costs at some point everything starts breaking down and also whereas some people will say there's more than sufficient water to supply the needs of the entire town, it's only working at 50 percent capacity…what statistical information do we have that would actually support that and would lead us to a comfortable belief that taking it on would be the right thing to do? How would we, if we choose to take on the responsibility, how would that be shared with…how would the cost be shared? Would we be taking on a huge white elephant? (I52).

A second case is with the water utility in the Town of Shelburne. The utility is owned and operated by the town, but most of its customers (e.g. hospital, high school, retirement home and community college) reside within the Municipality of Shelburne. However, the municipality does not pay for any of the costs associated with the water utility, even though the town is obligated to take on any customers from the municipality, as mandated by the URB. "The Utility Review Board, it's a provincial organization that tells [water utilities] what [they] can and what [they] can't do. What [they] must and what [they] must not do", which not only restricts decision-making power, but contributes to the internal tension. For instance:

> The pipes ... burst 3 times so we have to go in and repair them ... from our point of view that's frustrating because there's no requirement on the part of the district to cost share with anything, we go in there and fix the pipes and we're mandated by URB. ... One of my solutions to the fact that the district wouldn't pay any portion of the repairs to the road or the pipe or anything like that is just turn off the tap. But I can't do that because URB won't let us ... I mean I wouldn't do it anyway because it's just nasty but I mean it would nice to get some help from these guys especially since we're

> swimming in debt because of it. I'd like to get them to help us replace all the pipe, just put new pipe current technology pipe in there. Nope, not interested, you go ahead and fix it. They're under no obligation to anything about it.

Oversight, most likely due to a lack of planning and poorly defined roles and responsibilities, as well as passivity, have prevented the town from finding a solution to this problem (e.g. establishing a sustainable cost sharing model). The town puts the onus on the municipality to do something (i.e. charge users). The municipality feels it is the town's responsibility, and that they should directly charge users, rather than the municipality charging all of its residents (including the ones that do not use the town supply). Instead of working together to resolve this issue, it continues to fuel the conflict:

> I54: I don't really understand why that's such an issue because why don't they just charge them more for their water? Because if they're municipal residents instead of town residents, you just create a different rate for the municipal residents water.
>
> SP: has that been suggested?
>
> I54: I don't know …I guess that just seems obvious to me [laughs] but I don't know if that's been suggested. I don't really get involved in the political discussions to deal with that sort of thing.

5.4.2.2.2 Lack of Planning and Capacity Building

In the towns of Shelburne and Lockeport, inadequate leadership has also resulted in limited capacity for strategic and long-term planning for drinking water. For instance, in Lockeport the pipes are "buried in gravel, it's just in a little 12 foot wide road at water level or below water" (I51). In addition, there "aren't any shut off valves" so a problem in one area can cause water closures for everyone on the town system (I51). While there were good intentions in bringing a water facility to Lockeport (i.e. to boost the economy), planning for the future and uncertainty (e.g. climate change) was limited, if any. For example, there appears to have been no strategy in taking on new customers. Instead, additional customers were brought onto a water system that is meant and treated for commercial use (not drinking water). Therefore, the service expanded without the necessary planning and due diligence. However, at present, TIR refuses to bring on any additional customers to the water system, despite several requests from residents. This comes at a time when water shortages, and saltwater, bacterial and chemical contaminations are becoming more prevalent conditions, which are only expected to increase. Yet, some residents are unaware that getting onto the municipal supply is

not an option for them. For instance, "I guess that's always our option to go onto town water and then we wouldn't have to worry about it, but we'd have to pay for it" (I25). And when asked if they think they would be able to get on town water, the response was, "oh yeah you can get anything you want as long as you're willing to pay for it".

Moreover, TIR has had to significantly increase water rates, as they had not been adjusted in several years. This meant the utility was losing money rather than breaking even. Instead of having small price adjustments occur along the way, customers have been faced with huge price increases that tripled their rates, making it more financially challenging (I6), again indicative of poor planning. This is burdensome for many users (e.g. those on fixed and low income or ones with seasonal businesses). This also further encourages mistrust, false assumptions and frustrations. One participant shared, "I have high overhead when I'm not open with like water utilities. ... it's on an annual fee and not a seasonal ... which is very high" (I23).

Lack of planning and foresight is also evident within the Town of Shelburne as only "10-15 percent of the actual homes in town and businesses" are on town water (I47). However, millions of dollars were invested on an expansion project to attract more customers, but the upgrade did not yield the desired interest (see Section 4.6.3.2). Instead, the project resulted in significant debt for the town. No study or analysis was conducted before the project started, nor were there any firm commitments from residents or businesses willing to switch over to municipal water:

> At the time [town council] felt they had received sufficient commitment in principle from residents living along the route of the proposed line extension; no written commitment on the part of these residents was required. It was the decision of Council at the time that the costs of the extension would be carried by all water utility customers rather than by only those living along the route of the proposed line extension (personal communication, 2015).

In the end, the expansion project totalled almost $2 million, and only 21 homes and businesses made the switch to municipal water. Ironically, there are some homes and businesses that routinely run out of water, and wish to connect to town water, but the water lines do not run to their property (I37). It would cost them an exorbitant amount ($4000) to get the pipes extended to their property, which does not factor in the additional setup costs and water use fees. Not surprisingly, the town is unable to attract additional customers. Furthermore, given all the issues with the water utility, there is diminished legitimacy and trust (discussed further in Section 5.4.2.3). Attracting new customers is

also challenging, as well owners currently do not have to pay for their water. Well water is also perceived to be of better quality and quality, and does not have the poor taste and smell of chlorine that they would get from the municipal supply.

To address the significant debt, the Town of Shelburne put in an application to the NSURB (2014) to increase water rates by 48-71 percent, which has some customers upset (e.g. I15). After public hearings in 2014, where a number of residents voiced concerns, the NSURB approved a 47 percent increase for 2014/15.

Moreover, due to the complex nature of the source water, and the "chemical manipulation" required, the Town of Shelburne indicated to the NSURB (2014) that it is "prudent to engage the consultants each year to aid in the more efficient use of chemicals", which would increase expenses by three percent on an annual basis. On the other hand, a more sustainable, and perhaps empowering option, would have been to build capacity by gaining in-house knowledge and expertise rather than employing an external engineering consultant on a long-term and ongoing basis.

Another interesting planning choice for the Town and Municipality of Shelburne, was having the water and sewer lines buried together. This in itself may not be the best setup if there ever is any accidental mix-up. However, what makes this situation even more precarious is that the town owns and operates the water utility, and the municipality owns and operates the sewage system. Given the lack of communication and cooperation, it could make for an unfortunate situation:

> Once [the town] went in and did some work on [the] water system and made a hole in one of storm sewers and didn't tell [the municipality] and tried to fix it and didn't actually fix it properly and [the municipality] found it …a year later ... and went isn't that odd that the hole is right where the town water line crosses (I54).

