EXPLORING SOLUTIONS FOR SUSTAINABLE RURAL DRINKING WATER SYSTEMS

A STUDY OF RURAL NEWFOUNDLAND & LABRADOR DRINKING WATER SYSTEMS

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THE HARRIS CENTRE 10 YEARS
Memorial University

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It should be noted that this project was a collaborative effort between Municipalities Newfoundland and Labrador (MNL), Professional Municipal Administrators of Newfoundland and Labrador (PMA), and Grenfell Campus- Memorial University of Newfoundland. The project was led by Dr. Kelly Vodden and coordinated by Sarah Minnes. The project team and Advisory Committee members are thanked for their hard work and dedication to this project. Please visit the project website for the full list of researchers and organizations represented on the research team and Advisory Committee: http://nlwater.ruralresilience.ca. Furthermore, we thank all of the drinking water experts that attended the drinking water policy workshop in April 2014 and those provincial and federal employees who provided information and their expertise to the team throughout project. Lastly, the team gives a big thank you to all the case study communities involved with the project and to the municipal/local service district representatives and water operators who participated in the surveys. Also a special thank you to Sarah Breen, Derrick Bragg, Craig Pollet, Jerry Collins, Maura Hanrahan, Bing Chen and Mano Krishnapillai who graciously assisted with the editing and review of this report.

Executive Summary

The *Exploring Solutions for Sustainable Rural Drinking Water Systems* project was initiated in late February 2013 with funding from the Harris Centre – RBC Water Research and Outreach Fund. This project focused on communities of 1,000 residents or less in rural Newfoundland and Labrador (NL) and the unique challenges these communities face concerning their drinking water systems. The project also explored appropriate solutions to identified challenges. The scope of this interdisciplinary project was large, exploring four main components of drinking water systems: 1) source water quality and quantity; 2) infrastructure and operations; 3) public perceptions, awareness and demand; and 4) policy and governance. Though these components have been identified as separate in this project for the purposes of analysis and presentation of research findings, it is important to acknowledge that these aspects of drinking water systems are interrelated. Additionally, challenges faced by rural NL communities are often interconnected, cumulative and complex, interacting in sometimes unexpected ways. The search for effective potential solutions must take these interactions into account.

OVERALL FINDINGS

The state of drinking water systems in rural NL is varied. For example, during consultations with elected municipal officials at Municipalities NL events, many municipalities reported high drinking water quality. Furthermore, on a survey directed towards community administrators, 62% of administrators from local service districts (LSDs) and 69% of administrators from municipalities of 1,000 residents or less said in their opinion their town drinking water was "drinkable directly from the tap". Despite these survey results, considerable concerns for drinking water systems in rural NL were brought to the research team's attention through consultations with municipalities, case study community profiles, interviews with key informants, and two surveys (one directed towards community administrators and one towards water operators). The most common concern vocalized by communities of 1,000 residents or less was aging and degrading infrastructure. For instance, on a survey given to community administrators, 59% of LSD administrators and 44% of administrators from municipalities of 1,000 residents or less indicated a "lack of funds to make necessary repairs or upgrades" as an issue facing their drinking water systems.

In regards to health risks, consultations revealed that many communities are concerned about high disinfectant by-products (DBPs). DBPs, such as trihalomethanes (THMs) and haloacetic acids (HAAs) can occur when organics in the water react with chlorine. There has been links found between long-term exposure to DBPs and certain cancers, particularly cancer of the liver, kidneys, bladder and colon, as well as other health impacts (Dawe, 2009; Thomson, 2014). In a related vein, chlorine use and misuse (i.e. too much or too little in the water) has also been noted as a prominent concern amongst municipalities. Furthermore, the prevalence of long-term boil water advisories (BWAs) was found to be a concern particularly applicable in communities with 1,000 residents or less, resulting in compromised access to safe, clean drinking water in rural NL. While primary research related to public perceptions was not a focus of this research, case studies and consultations demonstrate that BWA and DBP concerns along with a distaste for chlorinated and/or discoloured drinking water, encourages some residents to turn to untreated water sources such as roadside springs.

Another objective of this project was to identify and understand the roles and responsibilities of key players in water governance in rural NL. Provincial agencies play a lead role in water governance together with local governments. We found that many communities of 1,000 or less lack the human, financial, technical and institutional capacity to address the drinking water challenges identified by this research. Finding and retaining certified water operators in communities of 1,000 residents or less poses a challenge to the sustainable and safe operation of drinking water systems, as well as making necessary repairs and upgrades on water infrastructure. In addition, strategic management of drinking water infrastructure, including organized leak detection programs and access to all related blueprints and as-builts, is deficient, especially in communities with uncertified water operators.

Finally, we set out to examine watershed management practices and drinking water systems strategies that can improve drinking water quality, such as the protection of source water supplies. Primarily due to the lack of human resources at the local level and the limited provincial resources supporting local communities, source water protection efforts are often overlooked in communities of 1,000 residents or less. Communities are given a great deal of responsibility in providing safe drinking water to their residents. However, in many small communities of 1,000 or less, fully meeting their mandated drinking water responsibilities is virtually impossible with existing human and financial resources. Similar issues of dwindling resources at the provincial level, combined with increasing responsibilities, are resulting in a lack of support for small communities from provincial actors. Overall, it appears that there is insufficient funding and human resources at both the local and provincial levels in NL to achieve sustainable drinking water systems.

RECOMMENDATIONS FOR RESEARCH, POLICY AND PRACTICE

Changes are needed in drinking water policy and governance in NL. For example, a greater understanding and emphasis at the local level on regional solutions is needed (e.g. regional operator programs, where funding can be better used to sustainably manage drinking water systems). Furthermore, greater focus is needed on community-based solutions that focus on capacity development and the engagement and education of local decision makers, staff, the public, and other groups that can help local governments address their drinking water challenges. Action is required to improve the state of drinking water systems in rural NL; however, this will be most effectively accomplished as a shared venture amongst local, provincial, and federal governments. Academia, non-governmental organizations, industry, and citizens also have important roles to play.

