Exploring the Sustainability of Drinking Water Systems in Newfoundland and Labrador: A Scoping Document

Drivers

Pressures

State

Impacts

Responses

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Table of Acronyms

Acronym	Definition
(D)WQI	(Drinking) Water Quality Index
BMP	Best Management Practice
BWA	Boil Water Advisory
CCME	Canadian Council of Ministers of the Environment
CDW	Federal-Provincial-Territorial Committee on Drinking Water
COTOL	Communities of a thousand or less residents
DBP	Disinfection By-product
DFO	Department of Fisheries and Oceans (Canada)
DOEC	Department of Environmental and Conservation (NL)
DNR	Department of Natural Resources (NL)
DPSIR	A causal framework for describing the interactions between society and the environment that focuses on Drivers, Pressures, State, Impacts, and Responses.
DWQI	Drinking Water Quality Index
EDC	Endocrine Disrupting Chemicals
EPA	Environmental Protection Act
GCDWQ	Guidelines for Canadian Drinking Water Quality
GDP	Gross Domestic Product
GWSHP	Ground and Water Sourced Heat Pump
HAA	Haloacetic Acid
MBSAP	Multi-Barrier Strategic Action Plan
MNL	Municipalities Newfoundland and Labrador
MRIF	Municipal Rural Infrastructure Fund
NL	Newfoundland and Labrador
NOM	Natural Organic Matter
OETC	Operator Education, Training, and Certification
pH scale	Measures how acidic or basic a substance is and ranges from 0 to 14
PPWSA	Protected Public Water Supply Area
PVC	Polyvinyl Chloride
PW(S)DU	Potable Water (Service) Dispensing Units
THM	Trihalomethane
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
WMC	Watershed Management Committees
WMP	Watershed Management Plans
WRA	Water Resources Act

1.0 Introduction

This report is a component of a larger project entitled *Exploring Solutions for Sustainable Drinking Water Systems in Rural Newfoundland and Labrador*. The larger effort is aimed at exploring solutions for sustainable drinking water systems in rural Newfoundland and Labrador (NL), with a particular emphasis on public drinking water supplies in communities of 1,000 or less residents (COTOLs)[1].

The current report presents the results of an integrated assessment of public drinking water systems. To conceptualize these complex socio-ecological systems, we employ a well-known integrated assessment framework known as DPSIR (Pinter et al., 2009; UNEP, 2009a). The DPSIR framework allows multidisciplinary knowledge to be integrated and is intended to provide a holistic understanding of the state of the environment. The report presented should be treated as a scoping document, which will be used as a first step in an integrated policy analysis. The report is based solely on secondary data sources. The report explores 3 fundamental questions: (1) What is happening to drinking water systems and why? (2) What are the consequences for the environment and people? (3) What is being done and how effective have these measures been?

2.0 DPSIR Approach

The DPSIR framework (fig 1) provides an overview of the relationship between natural systems and humans. The environment in this context is defined holistically and considers humans and the environment as a single complex system (Odum, 1994). The framework describes the anthropogenic and natural conditions (**driving forces**) that exert (**pressure**) on the environment and, consequently, affect the (**state**) of the environment. In this report the current state of drinking water systems results in (**impacts**) on human health, ecosystems and materials, which may elicit a societal or government (**response**) that feeds back on all the other elements. The DPSIR framework is useful in describing the origins and consequences of environmental problems. By using the framework, the relationship between humans and the natural environment is viewed as a more integrated one, which helps us gain new insights on linkages between impacts and the adaptation or mitigation responses implemented. In this report, we highlight qualitative and quantitative indicators required to describe drivers, pressures, state, impacts, and policy responses with respect to COTOLs, and then conduct preliminary analysis on the effectiveness of current policy approaches in achieving sustainable drinking water systems.

The results of the DPSIR scoping exercise provide the information required to develop more rigorous and context-specific qualitative and quantitative analyses of the key factors that influence vulnerability and resiliency of drinking water systems in COTOLS in NL. Compiling this secondary data review and using it as a knowledge base to elicit expert opinion on the nature and state of freshwater resource systems will provide the inputs required to build a more comprehensive integrated assessment tool (UNEP, 2011).

[1] For more information about this project visit the project website: http://nlwater.ruralresilience.ca

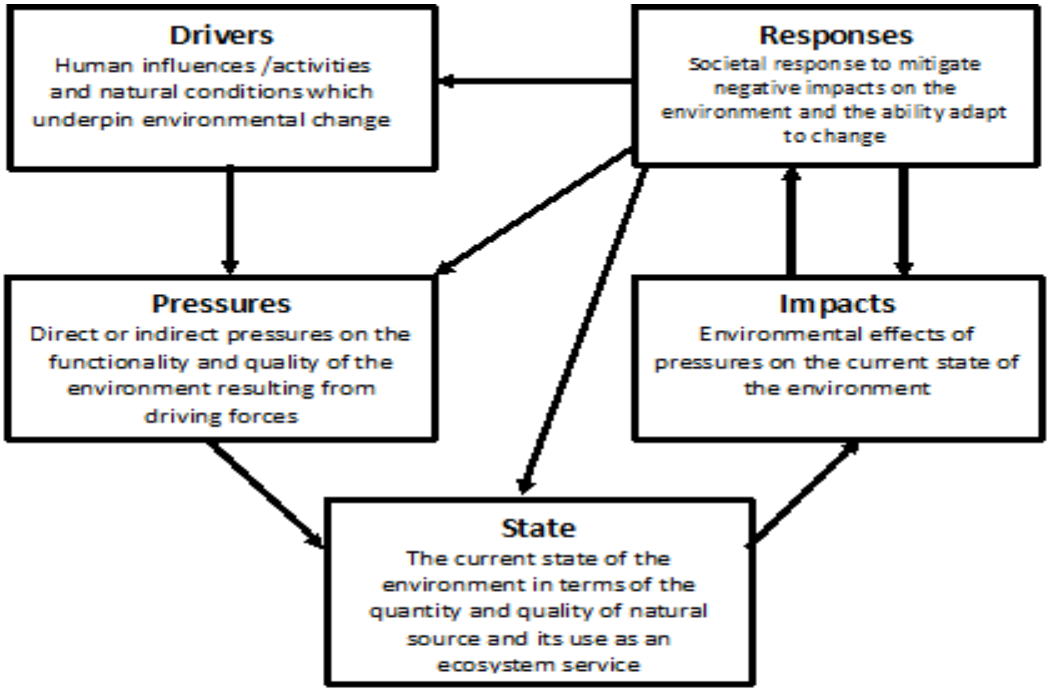

Fig 1 The DPSIR framework; Driving Forces-Pressures-State-Impacts-Response

What is happening to drinking water systems and why?

3.0 Drivers

Drivers are the human influences and activities, and natural conditions that underpin environmental change. Ecological, economic, and societal factors were identified by the authors as the key categories of drivers influencing drinking water systems in NL COTOLs.

3.1 Ecological Drivers

Geology Over 90 percent of the fresh, unfrozen water on Earth is stored underground (UNEP, 2008; Heath, 1983). Rock type can influence water availability in terms of both its quantity and quality. Drinking water can become contaminated due to an overabundance of naturally occurring substances, such as arsenic, iron, manganese, methane, sulphides, and through radioactive decay of uranium in bedrock (Environment Canada, 2010a). Similarly, the geology of Newfoundland and Labrador in some regions has negative implications for water quality (Sabau & Haghiri, 2008). For instance, high levels of arsenic, a toxic element in drinking water, have been documented in some portions of the province (Serpa, Batterson, & Guzzwell, 2009). Aluminum, ammonia, antimony, arsenic, cadmium, copper, fluoride, lead, magnesium, manganese, and selenium have been found in groundwater samples (DOEC, 2010b), with levels of uranium, arsenic, fluoride, iron, lead and manganese above levels recommended for public drinking water supplies by Guidelines for Canadian Drinking Water Quality in some communities (Sarkar, Krishnapillai, & Valcour, 2012; AMEC, 2008). Furthermore, in NL, wetland drainage can cause high levels of colour to surface water runoff due to an increase of organics in the water Conversely, less organic soils or exposed bedrock in a basin have little to no effect on surface runoff colour (AMEC, 2008).

Hydrology

Hydrology affects both the quantity and quality of water supplies. NL has extensive surface water and groundwater supplies. Lakes and ponds are a common feature of the landscape, and aquifers exist under nearly all parts of the province (Government of NL, 1992). Secondary data describing the source, quantity, and quality of water has been documented for many regions of the province (Government of NL, 1992; AMEC 2008, 2013a, 2013b, & AECOM, 2013).

Table 1 - *Statistics on Freshwater Supply and Demand in NL* (From Statistics Canada, 2010b; Rollings, 1992)

Statistics on Freshwater Supply and Demand in NL	
Water area	54,893 km^2
Precipitation	1,030 mm $\cdot yr^{-1}$
Range Annual Precipitation	600-1700 mm$\cdot$ yr^{-1}
Range of Annual Runoff	600-1400 mm$\cdot$ yr^{-1}
Average annual water yield (1971-2004)	325.5 km^3
Water yield per capita (2006)	642,178 m^3 per person

Mean annual precipitation varied across five regions of the province ranging from 600 in Labrador to 1700 in the southwest of the island portion of the province (Table 1). Importantly, the southern part of the Island of Newfoundland has nearly twice the amount of rainfall as the northern region (Government of NL, 2013j). Labrador has much less precipitation than the Island, and like Newfoundland, the quantity of precipitation increases as latitude decreases. Similarly, the mean annual runoff varied across four regions of the province from 600 – 1400 mm per annum (Rollings, 1992, p. 320) (Table 1). This variation in hydrologic inputs makes it difficult to generalize about COTOLs. However, it can be assumed that typically there is no absolute water stress or scarcity, due to the hydrogeology of the province. Indeed, using the Falkenmark Indicator for water stress as a metric, it is clear that NL is not experiencing water stress or physical water scarcity at the provincial level, as it has far greater than 1,700 m^3 of water per person per year (Brown & Matlock, 2011). However, this indicator does not show the accessibility or quality of the water. Heavy rainfall events are significant as they can transfer waterborne contaminants into water systems via runoff, as well as create changes in colour, taste, smell, and pH (Crane, 2014). In their study on arsenic presence in the province's water supplies, Rageh, Coles &, Lye (2007) point out that coastal Newfoundland is characterized by heavy precipitation year-round and that this can increase the presence of ions and metals in ground and surface water. They suggest that further studies are needed, however, to investigate the conditions leading to and effects of seasonal variation, different geological formations and other conditions on arsenic release and concentrations. Many factors influence the hydrological cycle, including "temperature, topography, vegetation cover, soil conditions, and significant drainage features of the watershed (e.g., large lakes). Many of these factors vary seasonally and from watershed to watershed" (AMEC, 2008, p. 34).

Climate Change

Climate change can impact the natural variability of water systems—affecting the supply and quality of both surface and groundwater. Though the effects of climate change are considered pressures in this document (e.g., extreme weather patterns), climate change itself is considered a major background process or phenomenon here, making it a driver rather than a pressure. Globally, the impacts of climate change on water are expected to include (but are not limited to): rising sea levels, salt water intrusion, changing sea ice patterns and conditions, retreating glaciers, drought, floods, erosion, increased frequency and severity of storms, and changes in temperature and precipitation (Environment Canada, 2009; Smith & Barchiesi, 2013; UNEP, 2005). Floods and droughts impact water availability, but the direct consequences of climate change that influence water quality are primarily the increase in extreme hydrological events and air temperature (Delpla, Jung, Baures, Clement, & Thomas, 2009). Other risks to water quality are associated with human land use, such as deforestation, urban sprawl, and pollution from urban and industrial activities; these activities can further degrade water quality indirectly through their contributions to climate change. Degradation of water quality and potential health impacts are primarily related to extreme meteorological events. Water quality parameters, such as micropollutants, dissolved organic matter, and pathogens are at risk of rising in concentration as a result of heavy rainfall events and temperature increases in air, water, and soil (Delpla et al., 2009; UNEP, 2005)[2]. The most dramatic effect of climate change in NL is predicted to be temperature increases (Finnis, 2013). According to a recent climate model study conducted by Finnis (2013), which measured change from the end of the 20th century (1968-2000) to the mid-21st century (2038-2070), potential climate change impacts for the province include increased temperatures and precipitation, with increases of 2-3°C on the Island of Newfoundland and 3-4°C in Labrador during the winter season (and increases as high as 4-6 °C in some high latitude areas). Summer and autumn increases are projected to be approximately 1°C. These increased temperatures will result in precipitation falling more as rain rather than snow in some locations and seasons, and during winter, will result in fewer frost days, delayed freeze-up, early melt, and more mid-winter thaws in some locations. Slight increases in mean precipitation are predicted for Labrador year-round and for the Island in winter and spring. Droughts are not expected to be a concern in NL. Finally, intense multi-day precipitation events are expected to increase throughout the province, particularly on the Island in the winter season and in Labrador during the summer. Climate change is expected to increase the frequency and intensity of hurricanes, storms, and flooding in

[2] For a detailed literature review on the impacts of climate change on water quality parameters (physiochemical, micropollutants, and biological), see Delpla et al., 2009.