These types of issues did not appear to persist for the Liverpool utility. This is most likely because services and responsibilities are clearly defined and streamlined after the Queens County amalgamation. However, the county is still dealing with poor planning choices from past activities. These impacts are not only being felt financially, but have also disrupted the town with major road construction and water problems (e.g. discolouration):

> Liverpool is a challenge because it's such an old town and the infrastructure is so old and things were done in such wrong ways. There have been lines dug up on one street about 4 years ago and the water line was put inside the sewer line so if there was ever a hole in

> the water line, like if that sewer ever corroded through and who would have ever known where the source was coming from. …. If there was a big rock there or maybe the town was short on money so they put a sewer line like this and they put their water line inside the sewer line. …I'm sure all old cities and towns across this country have stuff like that in the ground and there's no blueprints or plans so it's just like a puzzle (I9).

Finally, lack of planning and foresight is also evident with Shelburne's EMO position (see Section 5.4.2.1.2 for background information). For example, the volunteer EMO provided over a year's notice that he is retiring but the municipal units still had not begun to prepare for his departure: "I've been warning them now for several months. Well for over a year actually because one of the obligations is succession planning. So come on boys and girls, get your act together because come the 1st of September I'm going to be gone".

5.4.2.3 Legitimacy and Trust

Having strong leadership, with roles and responsibilities clearly defined, helps to build and foster legitimacy and trust, and empowers others. However, mistrust issues exist within the water facilities, resulting in various problems such as poor communication, false or premature assumptions. For example, with the prospect of the water utility divesture in Lockeport, one participant shared "[the province] just wants to get rid of [the water utility] because it's nothing but a cost and a burden to them" (I52). These types of perspectives lend themselves to negative feelings and dialog, or even shutting down dialogs. In another example, a water manager expressed there is a lack of trust and respect by town council for the skills and expertise of water managers: "initial reaction from council at the time was oh my God that's so expensive! Those valves cost $20k each, there's got to be a cheaper one". In this particular case, town council members proceeded to take matters into their own hands by finding a cheaper part.

In another water utility, trust issues were observed by the researcher when she met with a water operator. A lot of apprehension was observed and the respondent seemed very guarded while the tape recorder was on (as mentioned in Section 3.6.3). The researcher postulates this may be out of fear (e.g. getting in trouble or potential job loss) even though the person has been an employee for a number of years. The researcher also got the impression from the same interviewee that he did not believe climate change impacts were occurring, or that any changes were occurring with the source water, water utility or environment:

SP: are there any changes - increase, decrease, the times when that happens, is it happening later, earlier?

I: nope the seasons are pretty much the season regarding the times of year the colour changes. The colour hasn't increased over the 30 years. Another issue with our waters in these areas are the acid levels of the water. Over the 30 years the acidic levels haven't increased any.

SP: they haven't?

I: no the ranges have been pretty much the same for the 30 years which ranges anywhere from 4.2 to 5.2. So there's been no increase in acidic levels.

SP: that's pretty much normal over the last 30 years, you know when to anticipate that, you know it's always the same amount?

I: yes it's no reflection of increased challenges to do with climate change, nothing [like] that in here.

SP: are there any other challenges like financial, political, or social?

I: no, no changes it's the same

This contradicted responses from several participants (as indicated in Sections 5.2 and 5.4.1), including observations shared by residents who have reported more acidic waters and seasonal shifts. It is difficult to ascertain if the respondent was scared/anxious, not aware/knowledgeable about changes in water or climate change, complacent, indifferent or intentionally not being honest and forthright. This exchange may be a cause for concern, not only with respect to internal trust issues, but also issues of competency and due diligence in terms of planning and being prepared. An alternative perspective to this situation, is that perhaps the participant is correct in his account, and it is the researcher's positionality that affected how these results were interpreted.

As mentioned in Section 4.6.5.2, there are many unlicensed accommodations operating within Nova Scotia. Several participants showed dissatisfaction that unlicensed businesses are allowed to operate with the government's knowledge. This brings up issues of legitimacy, trust and accountability, as it shows the government is not accountable to the legislations it sanctions, diminishing its legitimacy and trust:

> I58: they're operating illegally. You can say they are a legitimate tourism business whereas the other ones are not.
>
> SP: I think because they're saying they put in a complaint and nothing could be done about it because maybe not enough money in the budget to enforce the…
>
> I58: the act doesn't give our department the authority to lay a fine. A fine can be laid from the act but we don't have enforcement officers or police officers employed here so it would have to go to the RCMP or somebody else to go and lay that fine, track down the visitor that stayed there, get statement, it takes up court time…like really.
>
> SP: so it would be up to the RCMP to pursue that if they choose not to there's nothing that you can do.
>
> I58: there's nothing you can do. ... Sometimes these people are not reporting to Canada Revenue agency and that's a whole process and that's very easy, just a tip line.

5.4.2.4 Accountability

As Sections 4.6.3.2 and 5.4.2.1 reveal, Shelburne's water expansion project landed them in significant debt. This prompted a rate increase request with NSURB. Part of NSURB's response and review process, is to initiate a public hearing before making a decision (see Section 4.6.3), which is recorded and transcribed. An excerpt from the public hearing transcript reads, "a Town Councillor, commented that he was not a councillor at the time the decision with respect to the watermain extension was made and he takes no responsibility with that matter" (NSURB, 2014). This lack of accountability (particularly on permanent public records) does not elicit or encourage a strong sense of leadership, cohesion or accountability. Rather, it purports negative perceptions that go towards diminishing trust and legitimacy. Moreover, during the hearing the Deputy Warden for the Municipality of Shelburne suggested the "base rate be charged to residents in an area where there is a watermain, even if they do not connect to the system, in order to spread the costs over a larger customer base". The NSURB (2014) responded by indicating that would violate the *Schedules of Rates, Rules and Regulations Act*. Instead a by-law would need to be created by the town, to charge residents who are not customers (NSURB, 2014). This again raises questions of legitimacy and trust when elected officials are not well versed in regulations, and moreover, are proposing solutions that may be considered unjust by some.

Accountability issues can also be framed due to lack of professionalism. For example, one stakeholder recounted a situation where she was not notified when the town issued a boil advisory.

The respondent was upset given that she serves customers tap water, and felt, had there been any water issues, her business may have been negatively affected. This example illuminates how poor communication and accountability can also inform negative perceptions:

> I was watching Live @ 5 and they said that there is a boil order for the [town] and I was thinking I didn't know that. So the town was closed –the town offices were closed at that point so I said to my husband we're under a boil water order so I ran up to the grocery store and started buying some cases of water, bottled water to put in their room and prepared little notes to put in and say please use this water until you're notified otherwise. When I was up at the grocery store no one knew about it. I bought all this water.
>
> I called the town the next day and …I spoke to the mayor …I said you know you think that we would be told about this. I've got guests coming in for breakfast and guests using water in their rooms and you would think that there would be a call of some kind and he says well we advertised on the radio. I said what station? He said the station out of Bridgewater and a station out of Liverpool. I said I listen to CBC right I didn't hear anything. I said I'm really upset that this is the way I find out. What if my guests get sick? What is the town prepared to do in that event? Not only that, the Yacht Club they were filling up sail boats with water that these people are going out to sea and it was potentially harmful. It was a safety measure (I32).