Though it would mean a significant monetary commitment at the provincial level, special attention should be given to addressing long-term BWAs as well as conducting a cost-benefit analysis of requiring filtration and/or other DBP reducing technologies for all communities that exceed the Health Canada guidelines for safe levels of THMs/HAAs. Further, we suggest that water rates better reflect the cost of service delivery, while keeping in mind equity concerns and that access to safe drinking water is a human right. Finally, conservation efforts, proper tracking of leaks and other asset management activities, should not be overlooked as important actions for achieving the sustainability of rural drinking water systems in NL.

List of Acronyms

Acronym	Definition
BC	British Columbia
BWA	Boil water advisory
Communities	Municipalities and LSDs
COTOL	Community of 1,000 residents or less (includes LSDs and municipalities)
COTOLs	Communities of 1,000 residents or less (includes LSDs and municipalities)
DBP	Disinfectant by-product
DOEC	Department of Environment and Conservation- *Water Resources Management Division*
DOHCS	Department of Health and Community Services
DPSIR	Drivers-Pressures-State-Impacts-Responses
DWQI	Drinking Water Quality Index
GCDWQ	Guidelines for Canadian Drinking Water Quality
HAA	Haloacetic acids
LSD	Local Service District
MAM	Maintenance Assurance Manual
MBSAP	Multi-Barrier Strategic Action Plan
MIGA	Municipal and Intergovernmental Affairs
MNL	Municipalities Newfoundland and Labrador
MOTOL	Municipality of 1,000 residents or less (only includes municipalities and excludes LSDs)
MOTOLs	Municipalities of 1,000 residents or less (only includes municipalities and excludes LSDs)
MUN	Memorial University of Newfoundland
OETC	Operator education, training, and certification
PMA	Professional Municipal Administrators of Newfoundland and Labrador
PPWSA	Protected Public Water Supply Area
PWDU	Potable Water Dispensing Units
QMRA	Quantitative microbial risk assessment
NL	Newfoundland and Labrador
THM	Trihalomethanes

1. Introduction

In rural Newfoundland and Labrador (NL), watersheds provide drinking water supplies as well as other resources and activities that support community livelihoods and identities. Healthy drinking water supplies are dependent on healthy watersheds as well as on supporting water policies, practices, and infrastructure. In February 2013 Dr. Kelly Vodden received funding from the Harris Centre-RBC Water Research and Outreach Fund to identify the types of risks and challenges influencing drinking water quality and availability in rural areas and to explore solutions for said risks and challenges. The results were also intended to help direct future drinking water research in NL. This study has a particular emphasis on communities of 1,000 residents or less (COTOLs[1]) in NL and is being undertaken in partnership with Memorial University of Newfoundland (MUN), Municipalities Newfoundland and Labrador (MNL) and the Professional Municipal Administrators of NL (PMA). This project chose to focus on small communities, as rural communities face unique challenges in the delivery of drinking water due to factors such as small revenue bases, limited potential for economies of scale, accessibility difficulties, and residents' rising expectation of services (Locke, 2011). This research project is a Rural Resilience research project. For more on Rural Resilience research please visit http://ruralresilience.ca.

This interdisciplinary research project addressed knowledge gaps related to drinking water systems in NL by providing a current and comprehensive picture of drinking water issues in small communities from a multitude of perspectives. This project draws from current and past research and existing knowledge at federal, provincial and municipal levels, as well as research from other jurisdictions. Engaging with a range of stakeholders has been critical for understanding the issues and exploring solutions for drinking water systems in rural NL.

The research drew from expertise at both the Grenfell and St. John's campuses of MUN with a research team comprised of faculty and research assistants from the departments of Environmental Studies (Environmental Policy Institute), Geography, Environmental Science, Civil Engineering, Community Health, and Humanities, as well as expertise from municipal, provincial and federal governments, industry and non-governmental organizations. The study examined four major components of drinking water systems. Each component encompasses interrelated issues that must be addressed to achieve sustainable[2] drinking water systems in rural NL:

- Source water quality and quantity;
- Water infrastructure and operations;
- Public perception, awareness, and demand; and
- Policy and governance.

This research project had the following objectives:

[1] The focus on communities of 1,000 or less was chosen after consultation among the research team, as communities of 1,000 or less were representative of rural communities in the Newfoundland and Labrador context

[2] The research team describes sustainable drinking water systems as systems that can provide safe and reliable drinking water to those that use them, without compromising the drinking water needs of future generations.

- To determine the current conditions of drinking water in rural NL, including key issues and challenges from municipal, human health, and resource sustainability perspectives;
- To profile the drinking water policies and infrastructure that currently exist in rural NL;
- To determine population perspectives and practices related to water contamination, environmental management, and sustainable solutions;
- To identify and understand the roles and responsibilities of the key players in water governance in rural NL;
- To research integrated watershed management and drinking water systems strategies for improving drinking water quality that have been employed elsewhere that may be applicable in rural NL, along with their relative strengths and weaknesses; and
- To make recommendations based on the above research for future research, as well as policy and practice related to water policies, programs and infrastructure.

This document serves as a high level summary of the various research activities and reports resulting from this project including: seven community based case studies; one topic based community case study; survey results reports, literature reviews, and consultation summaries. For a list of research outputs associated with this report, please see Section 9. All documents related to this research are available on the project website (http://nlwater.ruralresilience.ca). It should be noted that not all findings from the project are fully elaborated upon in this report; rather the focus is on the main findings. Please visit the referenced reports for more detail on specific results. Section 8 outlines recommendations as well as a list of future research needed.

2. Methodology

This research strove to be interdisciplinary in nature, bringing together various academic disciplines as well as perspectives from academic, federal, provincial, municipal, business and non-governmental sectors to gain a holistic understanding of drinking water systems in rural NL. A mixed methods research design was used to support this interdisciplinary research approach. This included both quantitative and qualitative research methods, which are further explained below.

2.1 Media Scan

In March 2013, Fiona Munro, Master of Resource Management candidate from Simon Fraser University, joined the research team as a visiting researcher and conducted a widespread **media review** of NL print newspapers (covering 16 papers in total) as well as CBC Radio news for stories and coverage related to drinking water in NL. Over 94 print newspaper articles as well as on-line newspaper articles were reviewed covering the period from January 2003-March 2013. All articles noted in the resulting tracking spreadsheet had to be about COTOLs. The articles were then organized into 15 different topics based on common themes. The results of this exercise illustrated what issues the media was reporting on concerning drinking water. In turn, this gave the research team a basic understanding of public perceptions related to drinking water and provided a foundational awareness of the issues that should be explored further in the research.