NL (Finnis, 2013)[3]. One additional climate change-related consideration, given salt water intrusion concerns noted in the Pressures section below, is sea level rise. According to a study released by the Government of NL's Department of Natural Resources (DNR), the majority of the coastline of Newfoundland and Labrador is at moderate to low sensitivity to sea level change. However, the northeast coast of the Burin Peninsula is rated as a highly sensitive zone (Batterson & Liverman, 2010).

3.2 Economic Drivers

Economic Growth

NL's economy has changed dramatically since the collapse of the cod fishery and the cod moratorium. Despite growth in the oil and gas sector, the province has shifted from goods-producing industries towards service-producing industries in the last five years (Statistics Canada, 2013b). Newfoundland and Labrador has decreasing unemployment rates, increasing capital investments, increasing personal incomes, and variable but strong gross domestic product (GDP) (Government of NL, 2013n). The province transitioned from "have not" to "have" status in 2008, with the province ceasing to qualify for equalization payments (Government of NL, 2008d). Provincial revenue in 2012-2013 came from offshore royalties (27.3 percent), other provincial sources (17.0 percent), personal income tax (15.4 percent), sales tax (13.5 percent), corporate income tax (10.5 percent), health transfers (6.3 percent), mining taxes and royalties (2.5 percent), social transfers (2.5 percent), and other federal sources (1.6 percent) (Government of NL, 2013o). According to the Province's Department of Finance, NL was expected to lead all Canadian provinces in economic growth in 2013 with real GDP growing by an estimated 5.8 percent this year (Government of NL, 2013o).This growth is due in large part to increases in investment, consumption, and exports related to oil and gas production. The outlook is for muted economic growth in 2014 resulting from lower nickel production and reduced investment in construction with real GDP remaining unchanged, and employment remaining stable. Beyond 2014, expectations are that natural resource development will continue to impact economic growth, with real GDP declining as major projects progress beyond their peaks and as oil production trends down (Government of NL, 2013o). While some communities struggle to deal with pressures associated with economic and population growth, many rural municipalities that continue to face challenges such as out-migration, aging populations, and dropping fertility rates (Harris Centre, 2009). Further, economic prosperity has led to increased property values and, therefore, increased assessment values and opportunities for municipal tax revenues. NL has the highest levels of economic inequality in Canada (Fast, 2011; Sharpe & Capeluck, 2012). Municipal leaders must, therefore, take into account the ability of low-income residents such as seniors on fixed incomes to absorb tax increases linked to economic growth. 55.6% of the province's GDP stems from goods-producing industries in 2011. As further shown in Table 2 below, the main income sources for the NL economy are (1) oil extraction and supported activities, (2) mining, (3) finance, etc., and (4) health care and social assistance. These sectors alone accounted for 60.3% of NL's GDP in 2011. In contrast, traditional economic industries in NL (agriculture, forestry/logging, and

[3] For more information on site-specific projections for climate change, see Finnis (2013).

fishing/hunting/trapping) only made up 1.3% of NL's GDP. Overall, the economy of NL is shifting towards a mixed services and natural resource exploitation based economy. Statistics regarding GDP and employment in communities with fewer than 1,000 residents are unavailable. However, it is likely that small rural communities contribute a higher proportion of the GDP and jobs attributed to agriculture, fishing, hunting and trapping, mining, and manufacturing fish products. According to a report released in 2005 by the federal government, rural and small town populations dominated employment in primary industries in NL compared to urban areas (De Peuter, 2005). The province has the highest average municipal per capita water use rate in the country, and this is partly attributed to industrial and commercial demands (CBCL, 2011c). In small towns, industrial, commercial, and institutional water use have significant impacts on municipal water systems. Industries such as fish plants exert large, often sporadic, demands on municipal water systems. Commercial and institutional sectors exert various demands on water systems as well, depending on the type. Schools and businesses generally use water between 8am and 6pm daily, but hospitals and nursing homes will use water throughout the day (CBCL, 2011c).

TABLE 2:

	GDP 2011		Employment 2012	
	$ Millions	*% of Total*	*Person 000s*	*% of Total*
Goods-producing industry	**17,621.0**	**55.6**	**50.1**	**21.7**
Agriculture	76.5	0.2	1.6	0.7
Forestry and Logging	133.5	0.4	0.7	0.3
Fishing, Hunting, and Trapping	217.9	0.7	3.6	1.6
Mining	3,300.0	10.4	3.3	1.4
Oil Extraction and Support Activities	10,350.0	32.7	6.9	3.0
Manufacturing	1,000.4	3.2	11.3	4.9
Fish Products	329.1	1.0	4.0	1.7
Other	671.2	2.1	7.3	3.2
Construction	1,867.6	5.9	19.8	8.6
Utilities	675.1	2.1	2.9	1.3
Services-producing industry	**14,062.0**	**44.4**	**180.4**	**78.3**
Wholesale trade	713.9	2.3	4.4	1.9
Retail Trade	1362.5	4.3	30.5	13.2
Transportation and Warehousing	819.1	2.6	10.9	4.7
Finance, Insurance, Real Estate and Business Support Services	3427.2	10.8	16.1	7.0
Professional, Scientific, and Technical Services	780.6	2.5	9.7	4.2
Educational Services	1353.0	4.3	18.6	8.1
Health Care and Social Assistance	2023.1	6.4	36.7	15.9
Information, Culture, and Recreation	737.9	2.3	7.3	3.2
Accommodation and Food Services	449.0	1.4	13.7	2.9
Public Administration	1877.2	5.9	18.8	8.2
Other Services	518.5	1.6	13.6	5.9
Total for all industries	**31,638.0**	**100**	**230.5**	**100**

3.3 Societal Drivers

Demographic Changes NL has a fertility rate of 1.45, which is the second lowest in Canada, and falls below the national average of 1.62 (Statistics Canada, 2013d). While NL overall experienced a 1.8% population growth from 2006 to 2011 (Government of NL, 2011b), NL COTOLs experienced a 6.2% population decline. COTOLs are generally decreasing in population while the provincial average population growth rate remains slightly positive (Statistics Canada, 2013c). Declining populations in COTOLS mean declining tax bases, which impacts funds available for the operations and maintenance of drinking water systems. Furthermore, in Canada, water use tends to differ depending on municipality size. Small communities generally have less industrial or commercial water use, which translates into the residential sector accounting for a larger percent of water use than bigger communities. In municipalities of less than 2,000, residential water use accounts for 70% of total use; as opposed to 56% in communities of over 500,000 (Environment Canada, 2011).

Urbanization NL is undergoing a process of urbanization, which began in the 1950s with resettlement policies, and intensified again following the collapse of the ground fishery in the 1990s and the subsequent trend of youth out-migration from rural communities (Martin, 2006; Government of NL, 2006). Twenty percent of NL's residents live in St. John's (Statistics Canada, 2013a). When Conception Bay South, Mount Pearl, Corner Brook, Paradise, Grand Falls-Windsor, and Gander are factored in (all communities with populations greater than 10,000), major urban communities accounted for 42% of the total population in 2011, and 40% in 2006 (Statistics Canada, 2013a). As noted earlier, the populations of rural regions are generally declining while urban centers are stable or slightly increasing. There is a shift away from rural towards urban (Government of NL, 2006). A decline in rural populations results in declining revenue base in small municipalities, which can in turn create difficulties in providing services to remaining residents in these communities (Government of NL, 2006). Small municipalities may lack the necessary tax base to manage and upgrade drinking water systems.

4.0 Pressures

Pressures include both natural processes and human interventions that have a direct impact on the issue in question (Pinter et al., 2009). These pressures often result from drivers, but can also be affected by societal responses to the environmental problem itself (Kristensen, 2004).This report identifies and explores five distinct but related pressures for drinking water systems: ecological, industrial, household, waste systems, and institutional.

4.1 Ecological Pressures

Flooding	In NL, floods are caused by rainfall, snowmelt, or a combination of rainfall and snowmelt. The annual cost of flooding to public property in NL is estimated to be in the hundreds of thousands of dollars range (Rollings, 1999). Flooding can impact drinking water infrastructure and threaten communities' drinking water supplies when this infrastructure is altered due to floods (Government of NL, 2013i).
Droughts	In any given year, droughts occur in at least one region in North America, and can have costly impacts. Drought mitigation requires monitoring by the government and the implementation of water conservation practices on an institutional, industrial, and residential level (USEPA, 2013). Recent projections state that Newfoundland and Labrador is at a low risk for droughts in the 21st century, with the majority of dry spells lasting approximately five days throughout the province (Finnis, 2013).
Microbiological pathogens	The highest priority for water treatment is dealing with microbiological contaminants that pose immediate harm to human health (Health Canada, 2012). As noted in a 2011 NL Government-commissioned study on the subject, pathogens of concern for drinking water include bacteria (Escherichia Coli, Legionella, Shigella), protozoa (Giardia lamblia, Cryptosporidium parvum) and viruses (Adenoviruses, Enteroviruses, Noroviruses) are frequently found in drinking water sources (CBCL Consulting, 2011b). However, if these occur in post-treated water, it is an indication that water treatment is not effective. Bacteriological test results in 2008 showed 0.67% positive results for E. Coli and 3.78% positive samples for total coliforms in public water supplies (Government of NL, 2008).
Natural Organic Matter	Natural Organic Matter (NOM), also referred to as organic carbon, is defined as a group of carbon-based compounds that are found in surface water and some groundwater sources. NOMs are the product of various decomposition and metabolic reactions in a water supply and its surrounding watershed. Common NOM compounds include proteins, polysaccharides, and humic substances. NOMs are not dangerous to human health on their own; however, some NOM compounds can react with chlorine and chloramines to produce disinfection by-products (DBPs) such as trihalomethanes (THMs) and haloacetic acids (HAA) that have been found to be carcinogenic and/or genotoxic (CBCL Consulting, 2011a).
Salt-water intrusions	In coastal areas in NL, groundwater and saline groundwater sometimes shifts inland or seaward. When groundwater from inland sources mixes with saline groundwater sources from the ocean floor, salt water intrusion occurs. Salt-water intrusion is a naturally occurring process; however, it can be influenced by human activity (e.g., pumping of groundwater). The presence of chloride in water samples is a sign of saltwater intrusion in drinking water (Government of NL, 2008). Once a groundwater source has been contaminated with salt water it can no longer be used as a drinking water supply (Government of Prince Edward Island, 2011). Coastal areas tend to have a high demand for groundwater, and in Atlantic Canada overexploitation of groundwater is the leading cause of saltwater intrusions (Cruickshanks, Gibb, & Hennigar, 1987; Government of Prince Edward Island, 2011). Salt water intrusions due to rising sea levels associated with climate change in NL are a concern. Baseline

data on potential sea-water intrusion public water supply wells has been collected in some areas of NL and will be used for monitoring salt water intrusion as sea-levels rise (Adams, 2011).

Groundwater levels Low groundwater levels can cause drought and low flow conditions for streams and rivers in an area using groundwater, potentially threatening public water supplies. In NL, residents, industry, commercial businesses and institutional buildings use groundwater for their water supply. The province's groundwater is monitored by the provincial government through ground water level and water quality monitoring (Government of Canada and Government of NL, 2008).

Physical obstructions Natural physical obstructions in a water source may sometimes be beneficial, as they provide fish habitat; however, obstructions also may prevent fish movement, alter sediment transport and increase water temperature. Furthermore, physical obstructions such as beaver dams can cause flooding as well as contaminations to the water through beaver fecal matter (see pathogens) (DFO, 2007).

Turbidity Turbidity is a measure of water cloudiness and is affected by the accumulation of solid particles in water such as clay, silt, or microscopic organisms (Government of NL, 1992; Health Canada, 2003). Suspended matter can also contain microorganisms and toxins such as heavy metals and biocides (Health Canada, 2003). Soil erosion can contribute to changes in water turbidity, as water passes through the land before it reaches the water body, taking solid particles with it (Elsin, Kramer, & Jenkins, 2010). Turbidity levels can be impacted by land use practices, farming methods and residential and commercial development. As a health-related parameter, turbidity is used as an indicator to assess the effectiveness of filtration in drinking water systems (Health Canada, 2003). Turbidity can interfere with disinfection, and best practice demands that turbidity levels should be reduced as low as possible in all drinking water systems (Health Canada, 2003). Turbidity is a key challenge for small, outdated systems, leaving them vulnerable to source water changes and extreme weather. In addition, organic turbidity is a precursor to the formation of disinfection byproducts (DBPs). Increased turbidity in source drinking water can result in higher costs to remove the particles at the water treatment plant (Elsin et al., 2010).[4]

pH, acidity, and alkalinity The pH value is a measure of acidity in water (Government of NL, 2008). Acidity in source water is caused by increased acid loads in lakes and rivers. Acidity is measured on the pH scale with 1 being most acidic, 7 being neutral, and 14 being most alkaline, or basic. Materials that significantly influence pH levels include: nutrients (phosphate, carbonate, ammonia, silicate, sulphide); metals (iron, manganese, magnesium); organic acids (amino, fulvic, humic); gases (carbon dioxide, hydrogen sulphide); and particulates (aluminum, iron and manganese oxides and hydroxides, clay minerals, organic particulates). In the province, low pH levels are common especially in areas where source water originates close to bogs (Government of NL, 2008b). A direct relationship between pH and human health cannot be determined because pH is related to many other drinking water quality parameters (Health Canada, 1979). However, increased levels of THMs occur when

[4] Canadian guidelines regarding turbidity and drinking water quality can be located at http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/turbidity/index-eng.php (Health Canada, 2003).

source water at a high pH level is subjected to chlorination treatment (Government of NL, 1992; Health Canada, 1979; Conestoga-Rovers & Associates, 2010).