5.4.2.5 Perceptions

Negative and ill-informed perceptions can also shape trust and legitimacy issues, particularly with water. For instance, increased chlorination affects the quality of water (i.e. taste and smell), leading to complaints. In some cases, it also erodes trust, and forms poor perceptions of public water. For example, "people generally assume that tap water isn't supposed to be that good" (I20). This was evident in Queens County when the researcher made three trips to the town's public well and each time observed and talked to several people filling up containers to take back home (even though they are on town water and pay for this service). When asked, most indicated they did not trust their tap water, and preferred the town's well to municipal tap water. In addition, several interviewees on town water reported filtering their tap water, or not drinking it altogether:

> We don't drink it ...I don't like it ...we have public well here, it's just up the street maybe about a mile and everybody, EVERY body …there are even people who come out of town to use the public well, it's beautiful spring water. That's what we use (I22).

> For my own personal consumption I use a Brita (I32).
>
> I20: we serve tap water. There's a filter.
> SP: what kind of filters?
> I20: it's like beneath the building, I'm not sure. It runs through the pub or something, I'm not sure.
> SP: do you know what the reason is for using a filter?
> I20: just in case
>
> People here … grew up on dug wells, ok and that's what they're use to (I47).

Perceptions of poor quality water standards and competency inspired one local resident to post to a blog after several town residents reported brown water from their taps, and elevated levels of cancer-causing trihalomethane (THM) recorded at the water utility (Gillespie, 2013). Moreover, during the public NSURB (2014) hearing, several residents voiced concerns, which illuminated not only the poor perceptions, but the lack of trust and legitimacy for the water utility. For instance, one person stated that prior to the water plant operator resigning, he had confidence in the water utility but when the operator left, "things went downhill". The same person remarked that the "[u]tility did not seem concerned with the discoloured water or high THM levels recorded which were reported by a number of customers". Other speakers at the hearing commented on the lack of experience of staff and that the "water treatment plant must be taken more seriously". Another resident commented that town council "ignored" the financial implications of the water expansion project.

Additionally, the researcher had an opportunity to visit the water utilities. One of them was poorly secured. Not only could anyone enter on to the property, but the lock on the water plant door was broken, and the employee used a screwdriver to enter (see Figure 22). From the researcher's perspective, the inside of the water plant seemed just as neglected and disorganized (e.g. Figure 23).

Figure 22: Broken lock to treatment plant

Source: Saveena Patara (2014)

Figure 23: Inside water plant

Source: Saveena Patara (2014)

5.4.2.6 Enabling Factors

While the Walkerton case was tragic and preventable, the incident has been the catalyst for inspiring and establishing new drinking water standards within Canada. For instance, Nova Scotia has embraced the *Guidelines for Canadian Drinking Water Quality.* This piece of legislation stands as a legal framework on how water facilities should be operating so there is consistency across the province. This regulation has been recognized as a positive factor for at least one of the water utilities:

> When Nova Scotia drinking water being the Department of Environment brought in new regulations, more stringent regulation which required much more training, brought in new certification which required expiry date with your certification and required that ongoing training to qualify for new certification as it expired. … [Walkerton] really had a positive effect on rules and regulations for the province of Nova Scotia and I'm sure other provinces throughout Canada.

NSURB can also be viewed as a source of support, as it provides structure, recommendations and guidance. In addition, NSURB incorporates stakeholder participation in their process (Sections 2.3.1 and 5.4.2.4) through initiatives such as public hearings. Yet, at the same time NSURB can also be an enabler of supporting poor decisions (e.g. Shelburne's water expansion project, and Lockeport and Shelburne's huge rate increases). Moreover, as mentioned in Section 5.4.2.1.1, more stringent regulations also place greater financial burdens on municipalities. This in turn calls for improvements in the ways in which the province supports and empowers its water utilities (discussed further in Section 6.3.2.3).

5.4.3 Adaptation Strategies

Based on participant responses and further analysis, it appears there is little action to adapt to or manage against the vulnerabilities outlined in Sections 5.4.1 and 5.4.2. However, as mentioned in Section 4.6.2, one initiative that has been undertaken by the province, is mandating that municipalities prepare Municipal Climate Change Action Plans (MCCAP). The Municipality of Shelburne, the Town of Lockeport, and Queens County each had an internal resource prepare their MCCAP. The researcher contributed to the Municipality of Shelburne's MCCAP, which can be found in Appendix C of the MCCAP. The Town of Shelburne opted to hire an external consultant to write their MCCAP. While there are some advantages in having a professional prepare the plan, it

may potentially inhibit capacity building. This is because external consultants may or may not have intimate knowledge of the local environment. They also may not have the same social connections to elicit local, tacit or implicit knowledge, as perhaps an internal resource might. Moreover, external consultants generally leave after the engagement, taking away non-documented (i.e. implicit and tacit) knowledge, whereas the internal person can tap into various knowledge types (see Section 2.3.2 for knowledge types). Additionally, given that resources are often limited for municipalities, actors tend to take on multiple roles. For instance, the author of the MCCAP may also champion some of the initiatives recommended. They may also be able to better prioritize recommendations, and may have more familiar knowledge as to what is feasible and realistic given the resource constraints.

5.5 Summary

In support of research objectives one, two, three, and four, this chapter presents the key findings from the data elicitation and analysis process. These findings are framed by the themes presented in Table 1, and are organized in three sections. Section 5.2, offers participant characterizations, in order to provide background context (e.g. type of stakeholders interviewed, environmental changes observed, and the major challenges experienced by the community). Section 5.3 presents the key challenges for tourism operators who get their main source of drinking water from their private wells by: 1) examining water vulnerabilities from a physical perspective (i.e. quantity, quality and access issues; 2) exploring the barriers and enabling factors; and 3) reviewing the adaptation strategies sought by stakeholders to address these vulnerabilities. Section 5.4 describes the key challenges for tourism operators who get their main source of drinking water from municipal supplies, and water facilities that provide municipal water. This section is organized similarly to Section 5.3 by examining vulnerabilities, barriers and enabling factors, and adaptation strategies. A more comprehensive summary of the findings are presented in Section 6.2.

Chapter 6
Recommendations and Conclusion

6.1 Introduction

According to Cervoni et al. (2008), there has been little research in examining local capacity building for water management in Atlantic Canada, which is particularly the case for rural coastal communities in Nova Scotia. Therefore, the aim of this research is to address this gap by exploring drinking water vulnerability and governance through a climate change lens, and the implications for water security. The rural coastal communities of Shelburne and Queens serve as the context for this research, which is guided by five objectives. The first research objective is addressed in Sections 5.3.1 and 5.4.1, identifying and assessing the current and projected human vulnerabilities associated with drinking water. Sections 5.3.2 and 5.4.2 focus on the second objective, examining the barriers and enabling factors for managing and governing drinking water that can either increase or decrease water security. The third objective explores how stakeholders are adapting, or may be able to adapt to the identified vulnerabilities, which are detailed in Sections 5.3.3 and 5.4.3. Chapter 5 and Section 6.2, support the fourth objective, summarizing the conditions related to climate change impacts and water resources for the community. Lastly, the fifth objective is offered in Section 6.3, providing insights for policy and practice in support of strategies to enhance water security. Section 6.4 concludes with a summary and closing remarks.