2.2 DPSIR Analysis and Drinking Water Policy Workshop

Beginning in March 2013 Dr. Michael van Zyll de Jong (Environmental Policy Institute, Grenfell Campus) conducted a **Drivers-Pressures-State-Impacts-Responses** (DPSIR) analysis along with several graduate student research assistants. The DPSIR analysis was used to conduct an integrated "desktop" assessment of public drinking water systems. The DPSIR technique was chosen for this project because it allows multidisciplinary knowledge to be integrated and can provide a holistic understanding of a policy area, in this case the state of drinking water systems in rural NL (Ramalho, Van Zyll de Jong, Will & MacLeod, 2014). The DPSIR report was based on secondary data sources (largely institutional data), that included provincial reports as well as provincial and federal legislation. Related academic sources were also reviewed. The report addresses three 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? The DPSIR analysis acted as a way to frame our secondary literature review, and served as a background and scoping document for an expert policy workshop.

Our **expert drinking water policy workshop** took place on Friday April 4, 2014 and was attended by policy-relevant actors from municipal, provincial and federal governments, a local conservation organization (Ducks Unlimited), and academia. At this workshop, participants used clicker technology to rate the drivers and pressures provided in the DPSIR document on a Likert scale of 1-7. The remaining portion of the workshop consisted of a facilitated discussion of current policy measures and potential policy reforms needed to achieve sustainable rural drinking water systems in NL. The full DPSIR document and the policy workshop proceedings are available on the project's website (see http://nlwater.ruralresilience.ca/?page_id=17).

2.3 Surveys

Two surveys were created and delivered by the research team: one directed towards community administrators (i.e. town managers and clerks and LSD key contacts), and the other towards water operators. The surveys aimed to uncover information about both municipal and LSD drinking water systems that could not be derived from existing provincial data reviewed for the DPSIR exercise. The surveys allowed the team to gain insights from a wide range of communities across the province, including LSDS and municipalities that may not attend MNL events and consultations. Surveys included municipalities of all sizes to allow for comparison of results between COTOLS and larger communities. However, it should be noted that the research team assumes that those communities with acute human capacity deficiencies were the most unlikely to answer either the community administrators survey or the water operators survey, likely resulting in an overly optimistic picture of drinking water systems in rural NL.

The community administrators survey focused more on resident's perception of the system as well as local level regulation and management of water systems. The water operators survey was focused on the treatment technology used, specifics on distribution infrastructure and overall maintenance and operations. Both surveys were developed in working groups by the research team and were largely based on the DPSIR Analysis findings as well as consultations with the Advisory Committee.

2.3.1 Community Administrators Survey

Researchers identified all municipalities and LSDs within the province of NL using a municipal directory administered by the Department of Municipal and Intergovernmental Affairs (MIGA). From this listing, researchers sent invitations to all LSDs and municipalities, inviting their administrators (or key contacts in the case of LSDs who may not have a paid administrators) to participate in the research process. Municipalities were contacted by MNL through the MNL e-mail mailing list. Municipal administrators were invited to either complete the survey online via Survey Monkey (an online data collection tool), or to print a paper copy, scanning and emailing the completed survey to the researchers. LSD administrators were provided with a paper copy of the survey via mail, along with a prepaid return envelope. This non-uniform survey distribution procedure was adopted due to connectivity issues in more rural parts of NL as well as varying use of (and access to) email.

One month was allotted for completion of the survey. If community administrators had not completed the survey during this time period, they were contacted by summer students and were asked to complete the survey as soon as possible. At this time they were provided the option of completing the survey over the phone. The survey ran for a period of approximately 2.5 months (July 5-September 13, 2013). Where community administrators opted to complete the survey over the phone or on a paper copy of the survey, research assistants entered those responses into the Survey Monkey data collection tool to ensure all data was centralized and included in the analysis. The survey took approximately 20 – 25 minutes to complete.

Researchers contacted 454 communities (178 LSDs, 276 municipalities). A total of 199 respondents returned surveys (48 LSDs, 151 municipalities), which constituted an overall response rate of 44% (27% of LSDs, 55% of municipalities).

2.3.2 Water Operators Survey

The research team identified water operators as having a more intimate understanding of the infrastructure and daily maintenance and operations of their communities' drinking water systems. As a result, a separate, more technical survey was created for water operators. This survey was released in Fall 2013 through the MNL email list and was mailed to the 27 LSDs who had filled out the previous survey in summer 2013 and had indicated they operate a water system for their residents. These LSDs received the survey via mail (the package was sent to their town office/contact to give to the water operators) and operators were given the option to either complete the survey online (via a link to Survey Monkey) or to complete the paper copy of the survey and return it to the researchers with prepaid envelopes that were provided. Paper copies of the survey packages were also distributed at PMA events in Fall 2013, at several MNL regional meetings in Winter 2014, and at the Department of Environment and Conservation's Annual Drinking Water Workshop in March 2014. This alteration to the data collection procedure was used to ensure the highest rate of participation possible. The data that was collected via paper copies were then entered into the Survey Monkey website to ensure the data was centralized.

Water operator survey data collection occurred over a period of approximately six months (October 2013-March 2014). This lengthy period of data collection was to ensure adequate time

to promote the survey throughout the province. Due to the various distribution techniques, it is uncertain how many communities/actual water operators were invited to take part in the survey. However, there are 319 permit owners (i.e. communities with Permits to Operate drinking water systems) in NL (Dawe, 2014), and in order to keep their permits, these communities must have at least one water operator. The survey had 71 respondents[3], therefore approximately 22% of communities that have permits to operate (i.e. that operate a water system for residents) answered the survey.