Erosion and silt

Silt refers to the suspended sediment particles that cause turbidity (see "Turbidity" above). Siltation is caused by the erosion of exposed soil as well as any development or human processes that release fine particles (i.e. mine tailings or rock crushing) (DFO, 2013).

Minerals and metals

Certain minerals and metals can be found in drinking water in NL. Some are harmful to human health while others merely contribute to poor aesthetic water quality. Copper, iron, and manganese are examples of the latter. They are naturally occurring elements that have been found to exceed recommended levels in the province (Government of NL, 2008b). Copper and iron in water are often due to leaching from piping made from these materials and can cause water to have a poor taste (Government of NL, 2008; Health Canada, 2012). Health Canada (2012) and the Government of NL (2008b) describe manganese as another element that simply adversely affects water taste; it is not listed as harmful to human health. However, mixed results have been presented in the literature on this, with some studies showing adverse health effects related to various forms of exposure to manganese and others showing no such problems (World Health Organization, 2011). Harmful dissolved metals found in NL drinking water systems include barium, arsenic, and lead. These metals have been found in NL water sources, in many private wells, and some small surface water bodies in the eastern, central, and western regions of Newfoundland (Rageh et al., 2007). These metals can be poisonous and can have adverse effects on human health. Dissolved metals are usually from natural sources; however, they can be produced by human activities such as mine tailings runoff or certain kinds of pressure treated wood. For example, arsenic–a carcinogen–is found more commonly in water that comes from wells that have been drilled into the bedrock (especially bedrock that contains high natural levels of arsenic) compared to surface water sources or dug wells (Government of NL, 2013b). Old infrastructure is also linked to dissolved metals in drinking water. In Canada, lead in drinking water is almost entirely attributable to lead distribution systems and corrosion issues (Health Canada, 2007).[5]

Freeze-thaw cycles

Freeze-thaw cycles have been more frequent as the climate changes in NL. Each component of a water system can be impacted by freeze-thaw conditions. When water in aging water distributions pipes freezes and then thaws repeatedly, they become more prone to breaks and fractures. Freeze-thaw cycles can also damage water treatment infrastructure and can corrode pipe walls causing metals (copper, lead and iron) to leach into the water, compromising water quality (Government of NL, n.da).

[5] For Canadian guidelines on drinking water chemical and physical parameters, see Health Canada (2012).

4.2 Industrial Pressures

Industrial water abstraction

The government data on water use by industrial sectors is over 20 years old, and thus, is considerably outdated (Government of NL, 1992). Amongst other changes, the data does not capture the collapse of the fishery, the closing of several large pulp and paper mills, or the growth of the province's oil and gas sector. In 1992, the total fresh water use by industries was approximately 350 million m^3 per year, with mining using over 200 million m^3 per year, pulp and paper using 120 million m^3 per year, and fish plants and Come by Chance's oil refinery each using approximately 2 million m^3 per year (Government of NL, 1992). Most of the extracted water was surface water. There is no specific data on the industrial use of water in communities of less than 1,000. However, a 2011 NL government-commissioned report explains a unique factor facing some small communities:

> Industrial users often exert large water demands on a water system. These demands may be regular or sporadic depending on the operating schedule of the facility. For example, many of the municipal water distribution systems in small communities in Newfoundland and Labrador serve fish plants that operate for only part of the year. When the plant is in operation, the water demands exerted on the system are characterized by large, regular demands during each shift at the plant. When the fish plant is not operating, water use patterns are more characteristic of small, rural communities in Canada (CBCL Consulting, 2011c, p. 5).

Point source pollution

Most point source pollution contaminating water sources could be from any of the industries operating in NL, such as mining, forestry, and oil refinery wastewater. The presence of sulphate, an aesthetic parameter that affects taste, is often attributed to industries that use sulphates and sulfuric acids, such as mining and smelting operations (Government of NL, 2008). Site-specific point source pollution has been observed in several locations throughout the island between 1986 and 2006. Examples include acid mine leachate from the abandoned ASARCO mine; effluent from Grand Falls pulp and paper mill; and leachate in the Corner Brook landfill (Dawe, 2006).

Nonpoint source pollution

Nonpoint source pollution contaminating water sources could be from various industries operating in NL or abroad. Examples include agricultural, silvicultural run-off, garbage left in watersheds by tourists or hunters and leaked fuel from boats, and atmospheric deposition. (USEPA, 2010). There has been a decreasing trend in levels of heavy metals including lead, copper, and mercury in NL watersheds (Dawe, 2006). This is attributed to improvements in national and global emission trends in industrial atmospheric pollution (Dawe, 2006).

Infrastructure (excludes water

The construction and operation of infrastructure can negatively impact water quality. This includes disturbances to water systems through residential and commercial *systems, discussed below in 4.4)*

development and salt and other pollutant runoff from the construction and maintenance of roads. Contaminants in runoff pollution from roads, highways, and bridges include issues with sediment, as well as other pollutants that adhere to sediment such as heavy metals, oils, greases, debris, road salts, pesticides, fertilizers, and herbicides (USEPA, 2010).

Physical obstructions

Most industrial physical obstructions in a water source are dams. Larger dams are usually used for hydroelectric power generation but are also used for tailings, water supply, irrigation, flood control, recreation, and various other purposes. Dams can impact the water quality of a water source. Aside from the potential loss of wildlife habitat, the accumulation of sediments in the reservoir can increase concentrations of harmful metal and organic compounds in the water source. Furthermore, the eutrophication process may occur at a faster rate and negatively affect water quality if vegetation is not removed from the dam before flooding occurs (Environment Canada, 2010b).

4.3 Household Pressures

Household water use

In 2011, total water use in NL was estimated to be 804 litres per capita per day—the second highest rate in Canada, compared to the other provinces and territories (Environment Canada, 2011, p.6). When adjusted for residential water use per capita, this rate is 395 litres per capita per day—marginally higher than any other Canadian province. This level of consumption exceeds the 340 litres per capita per day recommended in the NL Guidelines for the Design, Construction and Operation of Water and Sewerage Systems (Government of NL, 2005a). NL residents clearly use a significant amount of water on average, but it is difficult to determine actual water use per household in the absence of water metering, as this can vary greatly and is affected by lifestyle factors such appliance efficiency and washing habits (European Environmental Agency, 2001) However, the sheer number of communities with populations of less than 2,000 may help explain this trend, as rural communities are more likely to have higher per capita water use (CBCL Consulting, 2011c). According to Environment Canada, Canadian communities of less than 1000 have the highest residential use of water on average than larger communities (Environment Canada, 2011).

Point source pollution

Point source pollution at the household level has many possible origins. For example, cabin development without proper septic tanks and residential fertilizer application may be contributing to point source pollution. The results are increased nitrate, nitrite, and nitrogen in river basins (Dawe, 2006). Other point source pollutants can include car wrecks, garbage, and other illegal dumping.

Diffuse source pollution

Diffuse source pollution refers to non-point pollution from households. A major concern is the chemicals entering the water systems through wastewater. For example endocrine disrupting chemicals (EDCs) (e.g., drugs, cosmetics, disinfectants, plastic additives, and pesticides) can enter water systems through household activities and waste and can cause significant human health and environmental

	issues. For example, EDCs can interfere with hormones in the body and can signal early development in humans and cause irreversible damage (UNEP, 2010). In NL, there has been a reduction since the 1980s in some household pollution. One example is phosphorous; levels of this chemical in watersheds have decreased due to national legislation banning the chemical in detergents (Schreier, Hall, Brown, & Tamagi, 1997; Dawe, 2006).
Water-based activities	Certain activities are prohibited in a protected drinking water source in NL due to their potential detrimental effects on water quality (Government of NL, 2002c; 2009b). Such activities include bathing, clothes washing, boating, fishing, material deposit, swimming, and diversion of water for purposes other than municipal drinking water supply.

4.4 Water System Pressures

Cross Connections	A cross connection is any connection between potable water systems and a potential source of pollution and/or contamination. This situation usually a result of insufficient water systems knowledge and can pose risks to drinking water quality in the form of waterborne illnesses and even the release of potentially fatal poisons (MacNabb, 2003)
Aging Infrastructure	The majority of water distribution systems in Canada were constructed between 1950-1970, but some systems can be traced as far back as the early 1900s and late 1800s (Mirza, 2007). In addition, much of the early investments into drinking water infrastructure in rural Canada were made through government or industry funding that is no longer available. This has resulted in expensive water distribution systems that local governments cannot continue to fund either because the old systems require expensive updates or because new systems require more financial resources to operate than are currently budgeted (Mirza, 2007). According to the 2011 Municipalities Newfoundland and Labrador Census of Municipalities, 66.8% of municipalities surveyed responded that their water system is more than 20 years old (MNL, 2011).
Chlorination levels/ disinfection by-products	Chlorine is used by the majority of NL communities as their primary disinfectant (Government of NL, 2013g). Consistently maintaining levels of chlorine that are neither too low (which could result in e-coli or other contaminant poisoning) nor too high (which can stain laundry and result in bad taste) requires training and expertise. Disinfection by-products (DBPs) such as trihalomethanes (THMs) and haloacetic acids (HAAs) (which are known carcinogenic) can also occur when organics in the water mix with chlorine (Government of NL, 2013g).
Leakages	Water leakages occur in most water distribution systems. In older systems, leakages can result in the loss of up to 50% of distributed water per day. Leaks incur financial costs stemming from the cost of raw water, its treatment, and its transportation.

Leaks can also damage pipes (e.g., erosions and pipe breaks). Any damage to distribution lines can create openings that could allow contaminants to enter the water system that could adversely affect human health (UNEP, 2010). In NL, an average of 7.5% of water is lost through system maintenance and leaks (Environment Canada, 2011). At the national level, most water losses of this nature occur in large cities, with the lowest losses occurring in communities of less than 1,000 people (Environment Canada, 2011).

Corrosion

Corrosion is the "deterioration of material, usually metal, that results from a reaction with the environment" (Health Canada, 2009). Corrosion in Canadian drinking water systems is common, and materials such as metal pipes and fittings, polyvinyl chloride pipes (PVC), and cement in pipe linings can be affected by corrosion; leading to pipe failure or the leaching contaminants into water (Newfoundland Design Associates Ltd., 2004; Health Canada, 2009). The most significant water quality parameters related to corrosion and leaching of distribution systems are alkalinity (of less than 30mg/L) and pH (of less than 7.5 or greater than 9.5) (Health Canada, 2009). Other parameters are natural organic matter (NOM), sulphate, chloride, free chlorine residual, chloramines, calcium, and temperature (Health Canada, 2009). In 2009, the Government of NL released the results of a province-wide study which used lead as an indicator for corrosion in public water supplies. Results suggest that corrosion is not a major issue, as just 3% of samples taken were above the recommended guidelines for lead (Government of NL, 2009c). Knowing the state of public water systems is an important part of managing the resource. Best practices include: having municipal infrastructure and system maps; developing a condition assessment and rating system and assessing remaining useful life; and determining asset values and replacement costs. These asset management plans, and more specifically, knowledge of where the water systems are located, are not always readily available, which poses a risk to water systems (Cooper, 2013). The provincial Department of Environment and Conservation's (DOEC) Water Resources Portal is a web-based application allowing government departments to share water supply and water quality information. It has map services related to current boil water advisories, public water supplies, water resources monitoring stations, and other water-related data (Government of NL, 2014).

4.5 Institutional Pressures

Human Resources

One of the barriers to achieving sustainable drinking water systems in NL communities is a lack of human resources and leadership (Cooper, 2013.). According to a Municipal Sustainability Self-Assessment Project report, many municipalities are experiencing administrative difficulties in maintaining service levels (Lane & Quinton, 2009). Many NL communities have volunteer water operators or part-time water operators. Furthermore, certification in the OETC program is not required to become a water operator, resulting in untrained workers operating public water systems (Patey, 2013). Inadequate human resources in a community could result in a Boil Water Advisory (BWA) and puts the community's drinking water at risk.

Financial

Financial sources for operating water systems can be derived from local taxes, provincial sources and federal sources (Government of NL, 2013f). However, according to a Municipal Sustainability Self-Assessment Project report, many municipalities are experiencing fiscal difficulties in maintaining service levels (Lane & Quinton, 2009). Amongst other measures, water demand management includes water pricing (Halich & Stephenson, 2009). However, municipal water rates in Canada are amongst the lowest in the world (Brandes & Ferguson, 2004). And although residents of Newfoundland and Labrador have some of the highest water usage rates in the country (Sabau & Haghiri, 2008), charges for residential water service are relatively low compared to other provinces in Canada (Conestoga-Rovers & Associates, 2010). The highest recommended rates per household are typically required for small communities due to limited funding ability (Conestoga-Rovers & Associates, 2010). Different tax structures exist for NL's commercial sectors, and in some circumstances, water metering policy is in place (Murphy, Olson, & Ramirez, 2010). Charges for residential water service in NL occurs at a flat rate, rather than a consumption based one (MNL, 2011; Murphy et al., 2010). For example, the residential and commercial water rates are $120.00 per year and $144.00 per year, respectively in the town of Come by Chance (Town of Come By Chance, 2013). As of 2009, the average annual flat rate water tax was $200 per household in NL (Conestoga-Rovers & Associates, 2010). In contrast, a 2008 study of 1,600 Canadians determined that households spend an average of $500.00 per year for municipally-provided tap water (Dupont, 2009). This suggests that water service fees in NL are significantly less than the full cost of actually providing water services.