6.2 Summary of Key Findings

This section summarizes the key findings for the research. Section 6.2.1 offers a general characterization of the participants interviewed in order to provide context. Section 6.2.2 highlights the results for well owners, and the focus of Section 6.2.3 are the findings for water utilities.

6.2.1 Participant Characterization

Section 5.2 revealed that the research participants, in general, did not report being concerned by environmental issues, nor were they severely impacted. However, most did observe environmental changes when prompted. These variations include warmer winters with less snow, more violent and frequent storms, higher tides, and seasonal shifts. The biggest challenge and concern for most participants were economic issues such as high: taxation, unemployment, power and water rates.

Dissatisfaction, hopelessness and mistrust were general sentiments participants expressed towards the government, which many appeared to view as an impediment rather than a source of support. Diminished trust, collaboration and communication among actors (i.e. provincial and municipal governments, tourism operators and residents) were also prevalent findings.

6.2.2 Well Water

As Section 5.3.1.1indicates, water quantity issues are mainly a concern for those with shallow dug wells particularly during dry summer months, although those with artesian and drilled wells also have reported reduced water. As uncovered in Section 5.3.1.2, water quality issues were the most prominent water related theme. This is mostly due to high levels of iron and manganese, which produce an unpleasant odour and taste. Saltwater and bacterial contamination issues were also experienced by a number of respondents. While arsenic and uranium rarely came up in interviews, it does justify greater attention. These colourless, odourless and tasteless contaminants can have adverse impacts to human health, most notably cancer. Of note, Nova Scotia also has one of the highest cancer rates in Canada, and as a result, the correlation between drinking water and cancer rates in Nova Scotia is being investigated (Goodwin et al., 2009). Section 5.3.1.3 suggests that access issues have mainly been due to power outages, which have reportedly been occurring more often. This likely coincides with more violent and frequent storms that were also mentioned.

Section 5.3.2 showcases the many barriers to managing and governing well water that surfaced. For instance, one of the key challenges are the issues of perception and complacency. This is because many participants regard their water as pristine, abundant and generally free from threats. Other obstacles are the knowledge gaps with respect to well water, climate change impacts, and the water testing process (i.e. the requirements, collection and handling procedures). Barriers with the water testing process were also revealed, such as the inconvenience (e.g. time and distance) and costs. The effectiveness of the water testing procedures were also called into question, highlighting the need for ongoing evaluation of current policies and practices (discussed further in Section 6.3.1.2).

There are a number of mechanisms to support well owners and improve well stewardship and governance, as specified in Section 5.3.2.5. This information is primarily provided by Nova Scotia Environment (e.g. water testing and well maintenance guidelines, well observation monitoring, and information on drinking water threats). However, findings disclosed that much of this information is unknown to stakeholders.

Lastly, Section 5.3.3 describes the adaptation strategies sought by participants. Stakeholders experiencing water shortages have responded by reducing their water usage, securing alternative or backup sources (e.g. bottled water, fire department), and installing low-flow fixtures. Quality issues are mainly addressed by installing filtration systems, and while it is not optional, water testing is a form of adaptation. Access issues are primarily dealt with by having backup supplies, storing water or purchasing generators.

6.2.3 Municipal Water

Section 5.4.1.1 reveals that water quantity was not a concern for tourism operators on municipal water, or for water utilities that supply municipal water. However, tourism operators reported quality issues due to high chlorination levels, resulting in poor smell and taste (see Section 5.4.1.2). For water utilities, quality issues originate from high levels of organic matter, which is anticipated to increase with warmer temperatures. This makes it more challenging and costly for utilities to treat water, as higher levels of knowledge and expertise are required by staff. Increases in organic particulate in surface waters also translates to more treatment, and wear and tear on equipment. More treatment then suggests greater chlorination, which is likely to generate additional complaints from customers. Access issues were reported by some participants due to repairs and maintenance activities on aging, and damaged infrastructure, which is often due to inclement weather (see 5.4.1.3). It is anticipated that more extreme weather events are likely to occur, which suggests greater impacts to infrastructure, and thus, more cases of reduced water access.

There are a multitude of barriers in managing and governing municipal water for the study site (as described in Section 5.4.2), especially for the towns of Lockeport and Shelburne. Barriers around resources and capacity surfaced (e.g. limited operating budgets) that compete with high operating costs. Human resources are also a challenge, such as recruiting and retaining qualified personnel, particularly on a long-term basis. Additionally, there are significant challenges around leadership, roles and responsibilities, resulting in fragmented responsibilities, varied understandings and poor planning. As a result, current customers have been impacted through higher water rates, and on occasion compromised water access and quality. Potential customers may also be discouraged to switch to municipal water due to high start-up costs, and lack of infrastructure. At the same time, mistrust, diminishing legitimacy, and poor perceptions are also common, contributing to the small customer base.

Enabling factors for effective governance for public water supplies are limited to the improved drinking water regulations mandated by Nova Scotia Environment and the Nova Scotia Utility Review Board (see Section 5.4.2.6). Few, if any, adaptation strategies are being proactively sought by water utilities (see 5.4.3). Instead, there appears to be a high reliance on the province to find and implement solutions on their behalf.

6.3 Implication for Governance

To address the fifth objective of this research, Section 6.3 offers key governance recommendations to help enhance water security for the community by addressing the vulnerabilities and barriers outlined in Sections 5.3.1, 5.3.2, 5.4.1 and 5.4.2. These vulnerabilities also trace back to the governance themes identified in Table 1.

6.3.1 Well Water

This section examines the ways in which both private well owners and governments can adapt to the changes and challenges identified in Section 5.3. Section 6.3.1 also offers recommendations for capacity building in efforts to minimize vulnerabilities, and in turn enhance water security.

Section 2.3 describes that the conventional approach and common belief is that governments are solely responsible for managing environmental resources (Biswas, 2004; Simms & de Loë, 2010). However, emerging environmental narratives continue to reveal that there is a shared responsibility when it comes to governing environmental resources, particularly for well water, as it is generally managed at household scales. Shared roles and responsibilities become even more important to recognize when external influences have the capacity to affect water security (e.g. oil spills in watershed areas).

Section 5.3 suggests that bacterial contamination is a vulnerability that has the potential to reduce water security. According to Schuster et al. (2005), it is often difficult to link water contamination to illness, because the contamination may have already cleared (i.e. through treatment, repair or naturally) before signs of symptoms appear. Additionally, some pathogens have long incubation periods, prolonging the onset of illness, as well as delaying the identification of the source. The impacts of climate change add further complexity, due to both uncertainty and the change it brings. For instance, Schuster et al. (2005) suggest waterborne outbreaks in Canada follow a seasonal distribution pattern, where a greater number of outbreaks occur in the spring and summer months. In

these months, there is greater runoff from snowmelt and rainfall, which contain heavier concentrations of pathogens. Moreover, with warmer winters and less snowfall, there is reduced runoff, infiltration and soil moisture. Accordingly, incidents of water shortages and bacterial contamination may also increase.