2.3.3 Analyses of Surveys

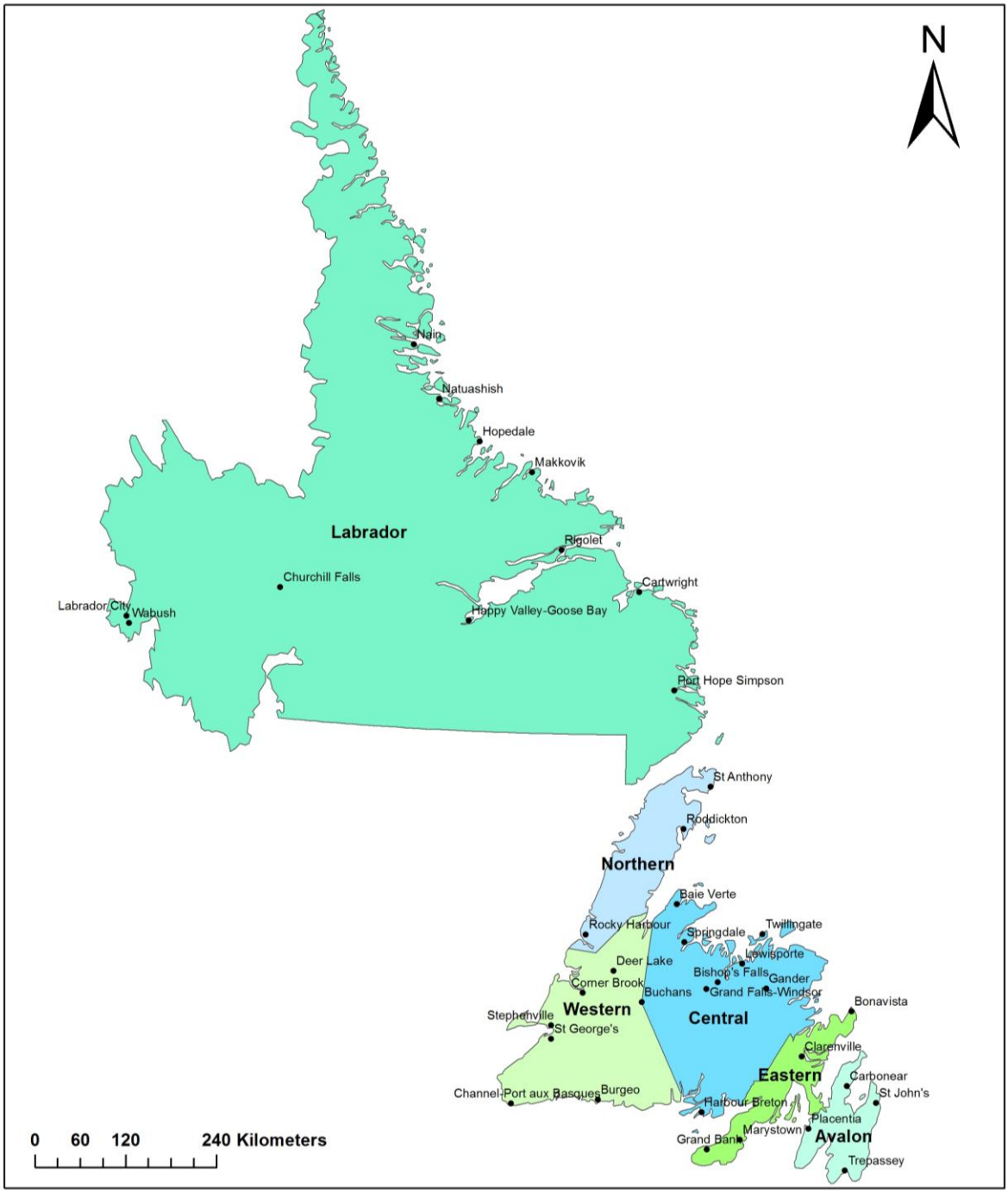
A full analysis of the community administrators and water operators surveys (including a copy of the surveys) is available on the project's website (see http://nlwater.ruralresilience.ca/?page_id=17). Both surveys were analyzed according to three main categories of respondents: 1) LSDs, 2) municipalities of 1,000 residents or less (MOTOLs), and 3) municipalities of more than 1,000 residents. These categories were chosen because the researchers found there were differences between MOTOLs and LSDs, and thus, decided to separate these different groups for certain analyses. However, when COTOLs are discussed in this report, they include both MOTOLs and all LSDs that answered the surveys. There were no LSDs of more than 1,000 that answered the water operators survey, and only one LSD (of 48 LSD respondents) that indicated a population of over 1,000 on the community administrators survey, so it was determined that survey answers for LSDs could also be considered a reflection of COTOLs' circumstances.

2.4 Community Case Studies

Analysis of the administrators survey provided evidence of some re-occurring topics, both issues of concern and proposed/attempted solutions that warranted further investigation. These topics included: Potable Water Dispensing Units (PWDUs), drought/water shortages, high disinfectant by-products (DBPs), regional water operators, fish plants, drought/low water issues, degrading infrastructure, untrained water operators, and negative perceptions of town drinking water. Case studies were determined to be the most appropriate way to obtain more in-depth understanding of these issues and of drinking water systems within COTOLs.

From these topics of interest, the project coordinator identified 26 communities (at least three in each MNL region) that could provide insight into one or more of topics of interest according to their responses to the community administrator's survey. Once the list of 26 had been created, the research team met to discuss possible case study communities and agreed on a shortened list of communities that retained three communities from each MNL region (see Figure 1). Communities were then contacted and at least one case study community per MNL region was chosen based on interest from the community contact (usually the town clerk/manager) while also retaining an appropriate mix of cases based on size and the above topics of interest.

[3] All water operators from LSDs that answered the water operators survey were from communities of 1,000 or less.