Operation and Maintenance

Operation and maintenance issues related to drinking water systems in NL can result in high BWA occurrence rates due to insufficient operator training and poor access to spare parts when repairs or replacement are needed. It was found that in NL when communities were under a BWA due to their disinfection system being offline for maintenance, spare parts and emergency repair parts were not available (Conestoga-Rovers & Associates, 2010). Access to proper training, expertise and parts is needed to properly maintain and operate a water system.

Enforcement

According to the policies associated with protected public water supplies, the rules and regulations pertaining to protected public water supplies are enforced through a system of permits and inspections/investigations (Government of NL, 2013f). If there is a noted non-compliance with the conditions of a permit, the DOEC's Water Resource Management Division should be notified. However, having municipal staff/volunteers to monitor this water can be a problem and relates back to Human Resources issues noted above.

What is happening to the drinking water systems and why?

5.0 State

The overall state of public drinking water systems in NL COTOLs is complex due to the sheer number of water systems, the differences between those systems, and the diversity of local socio-ecological systems within the province. While recognizing this complexity, the overall state of drinking water systems in NL COTOLs can be assessed by analyzing general trends of key indicators. Guiding questions include: Is the state of water systems generally deteriorating, stagnant, or improving? This aggregate level of analysis is suitable for this scoping exercise. The state of drinking water is determined using three indicators:

1. The current number and coverage of protected of public water sources,
2. The current number, duration, and cause of boil water advisories, and
3. The Drinking Water Quality Index (DWQI) values.

5.1 Protected Public Water Sources

As noted in the DOEC Water Resources Management Division's 2012 Annual Report on Drinking Water Safety, there are 483 public water supplies in the province of which 314 are protected under s. 39 and s. 61 of the *Water Resources Act* (WRA). That means 65% of all public water sources are designated as protected public water supply areas (PPWSAs). The Annual Report stresses that "these PPWSAs service a population of 372,212, representing 91% of the serviced population" (Government of NL, 2013g). However, the population of NL is 512,000, meaning that only approximately 72% of all NL residents (as distinguished from the "serviced population") get their drinking water from a PPWSA. Drinking water sources that are more widely used in rural settings (e.g., private sources and roadside springs) are not protected to the same degree. Furthermore, most source water protection measures under the WRA are the municipalities' or local service districts' responsibility to enact. COTOLs often lack human capacity, which could pose a problem in meeting mandated source water protection responsibilities.

Table 2 - *Reasons for Boil Water Advisories for sources serving less than 1,000 people, as of July 29, 2013* (Government of NL, 2013c).

Reason for BWA	Code	#
Water supply has no disinfection system	A	43
Chlorination system is turned off by the operator, due to taste or other aesthetic considerations.	B1	7
Chlorination system is turned off by operator, due to perceived health risks.	B2	2
Chlorination system is turned off by operator, due to lack of funds to operate.	B3	11
Chlorination system is turned off by operator, due to Non-consumption Order.	B4	1
Disinfection system is off due to maintenance or mechanical failure.	C1	40
Disinfection system is off due to lack of chlorine or other disinfectant.	C2	1
Water distribution system is undergoing maintenance or repairs.	D1	21
A cross connection is discovered in the distribution system.	D2	0
Inadequately treated water was introduced into the system due to fire flows, flushing operations, interconnections, minor power outage or other pressure loss.	D3	13
Water entering the distribution system or facility, after a minimum 20 minute contact time does not have a free chlorine residual of at least 0.3 mg/l or equivalent CT value.	E1	34
No free chlorine residual detected in the water distribution system.	E2	47
Insufficient residual disinfectant in water system primarily disinfected by means other than chlorination.	E3	1
Total coliform detected AND repeat samples cannot be taken as required	F2T	1
Escherichia coli (E. coli) detected AND repeat samples cannot be taken as required	F2E	6
Total coliforms detected and confirmed in repeat sample.	F3	13
Escherichia coli (E. coli) detected in an initial sample(s) is considered extensive and the water system has other known problems.	F4	0
Escherichia coli (E. coli) detected and confirmed in repeat sample.	F5	4
Viruses detected (e.g., Hepatitis A, Norwalk).	F6	0
Protozoa detected (e.g., Giardia, Cryptosporidium).	F7	0
Water supply system integrity compromised due to disaster (e.g., contamination of water source from flooding, gross contamination, major power failure, etc.).	G	0
Waterborne disease outbreak in the community.	H	0
None listed	Z	3

5.2 Boil Water Advisories

As of July 29, 2013, there were 256 boil water advisories (BWAs) affecting 184 communities in NL (Government of NL, 2013c). The causes of the BWAs as of July 29, 2013 are aggregated in Table 2 and Figure 1. All but 7 of the 184 communities (and 8 of the 256 sources) serve COTOLs, suggesting that COTOLs face a disproportionate number of BWAs. However, this is unsurprising as the Province has prioritized water system funding based on housing density (Government of NL, 2001b). More importantly, of the 248 BWAs issued for water sources serving less than 1,000 persons, over half of them (n=137) are long-term BWAs. They have been in place since 2008 or earlier with one exception: the town of Burgeo. All of the communities with populations greater than 1,000 have only recently issued BWAs (Government of NL, 2013c). This fact suggests that major long-term problems afflict small communities. The causes of the BWAs are not being addressed in adequate time. Based on the reasons behind BWAs, there are clear problems with operations and maintenance (83 incidences – codes B1-B4, C1-C2, D1) and treatment (183 incidences – codes A, D3, E1-E3). Detected substances (24 occurrences – codes F2T, F2E, F3, and F5) are also a persistent problem but less common.[6] It is encouraging that there are no BWAs due to cross connections, viruses, protozoa, compromised system integrity due to disasters, or waterborne disease outbreaks. The three sources without listed reasons (Chance Cove-Albert Rowe Well, Englee-Island Cove Pond), and L'Anse au Clair-Park Pond) should have their respective reasons released to help assess how concerning BWAs across the province actually are.

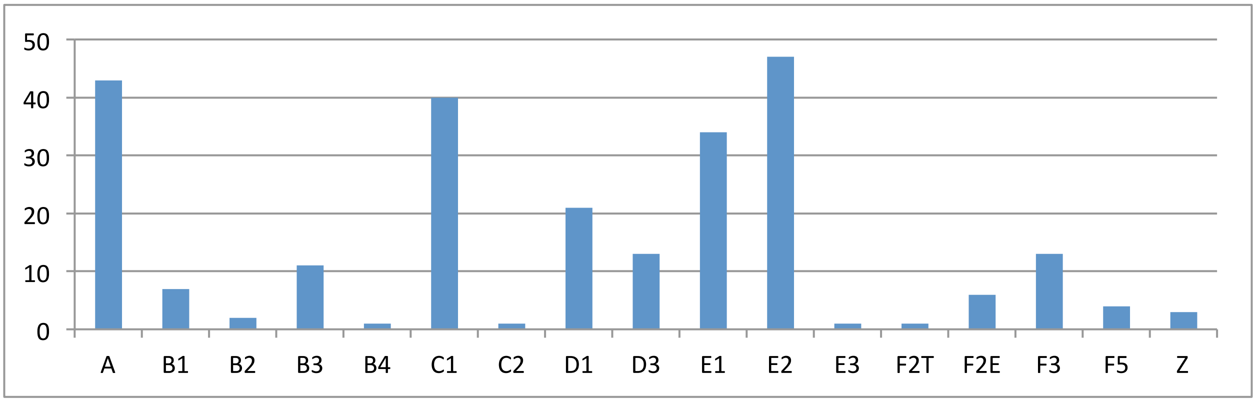

Figure 1 – *Number of Boil Water Advisories for sources serving < 1,000 people, by Code*

In sum, the current number, duration, and causes of BWAs in NL in general, and for COTOLs in particular, indicate that BWAs are neither short-term nor sporadic measures to protect residents from occasional exceedance of parameters. Rather, they have become institutionalized norms, which allow for drinking water issues to be managed but not solved. COTOLs, due to their small size, remoteness, and small tax base, bear the burden of being more likely to experience a BWA. This form of geographic inequality needs to be further addressed through policy responses.

5.3 The Drinking Water Quality Index

The third indicator used to evaluate the state of drinking systems in COTOLs is the Drinking Water Quality Index (DWQI). According to the DOEC, The DWQI is calculated by comparing the water quality data to Guidelines for Canadian Drinking Water Quality [GCDWQ]. The DWQI measures the scope, frequency, and amplitude of water quality exceedances, and then combines the three measures into one score. This calculation produces a score between 0 and 100; the higher the score the better the quality of water. Scores are then ranked into one of the five categories described below:

- Excellent: (DWQI Value 95-100) - Water quality is protected with a virtual absence of impairment; conditions are very close to pristine levels. These index values can only be obtained if all measurements meet recommended guidelines all of the time.
- Very Good: (DWQI Value 89-94) - Water quality is protected with a slight presence of impairment; conditions are close to pristine levels.
- Good: (DWQI Value 80-88) - Water quality is protected with only a minor degree of impairment; conditions rarely depart from desirable levels.

[6] However, it is unclear if a community with code A could also be identified as code F5, for example.

- Fair: (DWQI Value 65-79) - Water quality is usually protected but occasionally impaired; conditions sometimes depart from desirable levels.
- Marginal: (DWQI Value 45-64) - Water quality is frequently impaired; conditions often depart from desirable levels.
- Poor: (DWQI Value 0-44) - Water quality is almost always impaired; conditions usually depart from desirable levels.

DWQI scores are computed for each public water supply system that has been sampled during a sampling season. The same variables are used in the computation of the DWQI for all public water supply systems and only the six most recent samples are used. However if a public water supply system is on a BWA, or it has a current contaminant exceedance, or has a THMs average above the drinking water quality guideline, a DWQI score is not computed (Government of NL, 2013e). Results from the fall 2012 DWQI Summary, which included 255 public water supplies (total number is 483) in NL are detailed in Table 3. While the data from the DWQI are informative, it is important to note that, tellingly, these data are only given for 87 of 255 (34%) the sources included, which is a mere 18% of all public water sources. Of the public water supplies included, 168 (66%) were not given ratings because of BWAs, contaminant exceedance, or THM or HAA exceedance. In other words, most of them failed to meet the criteria to even get a rating.

Based on the preceding discussion, the state of drinking water systems in NL COTOLs is fragile. First, the current number and coverage of protected of public water sources does not extend to all residents, and disproportionately those in COTOLs. Second, the current number, duration, and cause of BWAs indicate a long-term reliance on these orders instead of making expensive capital investments. BWAs are not, therefore, being used as a temporary safety mechanism in emergency situations in many COTOLs as intended, but rather, as a long-term response to the underlying problem. Third, the fact that the DWQI values could not be calculated for 66% of the sampled public water sources (due to the described reasons) is indicative of questionable drinking water quality throughout the province.

Thus, the sustainability of drinking water systems is in danger due to the continuing lack of source water protection, the need for BWAs, and the failure to fall within the parameters in the CGDWQ. Due to the complex existence of, and interaction between, the identified drivers and pressures, drinking water systems in NL COTOLs continue to be afflicted by BWAs, unprotected sources (both public and private), and drinking water of questionable quality. Managing water problems through BWAs instead of solving them through more proactive, long-term policy measures results in a fragile state of affairs.

Table 3 - *Aggregate results from DWQI, fall 2012*

Ratings Categories of the DWQI	# of Public Water Supplies with that Rating
Number of public water supplies with an *excellent* rating	74
Number of public water supplies with a *very good* rating	9
Number of public water supplies with a *good* rating	4
Number of public water supplies with a *fair* rating	0
Number of public water supplies with a *marginal* rating	0
Number of public water supplies with a *poor* rating	0
Number of public water supplies not rated due to a BWA	112

Number of public water supplies not rated due to a current contaminant exceedance[7]	2
Number of public water supplies not rated due to a higher than THM guideline	28
Number of public water supplies not rated due to a higher than HAA guideline	26

What are the consequences for the environment and humanity?

6.0 Impacts

The current fragile state of drinking water systems in NL COTOLs impacts both the quality of ecosystems and the health of individuals. The Millennium Ecosystem Assessment presents a framework for determining the functionality of different aspects of the environment through "ecosystem services" and their impacts on "the constituents of human well-being" (UNEP 2009b; UNEP, 2005). The consequence of having fragile drinking water systems is that there are greater risks placed on the proper functioning of freshwater ecosystem services, threatening the determinants and constituents of well-being. Some impacts can be easily derived: exceeding contaminant standards for drinking water, the existence of water-borne illnesses, increases in droughts/floods, shortages of accessible and uncontaminated water (freshwater shortage), increased erosion, changed wildlife and fish habitats, modified natural stream flows, and negative perceptions of communities with known low-water quality. These are concerning impacts for the NL COTOLs that are experiencing outmigration and aging populations.