While not introduced by participants, document analysis reveals that the impacts from pulp mill discharge in drinking water sources are still unknown (Environment Canada, 2008). This may be of significance given that a pulp mill (Bowater Mersey Paper Company Limited) operated in the study site for over 80 years (see Section 4.4). Additionally, several Canadian towns (e.g. Elmira, ON, Abbotsford, BC) have encountered groundwater contamination due to poorly maintained landfill sites. Environment Canada (2008) warns landfills can harm drinking water sources for years to come (10-100 years), as studies show nutrients and metals from landfills are found in aquifers several kilometres away from the landfill (see also Section 2.2.1.2). This may also be of consequence to the study site, where a landfill is described as poorly operated and maintained (see Section 5.3.1).

6.3.1.1 Owners

The purpose of drawing attention to the factors above is to emphasize the importance of well owners in becoming better water stewards. This in turn brings up the concept of *shared roles and responsibilities*. One of the ways in which roles and responsibilities are already shared, is by having well owners proactively test their water on a regular basis. Well owners can take this initiative further, by also monitoring and observing changes in their environmental surroundings, and by tracking these changes, they can also serve as environmental indicators that may help them to better *adapt* to future water challenges. For example, observing dry, brown grass may suggest conditions that lead to depleting wells. Another practice, which many are already applying, is securing backup or alternative sources of water when either quantity is running low or access is limited due to inclement weather, equipment failure, etc. Engagement at this level allows individuals to participate in the governance of their water, and in turn fosters new ways of *learning* and *knowing*. Additionally, Section 2.4 offers a number of definitions for water security, which involve phrases such as "acceptable" or "adequate". By being engaged in the process, well owners may be able to determine what these acceptable water related risks are, and in turn what water security means for them.

It is also important for well owners to hold governments *accountable* and ensure they are meeting their set mandates, which would strengthen *legitimacy and trust*. This is essential, as many

government agencies are confronted by resource constraints (e.g. budget cuts). Moreover, governments have multiple roles to fulfill that are often competing (e.g. promoting the economy while protecting the environment). Therefore, it is incumbent upon well owners to be proactive in ensuring their water resources remain protected (see Appendix C for a community demanding an impact study on mink farming's effect on their drinking water supplies), which once again speaks to shared roles and responsibilities. It may be a worthwhile endeavour for community members to request an impact assessment on the landfill and paper mill sites to verify groundwater conditions in the area. This type of initiative requires proactive, passionate and committed individuals. Taking this *leadership* role can facilitate knowledge and learning, as well as the safeguarding of water resources, thus, maintaining or enriching water security.

Finally, there are 45 environmental stewardship groups in the province of Nova Scotia (Cervoni et al., 2008). However, the researcher was only able to identify/locate one within the study site (Friends of Port Mouton Bay established to contest local fish farms). This suggests there is an opportunity for the citizens of Shelburne and Queens to engage and organize an NGO that is dedicated to the protection, monitoring and education of local water resources. This partnership could also lead the process of initiating impact assessments, as recommended above. Additionally, these initiatives could also better inform (mis)*perceptions* and address some of the issues associated with *complacency*.

6.3.1.2 Government

While private wells are largely managed at household levels, government still has an important role and opportunity. Therefore, four recommendations are offered. First and foremost, it is critical for the province to continue its *leadership* role and with that, its effort and commitment in both producing and publishing current and relevant information on local water resources. This includes information on well maintenance, bacterial and chemical contaminants, etc. This is particularly crucial, as climate change impacts (e.g. flooding, saltwater intrusion and greater bacterial contamination rates), are projected to increase, and has the capacity to reduce water security (see Section 2.2.1). This recommendation is also in-line with the fourth objective of Nova Scotia Environment's (2010b) ten year roadmap for water management (*Water for Life: Nova Scotia's Water Resource Management Strategy*), to ensure citizens are engaged in water and water related issues. This recommendation would also help to promote water security through *accountability* and *legitimacy*, as well as help shape and promote different ways of *learning* and *knowing.* However, even though much of the

information is already made available by the province, research findings indicate that many stakeholders are still not aware of this information. Therefore, this recommendation also includes eliciting more effective communication strategies and channels.

The second recommendation for the province, is to have ongoing *evaluation* of its current policies and procedures to ensure that they are still relevant, effective, equitable and accessible, which in turn would help promote water security. The need for this recommendation comes from three findings offered by stakeholders. First, a participant questioned the effectiveness of the water testing process if contamination were to occur in between test periods. This is of particular relevance given seasonal shifts can change the timing of natural processes such as pathogen-rich snowmelt and runoff entering into waterways, especially if it is coinciding with the tourism season. Second, many participants brought up various barriers in getting their water tested (e.g. cost, distance, and time constraints). Some interviewees also mentioned finding it difficult to understand the results of the water tests. Third, several respondents showed dissatisfaction that unlicensed businesses are permitted to operate with the government's knowledge. This brings up two concerns. First, the government is not accountable to the legislation it sanctions, diminishing its legitimacy and trust. Second, unlicensed operators are not subject to water testing requirements that registered businesses are. This may pose potential health and liability issues for guests who may become ill while staying at an unlicensed operator. However, given the issues in tracking the source (as mentioned in Section 6.3.1), this may be unlikely, but still demands due diligence. Therefore, ongoing evaluation of policies should be mandatory to ensure they remain equitable, effective, relevant and accessible.

The third recommendation for improving water security is to refine the environmental impact assessment process. This recommendation is of importance in situations where there may be potential water related risks (e.g. impacts of landfills and paper mills on groundwater sources, or potential effects from proposed business ventures, such as oil exploration, mink farming, or agriculture). This recommendation is even more crucial since the amendment of Bill C-45 that has left most waterways in Canada unprotected (see Section 4.5.2)

Finally, the fourth recommendation for enhancing water security is for the province to explore the need, desire and feasibility for supporting the establishment of a conservation authority (CA), as none exist in the area. CAs would help to promote water education, conservation efforts, and adaptation, and could be viewed as an *integrating institution* (see Section 2.3.2). Integrating institutions support

making better use of human resources at varying scales, by integrating activities related to water resources into broader policy initiatives. For example, the CA could assist in obtaining local knowledge (e.g. observed changes in local environments, such as water contamination) that could help shape policy and adaptation strategies at municipal and provincial scales.

6.3.2 Municipal Water

Schuster et al. (2005) discovered that waterborne outbreaks have often been due to water treatment failures from system maintenance or equipment failures. Moreover, extreme weather events are often cited as one of the contributing factors for outbreaks of waterborne disease. This also has the capacity to damage infrastructure, as well as reduce water security. This suggests that proactive thinking and planning are essential in preventing or minimizing potential threats (Rizak & Hrudey, 2008). This also demands elicitation of knowledge from various sources, actors and scales (as described in Section 2.3.2) including customers, water utilities and government actors.