Data Source:
Government of Newfoundland and Labrador,
Department of Municipal and Intergovernmental Affairs

Prepared by:
Jerry Collins, Research Assistant
Environmental Policy Institute
Grenfell Campus, Memorial University

Figure 1: MNL Regions

Community agreements were signed with each case study community, confirming that the town had agreed to participate in the study as a case study community. The following communities were included as case studies:

- Port au Port East (Western region), population 598
- Woody Point (Northern region), population 281
- Makkovik (Labrador region), population 361
- Black Tickle-Domino (Labrador region), population 168
- Greenspond (Central region), population 305
- Centreville-Wareham-Trinity (Central region/topic based), population 1161
- Sunnyside (Eastern region), population 452
- Old Perlican (Avalon region), population 661[4]

Seven of the eight case studies looked at were COTOLs, with one community (Centreville-Wareham-Trinity) having a population of 1161 (Daniels, 2014b). The Centreville-Wareham-Trinity case study was chosen due to the town's experience with the regional water operator program as well as their use of Townsuite Municipal Software for asset management, a topic of interest raised early in the project. Townsuite participated in the project as a partner through the Mitacs internship program, allowing for the completion of the topic-based case study. Though the Townsuite Municipal Software program has been used in this report as an example of proactive management of infrastructure assets, the team acknowledges that this is one example of an asset management tool and there may be other programs that would achieve the same goal.

The case studies were conducted from January – April 2014 by research assistants from both the Grenfell and St. John's campuses of MUN. Research assistants used secondary document review (e.g. existing studies, policies and plans) as well as key informant interviews for their investigations. Key informants in the communities included town mayors, residents, the water operator, business owners, health representatives and other relevant actors in the community. There were 6-12 interviews conducted in each community. Several key provincial actors were also interviewed, which helped provide a more holistic picture of the case study (see Section 2.5). Community case study reports, including interview guides and methods, are available on the project's website (see http://nlwater.ruralresilience.ca/?page_id=17).

2.5 Interviews with Provincial Government Representatives

As mentioned, in conjunction with the community case studies several provincial government employees were interviewed. This helped the team cross reference certain findings, as well as gain a better understanding of rural drinking water systems in NL. In addition to the provincial departments represented on the Advisory Committee (Department of Environment and Conservation- Water Resources Management Division (DOEC); Department of Natural Resources; MIGA; and the Department of Health and Community Services (DOHCS), with representatives who provided input throughout the project, there were also two DOEC regional

[4] All population data derived from Census 2011 data found at: http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E

employees, two NL Services regional employees, and one MIGA employee who participated in an interview with a research team member.

2.6 Targeted Literature Reviews

In addition to the extensive literature review (academic and other literature) that informed the DPSIR analysis, the project identified common issues consistently raised by municipalities during consultations (described further below). In February 2014, one student from the Faculty of Engineering and Applied Science and one student from the Faculty of Medicine were hired to conduct targeted literature reviews focused on these commonly raised issues. The engineering student, supervised by Dr. Tahir Husain, was tasked with investigating DBP reducing technologies for small-scale water systems. The student from the Faculty of Medicine, under the supervision of Dr. Atanu Sarkar, was tasked with researching the impacts of contaminated drinking water sources on short and long-term health.

The project received further funding in July 2013 to specifically examine potential regional approaches to drinking water management in both rural British Columbia and rural NL. The extensive literature review associated with this project includes research at the intersection of drinking water management and the theoretical framework of New Regionalism, as well as literature on the relationships between regional drinking water management and rural resilience, sustainable infrastructure management, and best practices in source water management. A supplementary literature review is also being conducted to investigate drinking water challenges and solutions being employed in rural and remote areas in other parts of Canada. Literature review documents are posted on the project website (see http://nlwater.ruralresilience.ca/?page_id=17).

2.7 Consultation and Knowledge Mobilization

Consultation with key actors and knowledge mobilization were important, related aspects of this project. The first step was the creation of a project website (http://nlwater.ruralresilience.ca). This website facilitated knowledge mobilization with regular updates including new reports, presentations, and news about the project. The website also has a section that enables questions and feedback, allowing individuals to contact the research team.

In addition to the website, the project's findings were mobilized through presentations delivered by the research team from May 2013–October 2014 (see Table 1). MNL played a key role as a project partner in providing opportunities to discuss the project with municipalities across the province through their annual symposium, convention, and regional workshops. Team members also participated in national drinking water-related conferences and workshops to gather information on experiences in other rural regions, as well as share the emerging results of the project with others from across Atlantic Canada and the country.

Table 1: Project Presentations

- Exploring Solutions for Sustainable Rural Drinking Water Systems, MNL Convention,

October 11, 2014 (Vodden)
- Exploring Solutions for Rural Drinking Water Systems, Rural Forum, Corner Brook, NL, October 8, 2014 (Vodden & Minnes)
- Regional Revision: A regional approach to managing drinking water, CRRF 2014, Prince George, BC, September 27, 2014 (Breen & Minnes)
- Sustainable Drinking Water Management- A Tall Order for Local Governments, CRRF 2014, Prince George, BC, September 27, 2014 (Minnes & Vodden)
- Synergy Session, Harris Centre Session, St. John's, NL, September 23, 2014 (Vodden & Minnes)
- Sustainable Drinking Water Management- A Tall Order for Municipal Governments, The International Conference on Marine and Freshwater Environments, St. John's, NL, August 8, 2014 (Vodden, Minnes).
- Exploring Solutions for Sustainable Rural Drinking Water Systems in NL, WatIf Conference, Kingston, ON, May 6, 2014 (Minnes)
- Northern MNL Workshop, Municipalities Newfoundland and Labrador, Hawke's Bay, NL, March 28, 2014 (Vodden, Minnes)
- Avalon MNL Workshop, Municipalities Newfoundland and Labrador, St. John's, NL, March 21, 2014 (Vodden, Daniels)
- Exploring Solutions for Sustainable Rural Drinking Water Systems, CWWA Conference, Niagara-on-the-Lake, ON, March 6, 2014 (Minnes)
- Western MNL Workshop, Deer Lake, NL, February 28, 2014 (Will, Lightfoot)
- Combined Councils of Labrador AGM, L'Anse au Clair, NL, February 21, 2014 (Will)
- Eastern MNL Workshop, Clarenville, NL, February 7, 2014 (Daniels, Minnes)
- Central MNL Workshop, January 31, 2014 (Minnes, Will)
- PechaKucha Presentation, World Town Planning Day, Atlantic Planners Institute (Minnes)
- Drinking Water Presentation, MNL Convention, St. John's, NL, November 8, 2013 (Minnes, Vodden)
- Watershed Planning and Regional Development, Canadian Association of Geographers Annual Meeting, August 13, 2013 (Breen, Minnes)
- Presentation to the Great Humber Joint Council, Massey Drive Town Hall, May 25, 2013 (Minnes)
- Rural Water Quality Clicker Session (Slides and Responses), MNL Symposium, May 10, 2013 (Minnes, Vodden)

Events where the team had a tradeshow booth and/or facilitated discussions also served as opportunities for both consultation and knowledge mobilization (see Table 2).