6.1 Reduced Access to Necessity of Life

When residents are unable to safely ingest municipal drinking water, they experience reduced access to clean drinking water; a necessity of life which has been recognized in international law as a basic human right (United Nations, 2010). More than half of all NL COTOLs are on long-term BWAs, and many more experience short-term BWAs. These are due to issues such as system upgrades and high levels of THMs or HAAs. The reasons behind the BWAs indicate clear problems with operations, maintenance, and treatment in water systems and geographic inequality in the province regarding policy responses. In turn, the institutional norm created by regular BWAs may have a detrimental effect on residents' trust in the municipal system and preferences for publicly supplied water (Holisko, Speed, Vodden, & Sarkar,

[7] Arsenic in Flat Bay and Freshwater

2014). This may lead them to seek out alternative, yet possibly unreliable, sources of drinking water such as bottled water or natural springs.

6.2 Short and Long-term Health Effects

Contaminants in drinking water can have short or long-term negative health effects. The provincial government's guidelines for drinking water quality (Government of NL, 2008b) are based on those developed by Health Canada (2012).[8] Microbiological contaminants consist of bacteria, viruses, and pathogens. Bacteria may cause gastrointestinal upset (nausea, vomiting, and diarrhoea) or may infect lungs, skin, eyes, the central nervous system or liver (Health Canada, 2012). The most immediate threat to human health from drinking water is Escheria coli (E. coli) bacteria. Enteric viruses and protozoa (Giardia and Cryptosporidium*)* are linked with gastrointestinal problems (nausea, vomiting, and diarrhoea) and less commonly may result in respiratory problems, muscular syndromes, and liver or central nervous system infections (Health Canada, 2012). Turbidity has indirect associations with human health as particles in water may harbour harmful microorganisms, heavy metals, and biocides (Health Canada, 2012). Chemical and physical contaminants found in the province's water supplies are detailed each year in the Drinking Water Safety in Newfoundland and Labrador Annual Reports (Government of NL, 2008b). A complete list of chemical parameters can be found in Health Canada's guidelines (2012). Harmful heavy metals such as arsenic, barium, and lead have been detected in exceedances in tap water by the province (Government of NL, 2008b). Possible health effects from exposure to these contaminants include cancer (arsenic),[9] cardiovascular disease (barium), and biochemical and neurobehavioral effects (lead) (Health Canada, 2012). Disinfection by-product levels (THMs and HAAs) have also been found in exceedance of Health Canada's acceptable levels in the province (Government of NL, 2008b). Exposure to THMs is linked to liver cysts and kidney or colorectal cancers. Exposure to HAAs is associated with liver cancer and other organ cancers (Health Canada, 2012).

6.3 Costs of Addressing Drinking Water Concerns

Many drinking water systems in the province are old and in need of repairs or improvements in some capacity, with a number of systems being over 20 years old. The frequency and length of BWAs in the province can be a source of stress and inconvenience to residents as well as municipal representatives and staff. Barriers to addressing drinking water concerns in NL include poor asset management of water distribution infrastructure; a lack of human resources and training; and fiscal constraints regarding remuneration and the costs of system upgrades (Conestoga-Rovers & Associates, 2010). In addition, although NL has experienced significant economic growth over the past decade overall, a lack of economic development in rural areas has led municipalities in those areas to rely primarily on municipal operating grants and taxes from residents rather than taxes from businesses to pay for water upgrades (Conestoga-Rovers & Associates, 2010). A lack of economic development in NL COTOLs also translates into high unemployment rates and the low resident retention, which affects the tax base that supports water system upgrades.

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[8] For complete guidelines, see www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2012-sum_guide-res_recom/index-eng.php

[9] The consumption of arsenic through drinking water over a lifetime has been linked to certain types of internal organ cancers (Health Canada, 2006).

Legal liability for damages or harm is another major potential cost of these aging water systems. In NL, the majority of people receive their drinking water from public community water supplies. These sources are owned and operated by the municipality or local service district. The provincial Department of Environment and Conservation and Service NL monitor public drinking water quality. In addition, some municipalities in the province also monitor water quality parameters (Government of NL, 2008). Municipal water operators are responsible for testing the water for chlorine residuals twice daily in two different locations, which indicates whether there is sufficient chlorination. The provincial government is responsible for testing chemical, physical, and bacteriological parameters as well as disinfection by-products (Government of NL, 2009b).[10] The topic of liability becomes most salient in instances of illness due to water contamination. The Walkerton Tragedy, in which several people died and hundreds became ill after drinking contaminated water, is a well-known Canadian example (Wellington, Burley, & Rollinson-Lorimer, 2007). The water operators, who were not formally trained, were subjects of the criminal investigation into the tragedy, and eventually, pled guilty to a charge of common nuisance (R. v. Koebel, 2004). The Government of Ontario also launched a public inquiry (the Walkerton Inquiry) to investigate the cause of these events and the government policies and procedures related to water quality (Ontario Ministry of the Attorney General & O'Connor, 2002). Ten years after the Inquiry, Ontario has followed through on the majority of the recommendations it laid out to improve drinking water safety in the province. Though no comparable water crises have occurred in NL to date, between 1993-2008 there were four confirmed outbreaks of giardiasis in NL (Wilson et al., 2009). These outbreaks and the Walkerton event serve as reminders of the potentially tragic consequences of contaminated drinking water. It highlights the need for safe drinking water legislation to avoid similar disasters in the province in the future.

6.4 Ecosystem Services

Ecosystem services are defined as the benefits people obtain from ecosystems (UNEP, 2005). There are four types of services: *Provisioning* – products obtained from ecosystems*; Regulating* – benefits obtained from regulation of ecosystem processes; *Cultural* – nonmaterial benefits obtained from ecosystems; and, *Supporting* – services necessary for the production of all other ecosystem services (UNEP 2005). Freshwater ecosystems, the foundation of drinking water systems, provide irreplaceable services to NL residents. Table 4 summarizes the findings of the Millennium Ecosystem Assessment on the ecosystem services provided by freshwater and the hydrologic cycle (UNEP, 2005). These are the ecosystems services that may be negatively impacted by adverse changes in the state of drinking water systems, for example an increase in the amount of phosphorus pollution or organic matter in a drinking water source. Understandably, the main ecosystems services of interest are the provision of drinking water, the regulation of water quality, and the regulation of water levels. These services are intimately interrelated; a negative impact on water regulation through changed land use patterns upstream would impact the provision of high quality drinking water in sufficient quantities (Elsin et al., 2010). Moreover, the extraction of drinking water will impact the regulatory functions. It is a complicated but internally resilient system of ecosystem services, which is why it is necessary to ensure these services are not degraded by external perturbations. These ecosystem services are directly related to the determinants and constituents of well-being: health, security, basic material for a good life, and good social relations

[10] The provincial guideline for these can be accessed at
http://www.env.gov.nl.ca/env/waterres/regulations/policies/water_quality.html

(UNEP, 2009). For example, poor drinking water quality constitutes a threat to human health, and may strain social relations between residents and public works or industries.

Table 4 - *Ecosystem Services Provided by Fresh Water and the Hydrologic Cycle* (UNEP, 2005)		
Provisioning	**Regulatory**	**Cultural**
Water (quality and quantity) for consumptive uses, like drinking and irrigation.	Water purification: maintenance of water quality (natural water filtration and treatment)	Recreation Aesthetic Inspirational Cultural heritage
Water for non-consumptive uses, like hydroelectricity and transport.	Water regulation: buffering of flood slows, erosion control through water/land interactions	Tourism, including eco-tourism Sense of place
Aquatic organisms for food and medicines		Existence values
Supporting		
Role in nutrient cycling (maintain floodplain fertility)		
Predatory/prey relationships and ecosystems resilience.		

What is being done and how effective is it?

7.0 Responses

Now that we understand how important drinking water systems are for ecosystem services and human well-being, we need to determine what is being done to address, minimize, and mitigate drinking water issues in NL, with special reference to COTOLs. The review of secondary information includes government policies, plans, and programs. In order to describe policy responses and their effectiveness, it is necessary to briefly identify the key policy actors that are responding. There are multiple authorities responsible for drinking water policy in Canada due the country's federal system of government. Because neither "the environment" nor "water" are explicitly mentioned in the division of powers in the *Constitution Act, 1867* (i.e. Sections 91 and 92), jurisdiction over water is somewhat ambiguous and shared between the provincial and federal governments (Friends of the Oldman River Society v. Canada [Minister of Transport], 1992; Bailey, 2008). However, the provinces and one of the territories have primary authority over the management of water derived from four provincial legislative authorities: municipal institutions in the province (section 92(8)), local works and undertakings (section 92(10)), property and civil rights in the province (section 92(13)), and generally all matters of a local or private nature in the province (section 92(16)) (Environment Canada, 2010c; Bailey, 2008). The provincial governments are thus nominally responsible for providing safe drinking water except in areas within federal jurisdiction (First Nations lands, national parks, etc.), and are able to devolve power to municipalities who then operate and maintain drinking water systems and distribute drinking water to users (CCME, 2004; Government of NL, 2001a).[11] The relevant government actors are:

[11] For a more detailed analysis of the constitutional basis of environmental law in Canada, see (Valiante, 2001),

- *The Federal Government* - Environment Canada, Health Canada, Public Works and Government Services Canada, Intergovernmental Affairs with the Privy Council Office, Aboriginal Affairs and Northern Development;
- *The NL Government* - Department of the Environment and Conservation, Department of Municipal and Intergovernmental Affairs, Department of Health and Community Services, Department of Natural Resources, and Service NL;
- *The municipal governments/local service districts* - staff, officials, operators, volunteers; and,
- *The intergovernmental committees* - Federal-Provincial-Territorial Committee on Drinking Water.

Key non-state actors include individuals with private water sources, regional health boards, watershed management committees, well drillers, consultants, water operators, the general public (consumers), and the media. Beyond these actors, it is clear that the NL's largest industries (see Table 2) are also directly or indirectly engaged with drinking water policy.

7.1 Policy Commitment Review

Federal Government: The federal government expresses its commitments to Canadians through the Speech from the Throne, which outlines the government's agenda for the coming session of parliament where substantive measures such as legislation, policies, and funding opportunities will be debated. Many of the contemporary speeches directly address drinking water or general water quality. Examples include:

"Having made safe drinking water and effective waste-water treatment on-reserve a national priority, our Government will introduce new legislative measures to further this goal" (Parliament of Canada, 2010a).

"The Government of Canada… Will fund improvements to municipal water and waste water systems through the federal-provincial-municipal Infrastructure Canada program.…will also invest in research and development and advanced information systems to enable better land use and protect surface and ground water supplies from the impact of industrial and agricultural operations" (Parliament of Canada, 2010b).

"The great natural resources that we take into our second century will be vital to us in meeting our needs and in maintaining our position as a major world trader… Water itself is becoming a more and more valuable resource. Efforts to combat pollution are taking on an economic as well as a social significance and the federal government intends to press forward in cooperation with the provinces. In keeping with this objective, you will be asked to approve a new Canada Water Act which will provide a framework for the improvement and implementation of Canadian water policy" (Parliament of Canada, 1967).

The federal government's primary means of achieving its Throne Speech goals is to pass legislation. As noted in the 1967 Speech from the Throne, the *Canada Water Act,* administered by Environment Canada, is the most prominent piece of federal water legislation; however, due to the transjurisdictional nature of water policy and the Constitutional division of powers in Canada, it is, in fact, a "framework for cooperation with the provinces and territories in the conservation, development and use of Canada's water resources" (Environment Canada, 2012). Moreover, the federal government has recommitted itself to clean, sustainable drinking water for First Nations (see section 91(24) of *Constitution Act, 1867*) by enacting the *Safe Drinking Water for First Nations Act* in 2013. Its preamble states: "*… it is important for residents of First Nation lands to have access to safe drinking water*" (Government of Canada, 2013). Additional relevant federal legislation to the protection of drinking water are the *National Parks Act*, the *Canadian Environmental Assessment Act, 2012*, the *Fisheries Act*, the *Canadian Environmental Protection Ac*t, and the *Navigation Protection Act*.

Beyond the GCDWQ, Environment Canada's *Federal Water Policy, 1987* is the main federal policy document that pertains to drinking water. This broad-based policy is rooted in an ecosystems-based approach that strives "to protect and enhance the quality of the water resource; and, to promote the wise and efficient management and use of water" (Environment Canada, 2013). This policy document, like the *Canada Water Act,* is mostly a framework and respects the authority of the provinces and municipalities (CCME, 2004). This is not an exhaustive list of the Canadian federal government's commitments to drinking water, but reveals its primary sources and gives a general sense of its overall commitment. The federal government also provides funding opportunities for drinking water infrastructure, including Building Canada Fund–Communities Component, Building Canada Fund–Major Infrastructure Component, Municipal Rural Infrastructure Fund, and Infrastructure Stimulus Fund (completed), and Canada Strategic Infrastructure Fund (completed).

Intergovernmental: As noted above, the federal government and the provinces work together through the Federal-Provincial-Territorial Committee on Drinking Water. This body has provided three major documents which clearly demonstrate intergovernmental commitment to drinking water: th*e* GCDWQ, the Guideline Technical Documents, and the Multi-Barrier Approach to Safe Drinking Water. Moreover, since 1988 Canada and NL have the Canada—Newfoundland Water Quality Monitoring Agreement—reached under the auspices of the *Canada Water Act*. These intergovernmental committees, documents, and agreements reflect shared commitments to drinking water.