6.3.2.1 Customers

Even though the delivery of safe, clean municipal water is the responsibility of water utilities, customers can advocate for the security of their water through due diligence. This includes holding both the water facility and government *accountable*, and as such, requires a sense of ownership and *responsibility*. For instance, Section 5.4.2.3 relates a story of one participant not being notified of a boil water advisory released by the town. The participant followed up with the town to demand a better process for informing customers, to which the town responded favourably. Taking ownership and becoming water stewards is particularly important in smaller communities where resources and capacity are often limited and over-exhausted. de Loë et al. (2002), suggest that "an educated and aware citizenry is a foundation of participation" and groundwater protection.

6.3.2.2 Water Utilities

According to de Loë et al. (2002), it is essential for municipalities seeking to enhance environmental management, to increase its accountability through vertical and horizontal linkages, and to foster new and existing relationships. Vertical linkages refer to actors across scales, such as provincial governments to water utilities, which is discussed further in Section 6.3.2.3. Horizontal linkages describe actors operating at the same scale, such as water utility to water utility. Horizontal linkages for the study site could involve building or strengthening partnerships with nearby

municipalities and water utilities. This may help to build capacity by having another avenue of support. In Section 5.4.1.3, an example was provided, where a critical part had malfunctioned at one of the water utilities and was on backorder for six weeks. The response to this event was to have staff work 24/7 to continue the job of the malfunctioning part. Had there been a contingency plan, or even favourable working relationships established with nearby water utilities, things may have unfolded differently. For instance, another facility may have had the part available, or they may have had the technical expertise to repair or find a backup solution until a more permanent one could be implemented. In essence, this is what capacity building is about, rather than being reactive, as it often diminishes legitimacy and trust by actors (e.g. customers and decision-makers), as well as drains resources. This is particularly important for rural communities, where resource constraints are higher. Building partnerships can also be an excellent opportunity for *knowledge* sharing and transfer that could expand their *resources and capacity*, as well as reduce costs, again the process of building capacity.

However, as the findings indicate, due to past and present conflicts, fostering good relationships among some actors may not be easy. Yet, as Section 2.3.1 suggests, if such negotiations are facilitated in an effective and constructive manner, it may elicit positive results and garner greater momentum. This may involve an iterative process of building and earning *trust* and *legitimacy* (as identified in Section 2.3.2). Moreover, this type of engagement is likely to gain greater support if it is guided by trusted actors, such as mediators (discussed further in Section 6.3.2.3).

Cost and budgets are hot topic issues for water utilities given the constraints identified in Section 5.4. Therefore, it may be beneficial for water utilities to find more innovative ways to generate revenue, rather than solely relying on government funding and rate payers. This could include researching and applying for grants. Costs can also be reduced without impacting the quality of water delivered, through efficiencies, such as improving human resources. This could involve increasing morale of employees through empowerment, support and trust, which may promote greater efficiency, productivity and *accountability*. This requires strong *leadership*, whereby legitimacy and trust has been earned and established. Strong leadership is also necessary for long-term planning, including the development of backup and contingency plans. Strong leadership can also help to ensure water utilities are proactive because as Kreutzwiser and de Loë (2010, p. 188) suggest, "water

managers can no longer assume that the past will be a guide to the future". These are all initiatives that would help ensure that water remains secure for the community.

6.3.2.3 Government

Provinces generally delegate he responsibilities of water services to municipalities that may not have the required resources and capacity. However, because municipalities are the creations of provinces, water utilities are ultimately the responsibility of provincial governments (Kreutzwiser & de Loë, 2007). Therefore, it is imperative that provinces not only implement ongoing monitoring and evaluation of their policies and procedures, as suggested in Section 6.3.1.2, but also they do a better job of monitoring and supporting their water utilities. This recommendation comes after a recent report from the Office of the Auditor General Nova Scotia (OAG).

Nova Scotia Environment (NSE) is responsible for monitoring all water utilities in the province to ensure standards are being adhered to. Based on various factors and concerns for drinking water risks in the province, the OAG conducted the first ever audit of NSE's monitoring practices (personal communication with OAG, 2015). The report criticized the province for doing an inadequate job of monitoring water standards, and offered 18 recommendations. Some of the discrepancies the report highlights are that registered water utilities are not getting audited every three years as required, and that mandatory audit procedures are not being followed. The report also found errors with scheduled audit dates in the tracking system. In addition to staff not properly following guidelines, there is also a lack of guidance and procedures for staff to follow in many "important" areas, such as reporting and following-up on identified deficiencies. As a result, there are inconsistencies with how audits are performed, lack of timeliness for conducting audits and publishing the results. The report also found that follow-ups on the discrepancies were inadequate. Additionally, the report acknowledged that NSE is not using the department's information systems to its full capacity, which would help to resolve some of the shortfalls identified. Therefore, the first recommendation for the government (i.e. Nova Scotia Environment) is improving its monitoring and evaluation practices, which includes ensuring policies and procedures remain current, effective, accessible and relevant. The proper monitoring of water utilities by the province can have a significant impact on ensuring water security for municipalities. Therefore, it is imperative that the province is more proactive and proficient in its abilities to support water utilities.

As mentioned in Section 4.6.5, Nova Scotia has adopted IWRM as its framework for managing water resources and ensuring its security. However, according to Cervoni et al. (2008), the most significant barriers for implementing IWRM in Nova Scotia are related to capacity issues, as water managers feel there are insufficient human and financial resources to support water resource managers in the province. These findings are also supported by Timmer et al. (2007 as cited in Cervoni et al., 2008), who contend that there are insufficient resources at local scales for water resource protection. This suggests that governments are obliged to develop more sustainable funding models to support municipalities, which is the second recommendation for government.

Section 6.3.2.2 suggests that water utilities ought to form more collaborative relationships with other municipalities in order to expand their resource base and build capacity. However, a key finding discussed in Chapter 5, is the lack of collaboration, cohesion, communication, and cooperation among actors (e.g. municipal units). Governments could take on a stronger *leadership* role in helping to resolve these issues by bridging actors together. Or even better, providing funding for external mediators (i.e. non-governmental), since poor perceptions and mistrust of government exists (see Section 5.2). Using an external facilitator may also be beneficial in empowering municipalities, rather than having the province take an authoritarian position or approach, whether perceived or real. Thus, the third recommendation is for government to offer support by leading capacity building initiatives, with the goal of enhancing water security.

6.4 Summary and Concluding Remarks

This analysis reveals, that while water quantity supplies are currently not a major concern (except for those who have shallow wells), this issue can worsen as a result of climate change effects (e.g. drought conditions, evaporation, transpiration). Water use can also increase due to other factors that may not seem obvious, or even possible at the present time, but could in the future. For instance, several participants mentioned new migration trends occurring in the area, such as more Europeans and Americans relocating to the East Coast, which could affect future water demand and supply, "we had a lot of German people … and they were looking into buying property somewhere and they would stay here with us for a long length of time [while] they were looking" (I26).