Table 2: Consultations

- Exploring Solutions for Sustainable Rural Drinking Water Systems, MNL Convention, October 11, 2014 (Vodden)
- Exploring Solutions for Rural Drinking Water Systems, Rural Forum, Corner Brook, NL, October 8, 2014 (Vodden & Minnes)
- Synergy Session, Harris Centre Session, St. John's, NL, September 23, 2014 (Vodden &

Minnes)

- Municipalities Newfoundland and Labrador Symposium 2014, Hotel Gander, Gander NL, May 1-2, 2014
    - Focus Group on Regional Approaches, Hotel Gander, Gander NL, May 2, 2014
- Department of Environment and Conservation's Annual Drinking Water Workshop, Hotel Gander, Gander NL, March 25-27, 2014
- Water Day Celebrations 2014, City Hall, Corner Brook, NL, March 22, 2014
- MNL regional workshops 2014:
    - Central Regional Meeting - January 31, 2014
    - Eastern Regional Meeting - February 7, 2014
    - Labrador Combined Councils Meeting - February 21, 2104
    - Western Regional Meeting - February 28, 2014
    - Avalon Regional Meeting - March 21, 2014
    - Northern Regional Meeting - March 28, 2014
- Municipalities Newfoundland and Labrador Symposium 2013, Hotel Gander, Gander NL, May 10, 2013

Furthermore, as most of the project's consultation and knowledge mobilization activities were focused toward water experts and municipal actors, the research team decided to organize two public outreach activities for the UN recognized World Water Day, on March 22, 2014 in order to reach the general public and promote the research project. The research team collaborated with the City of Corner Brook, Ducks Unlimited, and Atlantic Coastal Action Program (ACAP) Humber Arm to plan two successful water day events. These included a community event hosted at Corner Brook City Hall aimed at children and families as well as an "Ode to Water" event at a local theatre hall in Corner Brook where performers of all kinds (e.g. poets, artists, photographers, and musicians) took the stage to express their appreciation and love of water. Pictures from the day are available on the project's website (see http://nlwater.ruralresilience.ca/?page_id=388).

Figure 2: Mitacs Intern Alice Will at the Registration Booth for World Water Day

The project also received considerable media coverage including two newspaper articles in the Western Star (out of Corner Brook, NL) following a presentation to the Humber Joint Council in March 2013, one after the Western MNL Regional workshop in February 2014, and another following the October 2014 Rural Forum held by MNL. Furthermore, the project gained attention after the 2013 MNL Symposium with articles in The Aurora (based out of Labrador City, NL), The Compass (out of Carbonear, NL), The Nor'wester (based out of Springdale, NL) and in the Northern Pen (out of St. Anthony, NL). Project Coordinator Sarah Minnes conducted an interview for Rogers TV's Corner Brook Café and Dr. Vodden was interviewed for VOCM radio after the Avalon MNL Regional Workshop on March 21, 2014. The project was featured in the September/October 2014 issue of Water Canada magazine and in MNL newsletters throughout 2013 and 2014.

An important part of the validation process throughout the research was the Advisory Committee meetings. There were three Advisory Committee meetings for the project, taking place in June 2013, November 2013 and August 2014. All meetings took place at MNL's St. John's office. The June 2013 meeting was focused on research methods, and the November 2013 meeting was focused on implications of the community administrators survey results and the DPSIR Scoping document. The final committee meeting, held in August 2014, was used to review the draft final report and conduct an ease/impact assessment to facilitate discussion on the future research needed as well as policy reform recommendations. A full list of organizations represented on the Advisory Committee is available on the project website (see http://nlwater.ruralresilience.ca/?page_id=316). All Advisory Committee members were also invited to the April 2014 Drinking Water Policy Workshop in Corner Brook; however, many members were unable to attend.

Funding obtained through the Mitacs-Accelerate internship program allowed additional knowledge mobilization activities in the Fall 2014. These activities include but are not limited to:

- Classroom presentations on water and watershed stewardship in collaboration with Ducks Unlimited programming
- A community-oriented summary version of this report highlighting project results
- Submissions to Plan Canada, Canadian Water Resources Association and a peer-reviewed academic journal article to share results beyond NL

2.8 Analysis

Analysis of the project data was done using various methods (see individual project reports for specific analysis activities). Analysis was needed throughout the research process to prepare for subsequent stages of the project. For example, the media scan, initial MNL Symposium consultations and the November 2013 Advisory Committee meeting were all used to shape subsequent data collection such as the two surveys and the case studies. The overall analysis of findings from all project reports was conducted through the use of a qualitative analysis program (NVivo). The research team created codes based upon the project's four components (i.e. source water; infrastructure; public perception; and policy and governance) and on major themes identified throughout all of the research outputs. After coding was completed, patterns were identified and all information was compiled into a draft report, which was then scrutinized and

discussed amongst the research team for content and missing information. Lastly, during the final Advisory Committee meeting, experts provided comments on the final report and an ease/impact assessment was completed concerning recommendations and areas for future research. During this exercise, Advisory Committee members were asked to rate each recommendation and area for future research according to the ease of implementation and level of impact the change would have on rural NL drinking water systems, helping to facilitate discussion of recommendations among Advisory Committee members. Additional feedback was obtained through presentations in Fall 2014 at Memorial University, the MNL Rural Forum and Small Towns Meeting of the MNL Convention, Corner Brook.

3. Background

3.1 Responsibilities for Drinking Water in NL

In Canada, the responsibility for ensuring the safety of drinking water supplies is shared by the various levels of government. The principal responsibility of ensuring the safety of drinking water generally rests with the provinces and territories, with local governments ensuring the day-to-day operations of treatment facilities and distribution systems (Health Canada, 2012a). In NL, federal, provincial and municipal/LSD actors all play a role in drinking water management, as described below.