***Provincial Government*:** The provincial government of NL has similarly expressed its commitment to drinking water through speeches to the throne. The most recent reference in 2011's speech stated that: "Regional cooperation will enable us to make great gains in… securing safe drinking water systems"(Government of NL, 2011c). While the 2010 speech spoke to working with municipalities to improve the accessibility of drinking water (Government of NL, 2010), the most explicit commitments came from the 2005 and 2002 speeches:

"*Several municipalities are also experiencing significant challenges in obtaining and retaining appropriately-trained personnel to operate the increasingly-complicated infrastructure needed to meet drinking water and waste water standards. Having learned from the errors of others, My Government is determined to protect our people from contaminated drinking water by working closely with our municipalities to ensure they have access to the necessary resources to carry out proper testing and proper reporting" (Government of NL, 2005b).*

"My Government will continue to implement its action plan to improve drinking water quality. It will increase the number of inspectors. It will increase the frequency of water testing. It will continue to provide funding to municipalities to install or upgrade chlorination equipment and provide appropriate training for municipal operators. And My Government will keep the public informed of the results of its testing program, consistent with its openness and accountability agenda" (Government of NL, 2002d).

The legislation, policies, and funding opportunities from the NL Government, primarily through the DOEC and the Department of Municipal and Intergovernmental Affairs, clearly reflect a commitment to clean, safe, and sustainable drinking water. The province has a divided regime governing drinking water. *The Water Resources Act* deals largely with management issues; the *Municipalities Act* addresses the practical service issues of water systems, and the *Environmental Protection Act*. These Acts are supported in part by the *Expropriation Act*, the *Hydro Corporation Act*, the *Forestry Act*, the *Mining Act*, and the *Provincial Parks Act.*

Table 5 - *Snapshot of the WRA and EPA*

	The Water Resources Act (2002)	The Environmental Protection Act (2002)
Purpose	"To ensure the continuing availability of clean water for the environmental, social and economic well-being of the province."(Government of NL, 2002c).	To provide "an up-to-date framework for environmental protection and preservation and contributes to the goal of sustainable development for Newfoundland and Labrador" (Government of NL, 2002b).
Underlying Principles	As explained in the Guides to the Acts: protection of human health, precautionary approach, sustainable development, stewardship, pollution prevention, wise use (WRA only), stakeholder involvement, polluter pays, efficient and effective administration, and enabling legislation.	
Main Features for Drinking Water	License regime for water rights, permitting regime for activities, source protection through the designation of public water supplies and non-domestic wellheads.	Regulating the release of substances that may cause an adverse effect on the environment, regulating the release of dangerous goods, prohibiting pesticides from entering a body of water

The province also has policies for issues like water use, development, monitoring, reporting, and operator certification. Information is made available to the public through the NL Water Resource Portal, a web-based tool that signifies a commitment to accessible information. The province's commitment to drinking water is also evident through its annual workshop focussed on small, rural systems (Government of NL, 2013a). These commitments are housed in what is known as the Multi-Barrier Strategic Action Plan (MBSAP) (see fig 2). Like many jurisdictions, NL has opted to use an overall plan to protect the quality and quantity of drinking water at all sections of water systems. This three-level protection scheme is intended to protect the 'source to the tap' and is derived from the aforementioned Multi-Barrier Approach to Safe Drinking Water of the Provincial-Territorial Committee on Drinking Water.

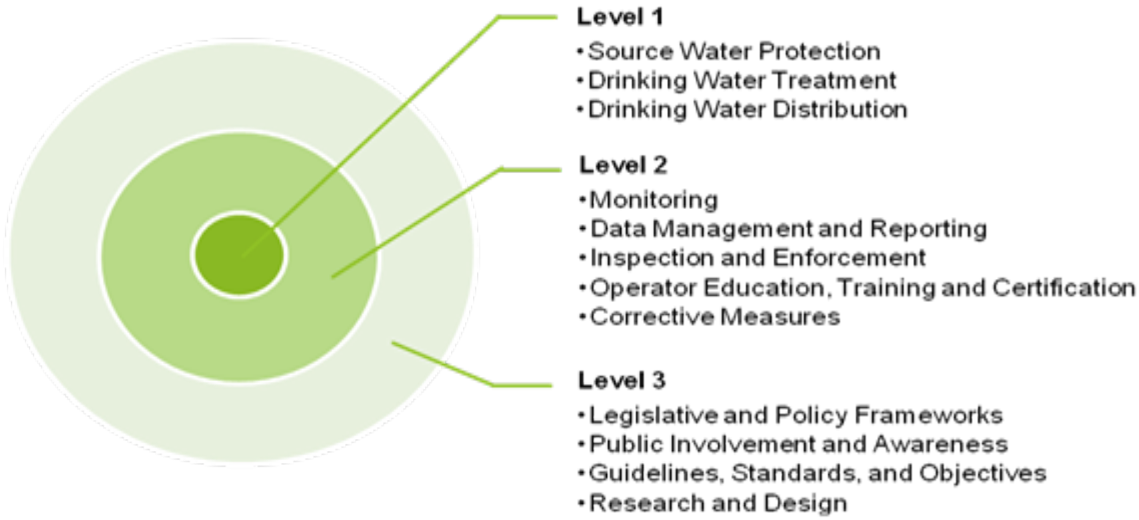

Figure 2 - *NL's MBSAP* (Government of NL, 2013g)

In 2009 the provincial government introduced a three-year Drinking Water Safety Initiative, which included identifying issues, creating sustainable plan of action to address those issues, and installing Potable Water Dispensing Units. When introducing the initiative Dave Denine, former Minister of Municipal Affairs said, "*We are committed to working with municipalities to identify shortfalls which may exist, and address water infrastructures which may require investment to ensure services are modern, secure, safe and accessible to all communities throughout Newfoundland and Labrador… Water is an essential part of our daily lives. This government understands the need for this basic requirement of life and will continue through the drinking water initiative to bring potable water to communities throughout the province"* (Government of NL, 2008a). Former Minister of Environment and Conservation, Charlene Johnson further spoke to the province's commitments to drinking water: "*The geography and various environmental factors of some of the smaller communities throughout Newfoundland and Labrador do not permit a 'one size fits all' approach to dealing with water quality matters…Through phase one and the subsequent phases of our initiative, we will continue to reaffirm our commitment to safe and reliable drinking water for all residents, determining the appropriate solution for communities* "(Government of NL, 2008a).

Finally, NL has committed financial support to initiatives aimed at drinking water safety. In order to minimize potential environmental damage from mega projects, the 2013-2014 Budget allocated $224,000 of new funding (total funding of $1.01 million) for real-time water quality monitoring (Government of NL, 2013d). However, the 2013-2014 Budget allocated $3,511,800 for all water resource management: Appropriations provide for the development and implementation of policies and programs governing surface and ground water, drinking water quality and wastewater management, the administration of hydrometric agreements in conjunction with the Federal Government, reporting on the state of water resources and the provision of various water-related investigations, studies and authorizations. Appropriations provide for the Water Quality Monitoring Agreement which is delivered jointly with the Federal Government. That amounts to a 17.2% decrease from the 2012-2013 Budget of $4,241,700 (Government of NL, 2013h). There are also numerous funds available from the province to support drinking water systems. For example, the province's 2013-14 budget allotted $130 million for the second year of a municipal Capital Works Program to fund infrastructure projects, including water treatment. Moreover, the Potable Water Dispensing Units Municipal Rural Infrastructure Fund (MRIF) was a "Federal/Provincial/Municipal cost shared program which invest[ed] $100,386,000 over the four year period between 2006 and 2010 in municipal and rural infrastructure projects;" of which, water improvements was a first tier priority (Government of NL, 2013k).

Local Government: Identifying the commitments of local governments is challenging. Their commitments are more diffuse because there are hundreds of communities, some with water systems managed by municipalities and others by local service districts. To gauge the overall support we looked at the Municipalities of Newfoundland and Labrador (MNL), which represents 276 incorporated municipalities, 89% of the population of NL (MNL, n.d.a). It has addressed issues of drinking water in its annual Municipal Symposiums, raised questions to federal candidates, critiqued the 2012 federal budget for providing inadequate funding for drinking water infrastructure, and hosted a Clean and Safe Drinking Water Workshop in March 2012. MNL has clearly demonstrated a commitment to drinking water in NL. Municipal government and local service districts are governed by Community Charters or Local Government Acts, as enabled by the province's *Municipalities Act.* Among other things, this enabling provincial legislation empowers local councils to provide public water supply systems. Municipalities are then able to enact their own by-laws and regulations within this framework, which may solidify their commitment to providing drinking water (MNL, n.d.). Other relevant Acts are the *Municipal Affairs Act* and the *Urban and Rural Planning Act, 2000* (Government of NL, 2013l). It is at this local level of government that municipal workers and officials experience drinking water conditions; it is their community, their household, and their water. The commitment of local government to drinking water sustainability was palpable at the 2013 MNL Symposium.

Table 6 – Water *Policy Commitment Report Card for NL*

Issue	**Goals and Targets**	**Strategy or Action Plan**	**Status**
The questionable sustainability of drinking water systems in NL COTOLs	1. Safe and reliable drinking water for all residents (present and future) 2. Source to tap protection 3. Various parameter values under the GCDWQ	MBSAP	MBSAP is implemented; however, major problems, (pressures, exceeding parameters, BWAs, limited protection, and critical public perceptions) continue.

In summary, the federal government has broad policy commitments for the protection and management of water in cooperation with the provinces. The provinces are responsible for providing the safe drinking water, and this responsibility is devolved to the municipalities or local service districts. The outcome of this overview of policy committeeman's is the Policy Commitment Report in Table 8, which qualitatively evaluates whether the commitments have been effectively fulfilled.

Overall, it is reasonable to say that the NL has constitutionally-derived commitments to drinking water. Ensuring the sustainability of drinking water systems is one way the province can ensure it meets these commitments today and for future generations. Beyond the Speeches from the Throne, NL has developed and implemented a new water resource legislative framework in the past 10 years. While, recent budget cuts for water resource management reflects overall spending cuts, the continued funding of infrastructure is a positive sign for continued commitment. However, there needs to be a balance in the budget between building and repairing drinking water infrastructure and supporting the proper administration, operation and maintenance of it. Moreover, in the COTOLs that are less likely to see a major infrastructure project to improve their drinking water system, the continued monitoring and reporting is vital to protecting human health and ensuring ecological integrity. With commitments across all levels of government, the province of NL is well-positioned to fulfil and build on its commitments to improve the source protection, monitoring, reporting, and general sustainability of drinking water systems.

7.2 Policy Scan

Some key elements were noted by scanning the policies in Table 8. First, the WRA and EPA are highly discretionary (ministerial), with only some prescriptive elements – see s. 1(2) of the WRA. The major protective mechanisms for drinking water sources apply only if designated as a PPWSA—and the designation process is optional, proponent led, and only applicable to public water supplies and non-domestic wellhead areas. This regime leaves many sources of water with the limited protection afforded elsewhere in the WRA and the EPA.

Second, the legislation is designed to be regulatory. That means there is major reliance on the regulation-making authority of the Lieutenant-Governor in Council under the WRA and EPA rather than being explicitly prescribed in the Act. While the process for drafting and approving regulations is no doubt more efficient than that of legislation, there are minimal drinking water relevant regulations made under these authorities. It does not appear that the Lieutenant-Governor in Council has exercised the authority to make regulations respecting the designation of public water supply areas and reservoir development areas and activities restricted and permitted in those areas, and respecting the protection of and regulation and control of water flow in those areas [s. 80(dd)]; prescribing the type and manner of protection of public water supplies and the types of activities permissible in a public water supply area [s. 80(ee)]; or establishing standards for water quality in the province and the requirements of persons, industries and institutions with respect to the maintenance of those standards, and respecting the inspection, testing and analysis of water, and the notification of the department of testing and analysis results from a body of water, waterworks, reservoir, well and other water supply by persons, institutions, industries, commercial facilities and well drillers with respect to water intended for domestic, municipal, industrial, institutional, agricultural, recreational, commercial, water power and thermal power purposes [s. 80(ll)].

Third, the main offense for causing an adverse effect to water supplies (all water supplies—not just public water supplies or PPWSAs) requires that the Crown prove the offence was committed willfully or negligently [s. 90(2) of the WRA]. Committing the offence itself is not, in and of itself, enough to be found guilty. The DOEC uses conditions of licensing and certificates of approval strategically to make mandatory requirements for waterworks and their operations. In general, it is noteworthy that establishing regulations is not the only mechanism by which to achieve compliance and enforcement.
Regulations can be cumbersome to update in a field where science and technology change rapidly, and can limit risk management options. Based on the state of drinking water systems and the policies scanned, it is evident that there is a reliance on guidelines and Best Management Practices (BMPs) rather than legally-binding statutory requirements. Municipalities and the Government of NL rely on BWAs due to the inability to meet the standards set out in the GCDWQ.

Fourth, the requirement for all waterworks, at all times, in the province to be maintained, kept in repair and operated in a manner and with those facilities that the minister may direct [s. 38(1)] is clearly not being held to the intent behind it. It is unclear what the minister has directed, but the number of longerterm BWAs that exist due to failures to maintain, repair, and operate facilities suggest that this requirement is under-enforced. Overall, the policy instrument scan produced a picture of provincial drinking water regime with piecemeal protection for its drinking water sources. While the requirements for wells seem the most robust, the reliance on nearly 20 year old voluntary guidance documents, highly discretionary permitting regimes, and the absence of strict or absolute liability for offences under the WRA indicate potential gaps in the current policy mix.