Additionally, if the region is seeking to attract new industry, businesses and residents (see Section 4.4), undoubtedly that will increase pressure not only for water supplies but also the potential for

water contamination. For example, if Shelburne were to follow suit and bring in mink farming like its neighbouring counties, it could have adverse effects on water resources (see Appendix C). There are also ongoing investigations to introduce agricultural opportunities to the community (as discussed in Section 4.5.1). However, the negative impacts of agriculture practices on water resources are well documented (as discussed in Section 2.2.1.2).

To conclude, while water vulnerabilities exist and have the capacity to diminish water security for the community, this analysis reveals that they are largely shaped by governance and socio-economic conditions, rather than the biophysical environment. However, through the institution and implementation of good governance and sound adaptation strategies, these vulnerabilities can largely be minimized, mitigated or prevented. This in turn would enrich water security. Yet, it is not sufficient just to achieve water security, but also to be able to sustain it. As such, highlighting these water linkages are critical to understanding the factors that affect water security, particularly in the face of climate change. Finally, the challenges identified for these Nova Scotia communities are not uncommon for Canada's rural areas. Therefore, this analysis may lend itself as a case study to assist other rural Canadian communities adapt to these local realities.

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Appendix A

Interview Guide

1. 1: Setting the Stage

1. Interviewee Name _____
2. Enterprise Name
3. Age range
4. What do you do for living?

Full-time ☐ Part-time ☐ Seasonal ☐

5. Do you have other sources of income? _____
6. How long has this establishment been in existence? _____
7. How long have current owners owned?_____
8. What is your role (employee, owner, manager)?
9. How long have you worked here? _____
10. How many people are employed? _____
11. What are the services/amenities offered?
    a. accommodations, restaurant, food, gift shop, museum, tours, spa, other
        i. B&B, cottage, campground, resort, hotel, motel
        ii. fine dining, casual dining/diner, café/coffee shop, fast food
12. Is this a family operated business? Do household members help?
13. Do you or employees reside here:
    a. Do you currently own or rent this house?
    b. How many people in the household?
    c. What are the ages of the all the people who permanently live in this household?
14. Do you live in the area? ____ How long have you lived here?

15. What brought you here? _____

16. Do you have circle of family/relatives/friends in the area?

17. Are you involved in local organisations?

    a. In what capacity? _____

    b. For how long? _____

    c. What is your motivation for participating? _____

2. Part 2: Identifying Exposure-Sensitivities, Adaptive Strategies

Questions posed to get participants to tell their stories through probing (non-prompting) techniques.

Operational:

3. How do you attract business from customers/tourists?
4. What are the challenges/opportunities for your operation?
5. What factors affects the livelihood of this establishment?
6. What are the challenges/opportunities for your establishment?
7. Do you deal with others in the tourism industry?
    - In what way? How often?
8. Are other businesses facing similar issues as you?

Changes:

1. Have you noticed any changes in your establishment over time?
2. What changes in the tourism industry have you noticed?
3. When did you start noticing it?
4. What do you think are the contributing causes for these changes?
5. What issues do you think are of main concern to the region's tourism industry?
6. Are there things that you would like to have changed but did not?

a. What were the barriers to this?)

Problems:

1. What issues have you had to deal with over the years?

   _____

2. Are you currently facing any problems? _____
3. Why are they a problem? _____
4. What do you think is the cause? _____
5. When did it happen? _____
6. How long did it last? _____
7. How did you respond? _____
8. How did that work? _____
9. Why that way? _____
10. Do you have help? _____
11. What are the biggest barriers your establishment is facing?

    _____

12. Are others facing the same? _____

Environmental:

1. Have you noticed any changes in your environment over the past few years?
2. Have environmental conditions affected your establishment?
3. Have environmental conditions affected your water in any way?

Decisions:

1. What factors influence the establishment's decision-making?
2. Have past events changed management strategies

Community:

1. Is community talking about environmental changes (temperatures, increase in natural hazards, changes in seasons)?
2. In what way/form? Who is talking about this?

Water sources:

1. What are your sources of water? Does it vary?
2. Do you experience any issues with water (quality/quantity)?
    a. Did this affect your neighbours? Has anyone gotten sick because of it?
    b. How would you rate the taste of your water?
3. Has your water source ever run dry?
    a. Follow up with frequency, cause, timing, recent climatic events?
    b. What things have you done in response? Were they successful? Why that way? Would you do anything differently?
    c. Are you able to anticipate the issues? Has anything been done to prepare for future incidences?
4. How concerned are you about your and your community's water quality (short/long run)?

Septic tank

1. Are you on the town's sewer system or private septic system?
2. Any issues? Contamination? Distance from well?

Water Practices:

1. Do you treat your water? How? How often? Main reason for treating? Any barriers to getting it treated?

2. Do you test your water? How? Where? How often? Results? Main reason? Do you keep log? Do you face any barriers in having your water tested?
3. Do you follow boil advisories?
4. Do tourists/customers get served from a different source?
5. Have you made any short or long-term lifestyle or behavioural changes to conserve water (appliances/toilets/shorter shower times/frequency of washing clothes/dishes, water lawn)?
    a. What motivated you to make these changes or what would motivate you?
6. Have you used any government resources or supports for water issues?

Well knowledge:

1. How deep? How old? Storage capacity? Intake protection zone?
2. Regularly inspect and maintain well? How? How often?
3. Have you ever had your well repaired, modified or a 2nd well put in? Why? When?

Action & Concern:

1. Has there been any community action regarding these issues?
2. In general do you think you need to worry about water issues?
3. What do you think are the biggest barriers/problems for water in area, is it even a problem?
4. Who/what responsible for your current/potential water issues?
5. Who think you is responsible for finding solutions?
6. Are there any other challenges you're facing? Anything else?

9. Part 3 & 4: Guided Interview & Future Exposure-Sensitivities/Adaptive Strategies

Part 3 follows up on key issues that came to surface in part 2 through direct prompting. Therefore questions will evolve during the interview itself that answer the questions of why, how, in what way, when, was this effective, etc.

Some of the key themes/areas to go over:

- Biophysical environment
    - SLR, climate variability, extreme weather patterns – flooding, heavy storms, coastal inundation and erosion, infrastructure damage, on shore waves
- Economic & Social
- Adaptive Strategies
    - Water management (e.g. conservation, other sources, testing, etc.)
    - Operational management of tourism enterprise (change ways of doing)
    - Financial (e.g. insurance, other employment)
    - Infrastructure (building enhancements to protect against storms/floods)
    - Social (develop social/kinship networks)
    - Governance
        - Are you aware of community and governments programs you can use?
            - Check in Nova Scotia – reservation and info system
            - Open Door Program
            - Bienvenue – French language businesses
            - Tourism development guides
        - Did you use the support of government organisations or resources in managing your operation?
        - Did you use any community resources or seek help for the community
            - Organisations, programs, help from neighbours/friends
- How do you think region's tourism industry can respond or adapt to environmental changes?
- What do you feel that you need to in order to adapt to environmental changes?