Federal Government

Federally, Health Canada works in collaboration with the provinces and territories, through the Federal-Provincial-Territorial Committee on Drinking Water, to develop the Guidelines for Canadian Drinking Water Quality (GCDWQ). The GCDWQ are published by Health Canada and are used by all Canadian jurisdictions (provinces, territories and the federal government) as a basis to establish their own enforceable requirements for drinking water quality. The GCDWQ[5] is mostly a framework and adherence to these guidelines is optional; provinces and territories are not required to enact legislative or policy measures to meet them.

Provincial Government

Drinking water is primarily a provincial responsibility, with the NL provincial government being responsible for ensuring public access to safe drinking water based on the provisions of: the *Municipalities Act, 1999,* the *Municipal Affairs Act, 1995* the *Environmental Protection Act, 2002* and the *Water Resources Act, 2002*. Where these acts apply to drinking water, the province of NL follows the GCDWQ (Government of NL, 2014a). There are a total of 478 public water sources (i.e. drinking water sources used for public drinking water system) across the province. Four provincial government departments share responsibility in managing drinking water services, with municipalities and LSDs, through the Multi-Barrier Strategic Action Plan (MBSAP) (Government of NL, 2014a). The MBSAP consists of three levels of governance, which are outlined in the 2013 *Drinking Water Safety in Newfoundland and Labrador Annual*

[5] See www.ccme.ca/assets/pdf/mba_guidance_doc_e.pdf

Report (see Table 3). The four provincial departments responsible for drinking water in NL are: The DOEC, the DOHCS, the MIGA, and Service NL (or Government Services - GS). Their specific roles and responsibilities in implementing the MBSAP are described in detail in the 2013 *Drinking Water Safety in Newfoundland and Labrador Annual Report* and detailed in Table 4 (Ibid.).

Table 3: Multi- Barrier Strategic Action Plan - Three levels of governance

Level 1	- Source water protection - Drinking water treatment - Drinking water distribution
Level 2	- Monitoring - Data management and reporting - Inspection and enforcement - Operator education, training, and certification - Corrective measures
Level 3	- Legislative and policy frameworks - Public involvement and awareness - Guidelines, standards, and objectives - Research and development

Source: Government of NL, 2014a

Table 4: Roles and Responsibilities of Provincial Departments Managing Drinking Water in NL

Department of Environment and Conservation (DOEC) - *Water Resources Management Division*	- Acts as the lead agency - Regulates development activities within protected public water supplies - Samples and reports on chemical and physical drinking water quality parameters in public water supplies from source to tap - Administers of Operator Education, Training, and Certification (OETC) program - Coordinates an Annual Clean and Safe Drinking Water Workshop
Department of Health and Community Services (DOHCS)	- Responsible for NL Public Health Laboratory and regional drinking water testing locations where municipal and private water supplies are tested for bacteriological indicators *E. coli* and total coliform bacteria - Conducts drinking water safety initiatives and review guidelines related to water which to enhance health and

		prevent disease
Municipal and Intergovernmental Affairs (MIGA)	-	Provides financial support to communities for the provision of drinking water infrastructure
	-	Involved in the NL Drinking Water Safety Initiative and installation of Potable Water Dispensing Units
Service NL (or Government Services- GS)	-	Samples and reports bacteriological water quality parameters in public water supplies from source to tap
	-	Environmental Health Officers contact municipality/LSD immediately if sample tests indicated *E. Coli* and/or total coliform bacteria, or if chlorine residual is inadequate, to enact a boil water advisory.

Source: Daniels, 2014a; Adapted from Will, 2014

In terms of provincial reporting to the public, the DOEC's Water Resources Management Division releases several public reports relating to drinking water quality (Government of NL, 2014a). Details of these reports are outlined in Table 5 below.

Table 5: DOEC Public Drinking Water Quality Reporting

Seasonal Community Drinking Water Quality Reports	-	An interpreted report of seasonal drinking water monitoring
	-	Indicates parameters that exceed the GCDWQ
	-	Provided to all communities with a public water supply
Exceedance Report	-	A report delivered via fax or email to communities immediately after water quality laboratory result is above the *GCDWQ*
Annual Drinking Water Safety in NL Report	-	Provincial report released annually
	-	Describes the province's activities under the MBSAP
Drinking Water Quality Online Resources	-	The Water Resource Management Division's website contains a regularly updated online tool with information on drinking water quality. See: *http://www.env.gov.nl.ca/env/waterres/whatsnew/index.html*

Source: Daniels, 2014a; Adapted from Will, 2014

Local Government

The daily operations of water systems (including daily testing of chlorine residual), as well as enforcement of source water protection measures (see section 4.4) are the responsibility of local governments. In NL public drinking water sources can be supplied from both surface water and groundwater. During the 2012-13 fiscal year, the province recorded 299 public surface water

supplies and 179 public groundwater supplies (Government of NL, 2014a). Municipal governments and LSDs are governed by Community Charters or Local Government Acts, as enabled by the province's *Municipalities Act, 1999* (Government of NL, 1999). This provincial statute enables, amongst other things, local councils to provide public water supply systems. Municipalities are then able to enact their own by-laws and regulations within this framework, which can solidify their commitment to providing drinking water (Ramalho et al., 2014). LSDs are able to also enact by-laws or regulations in relation to the running of a public water system, such as calling a water ban[6]. Other relevant pieces of legislation are the *Municipal Affairs Act, 1995*, the *Urban and Rural Planning Act, 2000* and the *Water Resources Act, 2002* (Ramalho et al., 2014). In situations such as remote, fly-in communities, activities that are normally a provincial responsibility (e.g. collection of bacteriological samples) are taken on by community staff, with samples being sent to the nearest Regional Government Service Centre office by scheduled flights (Government of NL, 2014a).