Table 7 - *NL Policy Highlights*

Category	Policies
Expenditure	• Collecting and testing water samples monthly • Treating (generally chlorinating) water • Supporting the introduction of potable water dispensing • Establishing a water portal • Improving access to training and certification for water operators • Providing some funding for new and improved water systems
Economic	• Implementing water rates at the local level
Institutional	• Watershed management plans • Watershed management committees
Regulatory	• Designating and protecting public water supplies and wellheads under the WRA • Regulating activities in designated areas using a permitting regime, founded in ministerial discretionary, under the WRA • Establishing water use (rights) restrictions under a licensing regime under the WRA • Prohibiting certain activities in protected public water supplies and wellheads under the WRA
Guidance	• Implementing boil water advisories • GCDWQ

Table 8 - Policy and Policy Instrument Scan

Direct Expenditure		
Instrument	**MBSAP**	**Implementation Status**
1. Operator Education, Training, and Certification (OETC) program (Government of NL, 2012a).	Level 2 and 3	Yes
2. Monitoring: collecting and testing of water samples (bacteriological, chemical, physical, aesthetics, contaminants) (Government of NL, 2008c).	Level 2 and 3	Yes
3. Research and development activities by the DOEC, specifically technical studies (Government of NL, 2002c, s. 30, s. 31, s. 62; Government of NL, 2002b, s. 5)	Level 3	Yes
4. In situ water treatment (including Portable	Level 2 and 3	26 water treatment plants (7 PWDUs); 106 drinking water

Water Dispensing Units – PWDUs)		treatment systems; 480 disinfection systems
5. Upgrades and new water distribution equipment	Level 1 and 2	Varies by source; $2.85 million for new water distribution; $8.75 million for upgrades to water distribution
6. Establishing a Registry of Water Rights	Level 1	Yes. It is publically available on the DOEC website.
7. Inspection, Compliance, and Enforcement	Level 2	Yes - In the 2011–12 fiscal year, DOEC staff carried out a total of 149 inspections/ investigations.[12] No summary convictions or other enforcement mechanisms identified in the research.
8. Reporting (see 51)	Level 3	Yes – 2 types of reports are prepared and mailed – 964 Seasonal Drinking Water Quality Reports to specific communities (community), 361 Annual Drinking Water Quality Reports (community). Annual Drinking Water Safety in Newfoundland and Labrador Reports and as needed exceedance reports (community) (Government of NL, 2009b).
9. Watershed management plans	Level 1	3 plans are implemented
10. Watershed management committees	Level 3	5 committees are established
Economic		
11. Taxes	None	Yes. Municipalities must impose and determine water and sewer tax rates, s. 130 – 134 of the Municipalities Act
12. Economic measures such as incentives, royalties, subsidies, administrative and other fees, and water use charges.[13]	None	Not Implemented
Regulatory		
Water Resources Act		
13. License regime for the allocation of water rights (resource management) [s. 14 to s.	Level 1 and 3	Yes

[12] Water and Sewer Construction= 66; Protected Surface Water Supplies = 22; Water System Operation = 12; and Protected Groundwater Supplies = 49 (Government of NL, 2013g).

[13] The WRA, s. 29(1), gives The Lieutenant-Governor in Council the ability to establish economic measures such as incentives, royalties, subsidies, administrative and other fees, and water use charges, for the purposes of ensuring the conservation and proper utilization of water resources, and for the financing of programs and other measures. The fees charged for permits and licenses under the Policy for Application and Other Fees is authorized by section 21 of the Executive Council Act.

28]		
14. Permit regime for activities in a PPWSA or a wellhead protected water supply area [s. 48]	Level 1 and 3	~ 110 permits issued during the 2011–12 fiscal year
15. Permit regime to construct water works [s. 36 and s. 37]	Level 1 and 3	156 permits issued during the 2011–12 fiscal year
16. Permit regime to operate water works [s. 38]	Level 1 and 3	330 active permits to operate water distribution systems and 16 active permits to operate water treatment system at the end of 2011–12 fiscal year
17. Permit regime for non-domestic wells [s. 58]	Level 1 and 3	38 non-domestic well permits were issued during the fiscal year
18. Ministerial discretion to designate, by regulation, source protection for current or potential public water supply areas (PPWSA) (surface and groundwater) after receiving an application [s. 39(1)]	Level 1 and 3	314 PPWSAs at the end of 2011–12 fiscal year
19. Ministerial discretion to define and establish wellhead protected water supply areas [s. 61]	Level 1 and 3	
20. Ministerial discretion to designate flood risk areas and floodways, to regulate land development therein, to establish a flood forecast centre, to construct flood control measures, and to designate flood control area [s. 33 and s. 34]	Level 1, 2, and 3	On-going – 38 communities have maps of flood risk areas
21. Ministerial discretion to establish and determine the rate groundwater is to be withdrawn from a well in order to minimize a risk of lowering the water table, which might consequently reduce the yield of nearby wells; avoid salt water intrusion into groundwater in coastal areas or near a source of pollution; maintain a balance between recharge and discharge rates of an aquifer and to minimize the risk of a permanent lowering of the static water level; and avoid other adverse effects. [s. 60(1) and (2)]	Level 1, 2, and 3	Unable to determine if this authority has been used

22. Prohibition on placing, depositing, discharging or allowing to remain in that area material of a kind that might impair the quality of the water in a PPWSA [s. 39(4)(a)]	Level 1 and 3	Yes, but unknown if being enforced
23. Prohibition on fishing, bathing, boating, swimming or washing in, or otherwise impairing the quality of the water in a PPWSA [s. 39(4)(b)], with an exemption power for the Minister to authorize these or other activities if he or she is satisfied that the nature and size of a PPWSA is sufficiently large to preclude an adverse effect. [s. 39(5)]	Level 1 and 3	Yes, but unknown if being enforced
24. Prohibition on using or diverting water that may unduly diminish the amount of water available in a PPWSA [s. 39(4)(c)]	Level 1 and 3	Yes, but unknown if being enforced
25. Prohibition on placing, depositing, or allowing to remain in that area, material which might impair the quality of the groundwater in a wellhead protected water supply area [s. 61(2)(a)]	Level 1 and 3	Yes, but unknown if being enforced
26. It is an offense to willfully or negligently put, or allow to pass into, a well, spring or other source of water supply used by a person, a substance or thing that may cause an adverse effect to a water supply [s. 90(2)]	Level 1 and 3	Yes, but unknown if being enforced
27. Requirement for all waterworks in the province to be maintained, kept in repair and operated in a manner and with those facilities that the minister may direct at all times [s. 38(1)]	Level 1, 2, and 3	Not being met – see BWA list
28. Requirement for a person to have a license to drill, alter, or repair a well [s. 55].	Level 1 and 3	Unknown if being enforced, but there is a publically available list of licenced persons
Environmental Control Water and Sewage Regulations		
29. Prohibition on discharging sewage or effluent into a body of water, as prescribed [s. 6]	Level 1 and 3	Yes, but unknown if being enforced

30. Nothing in these regulations shall be construed to permit the discharge of a pollutant into a body of water [s. 7]	Level 1 and 3	Yes, but unknown if being enforced
Well Drilling Regulations, 2003		
31. Requirement for a well driller to locate a well a sufficient distance away from sources of pollution to prevent contamination of the well by groundwater flow or seepage [s. 9(1)]	Level 1 and 3	Yes, but unknown if being enforced
32. Requirement for ministerial approval to construct a well in a site close enough to a sanitary landfill, garbage dump or other massive source of contamination that it might contaminate the well [s. 11]	Level 1 and 3	Yes, but unknown if being enforced
Municipalities Act		
33. Authority for a municipal council to construct, acquire, establish, own and operate a public water supply system for the distribution of water within or, with the approval of the minister, outside of the municipality. [s. 156(1)]	Level 1 and 3	Yes
34. Authority for a municipal council to acquire waters required for the purpose of providing a sufficient supply of water for the municipality; and to acquire by purchase or expropriation lands adjacent to those waters to prevent pollution of those waters [s. 156(1)]	Level 1 and 3	Yes
35. Authority to declare an emergency in a municipality, or part thereof, because of a shortage of water [s. 204(c)]	Level 1 and 3	Unable to determine if this authority has been used
36. Authority for a local service district committee to contract for or construct, acquire, establish, own and operate a public water supply system and to in relation to the public water supply system determine the time, manner, extent, nature and recipients of the supply [s. 392]	Level 1 and 3	Yes
37. Prohibition for a person, within a municipality, to make or use a new water	Level 1 and 3	Yes, but unknown if being enforced

supply or system except in accordance with a written permit from the council [s. 195(1)(b)		
Environmental Protection Act		
38. Requirement for the minister to, in accordance with the regulations, encourage the prevention and reduction of litter with respect to regulating the disposal of waste on, in or under water and ice; [s. 14(1)(d)]	Level 1 and 3	No – no regulation made under the EPA
39. Prohibition on releasing waste upon land whether or not that land is developed or covered by water unless that waste is disposed of in a receptacle or container placed or located specifically for the purposes of collection of that waste [s. 16(a)]	Level 1 and 3	Yes, but unknown if being enforced
40. Prohibition on washing or submerging in a body of water an apparatus, equipment or container used in the holding or application of a pesticide; and allowing a pesticide or water used to clean an apparatus, equipment or container used to hold or apply a pesticide to enter a body of water [s. 41]	Level 1 and 3	Yes, but unknown if being enforced
41. Ministerial discretion to destroy or prohibit/ restrict the sale, handling, use or distribution of water that is contaminated by a pesticide [s. 42(a) and (b)]	Level 1 and 3	Unable to determine if this authority has been used
42. Prohibition on releasing or permitting the release of a substance into the environment in an amount, concentration or level or at a rate of release that in the opinion of the minister causes or may cause an adverse effect, unless authorized under this Act or an approval issued under this Act [s. 7(1)]	Level 1 and 3	Yes, but unknown if being enforced
43. Prohibition on releasing or permitting the release of a substance into the environment in an amount, concentration or level or at a rate of release exceeding that expressly authorized under this Act or an approval	Level 1 and 3	Yes, but unknown if being enforced

issued under this Act [s. 7(2)]		
Urban and Rural Planning Act		
44. Ministerial discretion to designate an area as a municipal planning area, including land that is necessary for the municipal council to control watersheds for the purpose of municipal water supply, whether within or outside its boundaries [s. 11]	Level 1 and 3	Unable to determine if this authority has been used
45. Ministerial discretion to designate an area outside a municipality as a local planning area, with a local area plan, including water supply [s. 31]	Level 1 and 3	Unable to determine if this authority has been used
Policy Frameworks		
Policy for Drinking Water Quality Monitoring and Reporting for Public Water Supplies		
46. Requirement for all public water supply systems to be monitored for drinking water quality purposes	Level 1, 2, and 3	Yes
47. Prescribes the seasons for water quality monitoring	Level 2 and 3	Yes
48. Prescribes the monitoring parameters	Level 2 and 3	Yes
49. Prescribes the frequency and location of samples (tap and source)	Level 2 and 3	Yes
50. Prescribes the performance monitoring for water treatment plants	Level 2 and 3	Yes
51. Prescribes the collection of water samples	Level 2 and 3	Yes
52. Prescribes reporting requirements	Level 2 and 3	Yes
Policy For Flood Plain Management		
53. Prescribes the limitation of developing lands that flood periodically with planning, zoning regulations and by removing any economic advantages or subsidies that would otherwise encourage such development	Level 2 and 3	Yes
54. Prescribes flood proofing measures for areas already developed	Level 2 and 3	Yes