Appendix B
Aquaculture

Aquaculture is the farming of any aquatic life (e.g. fish, plants), which can be off-shore or on-shore, open or closed-pen nets, and either in fresh or saltwater. Fish farming is integral to supporting food production and economic development globally. According to Bush et al. (2013), aquaculture provides approximately 50 percent of the global seafood stocks, and 13 percent of animal protein supplies, in addition to employing 24 million people worldwide. Aquaculture is a growing industry in order to help keep up with the growing demand for seafood, and to alleviate the pressures on depleting fish stocks. For Nova Scotia, aquaculture is a crucial industry that generated $55 million in 2013, and employed over 600 people (DFA, 2013a; 2013b). According to one study conducted by consulting firm, Stantec (2009, p. 4.9), the South Shore is "one of the best opportunities for future aquaculture development in Nova Scotia". This is because temperatures and depth of water is favourable to accommodate a wide variety of aquatic species, and the many bays and outlets of the South Shore provide a source of protection against wind and wave action.

Just like agriculture, aquaculture also can have negative impacts on drinking water supplies, and thus, is listed as a threat to drinking water, according to the Ontario Clean Water Act (2006). This is mostly due to pathogens from aquaculture processes that can make their way into surface or groundwater sources, as well as salinize drinking water (FAO, 2011b). Some of the impacts also have caused unsightly by-product, such as foam to encroach along beach and shorelines (see Figure 24). These impacts have been one of the leading drivers for community opposition, resulting in the formation of "Friends of Port Mouton Bay" (FPMB). FPMB is a local non-profit organization group established to oppose new fish farm licenses in Port Mouton Bay (FPMB, 2010). The FPMB website and the Stantec report both reveal many groups are opposed to aquaculture, including tourism operators, commercial fishers and beachfront landowners.

Figure 24: Foam from Summerville Beach

Source: photo taken by Ruth Smith, 2012 - obtained from participant

Appendix C
Mink Farming

Mink farming is a $140 million industry for Nova Scotia, which produces half of Canada's minks, and is the largest agriculture export for the province (CBC, 2013). However, it is a fairly understudied and under-regulated sector (NSDA, 2014). This is of significance, considering the pollution generated from mink farms. Moreover, this waste can significantly impact water quality due to effluent runoff, and dumping of waste into surface waters (NSE, 2010). While mink farming is currently limited in the South Shore (there is one mink farm close to the study site – Port Clyde near Little Goose Creek), it is prevalent in neighbouring counties, such as Yarmouth and Digby. This can impact Queens and Shelburne in at least two ways. First, it can encourage the development of new mink farms. Second, any waste discharged into ground or surface waters can adversely impact the drinking water for the residents of the South Shore. For instance, a few impact assessments have been conducted by Nova Scotia Environment (NSE) in Yarmouth and Digby. The study's findings reveal that several lakes are being "severally impacted" with "impaired" water quality due to nutrient surplus, resulting in high concentrations of alga. In some cases these alga are producing a toxin (microcystins) that can be harmful to humans, livestock, and wildlife (Brylinsky, 2011, p. 61).

There are also concerns due to the lack of regulation and monitoring. For instance, the cases investigated by NSE were prompted by public concern, after residents experienced poor water quality. The investigations were not proactively initiated by NSE, nor were these sites previously monitored. Before the mink farm was established in Port Clyde, Shelburne, the public demanded an impact assessment on water quality, which is what prompted NSE to conduct a study. The study was meant to gather baseline data before the mink farm began operation (see NSE, 2010a). However, no subsequent report was found at the time of writing this thesis.

The president of the Nova Scotia Mink Association acknowledges that farmers are making mistakes, which helped push for new legislation that will be enforced in 2016 (CBC, 2013). This is important, as the mink farming industry often seek out remote, rural communities with nearby fish processing plants (because fish waste is fed to minks) (I44). Shelburne and Queens may not only be an attractive option for the industry, but also for the community, given the declining economy (see Section 4.4), and the high demand from China and Russia (CBC, 2013).

Appendix D

Climate Change Scenario data for Liverpool, NS

Parameter	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Temperature (°C)	7.4	8.5	9.8	11.0
Annual	-3.2	-1.9	-0.5	1.0
Winter	5.3	6.4	7.5	8.6
Spring	18.0	19.1	20.3	21.4
Summer	9.4	10.5	11.7	13.0
Autumn				
Precipitation (mm)	1646.7	1691.9	1705.9	1756.5
Annual	502.3	526.7	539.3	568.7
Winter	424.1	438.2	444.5	461.9
Spring	287.2	292.0	291.1	291.5
Summer	433.0	438.3	437.6	447.5
Autumn				
Heating Degree Days	4017.2	3679.6	3321.7	2975.0
Cooling Degree Days	153.0	220.0	313.9	425.1
Hot Days (Tmax > 30)	6.2	11.8	20.4	29.9
Very Hot Days (Tmax > 35)	0.0	0.5	1.1	2.6
Cold Days (Tmax < -10)	2.5	1.5	0.7	0.2
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1915.9	2150.8	2432.0	2743.8
Growing Degree Days > 10	1001.6	1169.0	1371.6	1594.6
Growing Season Length (days)	182.4	196.8	213.6	229.1
Corn Heat Units (CHU)	2610.0	2904.6	3257.0	3586.6
Corn Season Length (days)	148.7	158.8	171.3	179.0
Freeze Free Season (days)	184.8	211.7	231.9	249.4
Days With Rain	139.0	148.1	151.4	153.7
Days With Snow	25.0	45.9	37.9	30.9
Freeze-Thaw Cycles - Annual	109.8	99.2	83.8	70.2
Winter	48.8	48.7	46.5	43.9
Spring	37.3	32.3	24.4	18.1
Summer	0.1	0.1	0.0	0.0
Autumn	23.6	18.1	13.0	8.3
Water Surplus (mm)	1356.2	1132.6	1098.0	1112.9
Water Deficit (mm)	39.0	46.8	56.0	66.3
Δ Intensity Short Period Rainfall (%)	0	5	9	16

Sea Level Rise

Extreme Total Sea Level (metres CD) – Liverpool						
Return Period	**Residual**	**Level 2000**	**Level 2025**	**Level 2055**	**Level 2085**	**Level 2100**
Total Sea Level Rise (m)			0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme TSL - 10 Yr Ret Period	0.71 ± 0.20	3.01 ± 0.20	3.16 ± 0.23	3.44 ± 0.35	3.84 ± 0.56	4.07 ± 0.68
Extreme TSL - 25 Yr Ret Period	0.81 ± 0.20	3.11 ± 0.20	3.26 ± 0.23	3.54 ± 0.35	3.94 ± 0.56	4.17 ± 0.68
Extreme TSL - 50 Yr Ret Period	0.88 ± 0.20	3.18 ± 0.20	3.33 ± 0.23	3.61 ± 0.35	4.01 ± 0.56	4.24 ± 0.68
Extreme TSL - 100 Yr Ret Period	0.95 ± 0.20	3.25 ± 0.20	3.40 ± 0.23	3.68 ± 0.35	4.08 ± 0.56	4.31 ± 0.68

Source: W. Richards Climate Consulting, August 2011