55. Permitting regime for different project classifications in different flood plain classifications	Level 2 and 3	Yes - unable to determine number of permits authorized
Policy for Construction of Ground and Water Sourced Heat Pumps		
56. Prohibition on installing a GWSHP within 15m of the nearest water well, to prevent the occurrence of well interference between a GWSHP well and adjacent groundwater users	Level 1 and 3	Yes, but unknown if being enforced
Policy for Infilling Bodies of Water		
57. Permitting regime, but generally discouraged	Level 1 and 3	Yes - unable to determine number of permits authorized
Policy for Land and Water Related Developments in Protected Public Water Supply Areas		
58. Ministerial discretion to approve new developments or allow existing developments that are impairing water quality or may impair water quality.	Level 1 and 3	Unable to determine if this authority has been used
59. Permitting regime for development activities, others strictly prohibited.	Level 1 and 3	Yes - unable to determine number of permits authorized
60. Ministerial discretion to require the correction of harmful conditions	Level 1 and 3	Unable to determine if this authority has been used
Policy for Development in Shore Water Zones		
61. Permit regime for development activities in and affecting shore water zone, others strictly prohibited	Level 1 and 3	Yes - unable to determine number of permits authorized
62. Mitigation and restoration measures as outlined in the terms and conditions of the environmental approval	Level 1 and 3	Yes
Policy for Development in Wetlands		
63. Permit regime for development activities in and affecting wetlands, others strictly prohibited	Level 1 and 3	Yes - unable to determine number of permits authorized
64. Mitigation and restoration measures as outlined in the terms and conditions of the environmental approval	Level 1 and 3	Yes
Policy for Treated Utility Poles in Water Supply Areas		
65. Minimizing the impact of chemically treated utility poles in protected water supply areas by requiring re-routing or alternatives.	Level 1 and 3	Yes
Policy for Use of Creosote Treated Wood in Fresh Water		
66. Unclear if still in use as it references a	Level 1 and	Unclear – outdated

replaced Act	3	
Policy for Allocation of Water Use		
67. Unclear if still in use as it references a replaced Act	Level 1 and 3	Unclear – outdated
Non-regulatory Guidance (voluntary)		
Policy for Drinking Water Quality Monitoring and Reporting for Public Water Supplies		
68. Best Management Practices for the Control of Disinfection by-Products in Drinking Water Systems in NL	Level 2 and 3	Yes, but not enforceable
69. Bridges		Yes, but not enforceable
70. Chlorination Equipment Selection Guidelines	Level 2 and 3	Yes, but not enforceable
71. Culverts	Level 2 and 3	Yes, but not enforceable
72. Diversions, New Channels, Major Alterations	Level 2 and 3	Yes, but not enforceable
73. Groundwater Supply Assessment and Reporting Guidelines for Subdivisions Serviced by Individual Private Wells	Level 1 and 3	Yes, but not enforceable
74. Guidelines for Disinfecting Dug and Drilled Wells	Level 2 and 3	Yes, but not enforceable
75. Guidelines for Sealing Groundwater Wells	Level 2 and 3	Yes, but not enforceable
76. Guidelines for the Design, Construction and Operation of Water and Sewerage Systems	Level 2 and 3	Yes, but not enforceable
77. Management of Protected Water Supply Areas	Level 1 and 3	Yes, but not enforceable
78. Pipe crossings	Level 2 and 3	Yes, but not enforceable
79. Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units	Level 2 and 3	Yes, but not enforceable
80. Watercourse Crossings	Level 2 and 3	Yes, but not enforceable
81. Issuance of boil water advisories under the authority in s. 76 of the WRA	Level 2 and 3	Yes, but not enforceable
82. The Guidelines for Canadian Drinking Water Quality (GCDWQ)	Level 2 and 3	Yes, but not enforceable

7.3 Policy Gap Analysis

A policy gap analysis looks at how the policies in place match the identified pressures. In other words, it determines if the major issues are addressed by the policies. The federal-provincial-territorial *Source to Tap* document identifies the need for this type of analysis "Mindsets may need to shift from simply setting or meeting rules to evaluating existing programs, identifying deficiencies or gaps, and correcting them." (CCME, 2004). A policy gap analysis determines if all relevant policies are implemented, judges whether any particular types of policy instruments are missing or underutilized, and compares the policies to the identified pressures.

Most of the policies are assumed to be implemented; however, we were unable to determine the compliance and enforcement of the policies. Moreover, some of the policies–many of the guidelines in particular–are more than 20 years old. The GCDWQ is an exception to this, however, as the Federal-Provincial-Territorial Committee on Drinking Water (CDW) revisits a priority list on an ongoing basis, to do updates or new guidelines based upon the criteria of risk, prominence, and feasibility. Old guidelines may not be prioritized for updating if the related science and technology have not changed significantly. Some become archived if the contaminant of concern no longer occurs in Canada, e.g., old discontinued pesticides no longer detected in the environment (Personal communication AS). In addition, research indicates that some of the policies are not implemented. For example, s. 14(1) (d) of the EPA requires the minister to, in accordance with the regulations, encourage the prevention and reduction of litter with respect to regulating the disposal of waste on, in or under water and ice. But no regulation made under the EPA has this purpose. Most of the policies and policy instruments are regulatory, institutional, or direct expenditure, highly discretionary, generally preventative, reactive in the case of BWAs, and reflect the principles of supply-side management. Consequentially, there is an underrepresentation of economic instruments. As noted in Table 8, section 29(1) of the WRA gives the Lieutenant-Governor in Council the authority to develop economic measures such as incentives, royalties, subsidies, administrative and other fees, and water use charges for the purposes of ensuring the conservation and proper utilization of water resources, and for the financing of programs and other measures. However, this authority has not been used to date. Furthermore, while the supply-side policies in place are necessary, there are missing demand-side policies that could influence user behavior (i.e. water use) (Lavee, Danieli, Beniad, Shvartzman, & Ash, 2013; Renwick & Archibald, 1998).

Comparisons of pressures are linked to the policies and policy instruments implemented is located in Appendix 1. The policies are noted in the rows and the pressures in the columns. If a policy relates to a pressure, an 'X' is included at their intersection. This matrix is used to determine if a policy attempts to address a pressure. Extreme weather (e.g., hurricanes), ecological physical obstructions (e.g., beaver dams), freeze and thaws, and nonpoint pollution were the only pressures that did not fall under one of the identified policies or policy instruments. However, that does not mean the pressures are adequately addressed by the policies. Oftentimes the policies are narrow and at the discretion of the minister. For example, s. 60(1) of the WRA addresses salt-water intrusions, but it really only gives the minister the authority to interfere in wells by establishing and determining withdrawal rates from groundwater to avoid saltwater intrusion. Further, throughout the legislation it does not place any parameters on what can determine ministerial opinion, (e.g., best scientific data, economic considerations). As noted earlier, these policies do not apply to private drinking water sources. Moreover, there is limited for protection for water supplies that are not designated as PPWSAs – the only major offense is to wilfully or negligently put, or allow to pass into, a well, spring or other source of water supply used by a person, a substance or thing that may cause an adverse effect to a water supply [WRA s. 90(2)]. It is also concerning that NL residents have been observed collecting water from roadside springs (AMEC Earth and Environmental, 2008). These springs are not regulated and are minimally protected, for example under s. 90(2) of the WRA. Finally, the gray rather than black boxes indicate uncertainty regarding the implementation of the policy. Few policies exist regarding water conservation in the province (Sabau & Haghiri, 2008).

7.4 Policy Conclusions

Funding is clearly a major barrier to the success of the MBSAP. The relationship between water use, water rates, and the cost of treating water is also important. A 2010 NL study determined an average water rate of $200, with a max of $325. Existing rates would not fully recover the cost for treating water, an estimated $61 - $1,688 per household (3 person household) (Conestoga-Rovers & Associates, 2010). Importantly, smaller communities have higher per household costs. That is, they fall more towards the $1,688 range of the scale. Further study is needed to determine exactly how water rates are actually derived, but due to the generally low rates currently in place, it is assumed that these methods undervalue water since in many cases the rates do not even cover operating costs. Moreover, all the communities researched were on a fixed rate rather than a metered rate (Conestoga-Rovers & Associates, 2010). COTOLs do not have a good business case for establishing and maintaining expensive drinking water systems due to (1) the current and projected demographic trends, (2) the cost per capita—economics of scale, (3) the small tax base, and (4) the human resource capacity challenges.

The compliance to the WRA appears suspiciously high given the rate of incidence and duration of BWAs. A review of legal cases in NL using CanLII produced only two relevant cases (dealing with the same offence) relating to COTOLs.[14] There are several additional cases about drinking water, but they pertain to communities beyond the scope of this report.[15] The majority of cases that involved water pollution relied on other legislation, particularly federal legislation (e.g., the *Fisheries Act*).[16] From this analysis, several scenarios seem likely: 1) persons are fully compliant with the WRA; 2) the minister has used his or her discretion to authorize many activities or 3) the reliance on the reporting and minimal monitoring by the DOEC is insufficient to catch instances of non-compliance.

Perceptions of water insecurity are more likely associated with drinking water exceeding the parameters of the GCDWQ rather than absolute water stress. The yellow colour and taste of chlorinated water, the higher levels of turbidity, the reliance on BWAs, and the other various physical and chemical influences appear to have prompted people to collect water from unregulated sources, in particular roadside springs (Nicol, 2009; Holisko et al, 2014). Interestingly, the 2001 *Source to Tap* report noted there were 322 boil water advisories affecting 223 communities (Government of NL, 2001c). This amounts to a 20.5% reduction in BWAs overall and a 17.5% reduction in the number of communities with a BWA from 2001 to 2012 (Government of NL, 2013g). Progress has been made. The timing would suggest that this reduction is in part due to the introduction of the WRA and EPA in 2002. While it would be unwise to suggest that the province mandates in law, maximum physical and chemical parameters (rather than

[14] Cole v. Aviva Insurance Company of Canada, 2010 NLTD 80; and Cole v Aviva Insurance Co, 2007 NLTD 173

[15] Examples include Allen v. Conception Bay South (Town Council), 2002 CanLII 45645 (NL SCTD); and Crawford v. Town Council of The Town of Torbay, 2008 NLTD 161 (CanLII)

[16] R. v. Corner Brook Pulp and Paper Limited, 2010 CanLII 33018 (NL PC)

being recommended in the GCDWQ), communities need to have some impetus to improve the status quo, whether it be regulatory or economic in nature. Furthermore, there are only 5 Watershed Management Committees (WMCs) in NL. In the *Source to Tap* report the DOEC noted that there were 6 approved. Negative progress has been made over the past 11 years in this respect as well.

While water quality, not quantity, is typically the major concern, the DOEC should consider exploring demand-side policy instruments to urge residents to start thinking more about the value and scarcity of water, and ultimately, help reduce water consumption. The NL Water Atlas is 21 years old. The *Source to Tap* report is over 10 years old, but more importantly, was published before the WRA. Many of the guidelines are 10 or 20 years old, (e.g., pipe crossings). Importantly, these guidelines refer to an outdated legislative regime, were published prior to the recent significant economic changes that have occurred in NL, and before climate change was fully on the agenda.

Operator certification is still voluntary for COTOLS, even though more municipalities are requiring their operators to become certified. However, finding and retaining a water operator is a challenge for many COTOLs due to the changing demographics and economic growth in provinces such as Alberta, where residents of rural Newfoundland and Labrador are increasingly finding work. There is little the DOEC can do to impact either trend.

Lastly, The WRA is designed to be discretionary and rely on regulation-making authority granted under s. 80. As discussed earlier, this authority has been minimally exercised generally and barely for issues relating to drinking water. Some of the policies and guidelines are very old, and although they have been applied to some key issues, further analysis is needed to see if they need updating for their implementation to be meaningful. Some of the policies are identified that are not implemented. For example, s. 14(1) (d) of the EPA requires the minister to encourage the prevention and reduction of litter with respect to regulating the disposal of waste on and on, in or under water and ice, but there is no regulation made for this purpose. The federal government has broad policy commitments for the protection and management of water in cooperation with the provinces. The provincial government has constitutionally-derived responsibilities related to drinking water. Pertinent information regarding numerous policy issues like water use, development, monitoring, reporting, and operator certification are made publicly available through the NL Water Resource Portal and the Drinking water safety in Newfoundland and Labrador annual reports. Policy commitments are outlined in the Multi-Barrier Strategic Action Plan (MBSAP). It is evident that policy instruments are chosen with greater reliance on guidelines and BMPs than on legally binding requirements. The requirement of ministerial direction [s. 38(1)] for all waterworks is clearly not being held to the intent behind it.

As this report has highlighted, drinking water systems in NL are affected by complex interactions between humans, their socio-economic and cultural systems, and the environment. The DPSIR framework provides a useful means of making sense of these multifaceted and interrelated relationships, while structuring them in a way that facilitates more rigorous, systematic investigations into their component parts and dynamics. Accordingly, this scoping exercise is an important first step in eliciting expert opinion to develop more comprehensive, integrated assessments of the sustainability of NL's drinking water systems. Further work in this vein is necessary if public policies towards this critically important resource are to be developed, analyzed, evaluated, and ultimately, improved upon.

8.0 Reference List

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9.0 Appendix

9.1 Appendix 1: Policy and Pressure Matrix

Appendix 1 . Policy and Pressure Matrix

Type	Policy	Pressures																																		
		Ecological														Industrial, Household, and Cabin						Water System										Institutional				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Direct Expenditure	1																															■				
	2					■	■				■	■	■	■			■	■							■											
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	8																																	■		
Institutional	9																																	■		
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Economic	11																																■			
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Regulatory – Legislation	13																																		■	
Water Resources Act	14																		■	■	■															
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WRA Reg – E.C.W.S.R.	**29**
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WRA Reg – W.D.R.	**31**
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Municipalit-ies Act	**33**
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EPA	**38**
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U. &. R.P.A.	44
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Policy for DW Quality Mon. and Rep. for Public Water Supplies	46
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Policy For Flood Plain Manag't	53
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Policy for CGWS Heat Pumps	56
Policy for IBW	57
Policy for L and W Dvms in PPWAS	58
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Policy for DVM in S.W.Z.	**61**																																			
	62																																			
Policy for DVM in Wetlands	**63**																																			
	64																																			
Policy for TUP in WSAs	**65**																																			
Policy for Use of CTW in FW	**66**																																			
Policy for AWU	**67**																																			
BMP for the Control of DBPs in DWSs in NL	**68**																																			
Bridges Guidelines	**69**																																			
Chlorination Equipment Selection Guidelines	**70**																																			
Culverts Guidelines	**71**																																			

DNCMA Gudelines	72																																			
Guidelines for GSA & RG for SS by IPW	73																																			
Guidelines for DD and DW	74																																			
Guidelines for SGW	75																																			
Guidelines for the D,C and O of W and SS	76																																			
M of PWAS Guidelines	77																																			
Pipe crossings Guidelines	78																																			
Selection Criteria and Guidelines for the D, C, and O of PWDUs	79																																			
WC Guidelines	80																																			
BWAs	81																																			
GCDWQ	82																																			