Public drinking water systems in NL are regulated by the DOEC's Permits to Operate for Water Distribution Systems and Water Treatment Plants (as applicable), which are required under Section 38 of the *Water Resources Act* (Government of NL, 2014d). These permits relate to various aspects of water management: source protection; treatment system; water quality and quantity monitoring; waste and quantity monitoring; waste and process wastewater; distribution system; operation manuals; logbooks; contingency, emergency and long term planning; security and safety; consumer relations; reporting, notification and corrective actions; and operator certification and training (Government of NL, 2014a). The Permit to Operate Drinking Water System Inspection Program was initiated in 2012 and includes up to 85 questions pertaining to the required permits. It is stated in the *Drinking Water Safety in Newfoundland and Labrador: Annual Report 2013*, that only seven communities have been inspected to date, all with water treatment plants; however, the DOEC's Water Resources Management Division aims to inspect all public drinking water systems serving a population of 500 people or more within the next five years (Government of NL, 2014a).

Analysis of the community administrator survey discovered some interesting information concerning drinking water policies in rural NL. For example, while many LSDs indicated that the provincial regulations addressing drinking water were appropriate for their communities, this result was not unanimous as only 2/3 (69%) of LSD communities agreed with the statement. Of the MOTOLs administrators 77% thought the province's drinking water policies were appropriate for their municipality. In a related vein, although LSDs believed they had the appropriate resources to govern their water supply, they have limited formal authority to implement bylaws and regulations (unlike incorporated municipalities). MIGA representatives explained that, under the *Municipalities Act, 1999*, LSDs are given the power to operate their water supply and determine the "time, manner, extent, nature and recipients of the supply". It was suggested by provincial officials that this could include something such as imposing a water ban, but would not include the authority to enact regulations or make bylaws with respect to conservation efforts.

Further discussion on the role of local government in source water protection efforts is provided in section 4.4 below.

[6] This was confirmed through correspondence with representatives at MIGA.

Indigenous Government

In NL, policies and programs for Indigenous people are often sporadic and inconsistent (Hanrahan, 2014). Indigenous people were not mentioned in the 1948 Terms of Union between Newfoundland and Canada (Hanrahan, 2003), which resulted in some typically federal responsibilities (e.g. the delivery of health, education, drinking water and other social services) becoming provincial responsibilities in NL by default (Higgins, 2008). For example, the provincial government is the lead authority for drinking water management in Indigenous communities in NL. As with any public drinking water system in NL, water systems in Indigenous communities are overseen and managed (as per the MBSAP and the *Municipalities Act, 1999*) by the provincial government with their local community governments (see above for description of local government responsibilities). In the case of the Nunatsiavut Government, the Nunatsiavut Government defrays a significant portion of the costs of maintaining, staffing, and operating the water systems in their communities (Lightfoot, 2014b). NL Indigenous peoples include the Inuit, Southern Inuit and the Innu of Labrador and the Mi'kmaq people of the Island of Newfoundland. These peoples are governed by the Nunatsiavut Government (and community councils of Nain, Hopedale, Postville, Makkovik and Rigolet), Innu Nation (and the two band councils of Natuashish and Sheshatshiu), NunatuKavut Community Council, the Qalipu Mi'Kmaq First Nation Band Council (with several affiliated communities and local Band Councils) and the Miawpukek First Nation Band Council (Vodden & Hall, 2013; Qalipu, 2014; Higgins, 2008).

3.2 Previous Drinking Water Research in NL

It was an objective of this project to synthesize and build upon previous drinking water research conducted in NL. As a result, previous Harris Centre – RBC Water Research and Outreach Fund reports were heavily utilized in this research. For example, a study conducted by Dr. Sarkar, Dr. Krishnapillai, and Dr. Valcour (2012) entitled "A Study of Groundwater Quality of Private Wells in Western Newfoundland Communities" helped inform the project's research. Even though private wells were outside the scope of the research project, it was still important for the researchers to have a fundamental understanding of groundwater contaminants, as many public drinking water systems in NL use groundwater sources. Having Dr. Sarkar and Dr. Krishnapillai as co-investigators allowed the project to draw from their previous work and expertise. Furthermore, previous research conducted by Dr. Vodden and Dr. Sarkar fed into this project, especially their work in the Indian Bay watershed and the results of their household survey on drinking water perceptions and uses (Holisko, Speed, Vodden, Sarkar, & Moss, 2014). Other drinking water researchers who were funded through the Harris Centre – RBC Water Research and Outreach Fund were also important resources. For example, Dr. Maura Hanrahan joined the research team in December 2013 due to her drinking water research in the LSD of Black Tickle-Domino. Dr. Hanrahan contributed a case study of that community.

Another relevant piece of research was the 2009 report written by Dr. Sue Ziegler, Kelly Butt, and Dr. Tahir Husain, which explored various aspects of drinking water issues in NL. The drinking water quality research database (Ziegler, Butt & Husain, 2009), as well as the Mitacs funded report that came out of a Provincial Rural Water Quality Management Workshop entitled

"Water…A mixed Solution" (Mitacs, 2009) provided a foundation for this project. Both Dr. Ziegler and Dr. Husain have been engaged in this research. Dr. Ziegler was a participant in the Drinking Water Policy Workshop, and Dr. Husain was a member of the project's Advisory Committee and supervised the literature review on technologies for reducing DBPs. Their previous publications and input on the project's research have helped us better understand the risks and challenges facing rural NL drinking water systems.

Several other NL specific studies concerning resident's perception of drinking water benefited the research team. This included a study conducted in 2010 by Kelly Butt entitled "Perceptions of Public Drinking Water in NL: A Mixed Method Study", as well as a phone survey conducted in July 2003 by the DOHCS concerning resident's attitudes and practices surrounding drinking water. Other research that was of great help to the team also include a recent thesis by Paula Dawe (2013) entitled, *"Using Quantitative Microbial Risk Assessment to Determine if Health Risk Warrants Boil Water Advisories in Newfoundland and Labrador: Time for a New Approach"* as well as Christina's Goldhar (2011) thesis entitled, " Water Ways: Vulnerability to Freshwater Changes in the Inuit Settlement Region of Nunatsiavut, Labrador".

The aforementioned NL focused drinking water research projects are just a sample of the background information used in this research project. Further literature review information can be found in the DPSIR document, as well as literature reviews on other drinking water related topics commissioned for this project and posted on the project's website.

3.3 Indicators of Drinking Water Quality in NL

There are several indicators and indices that the provincial government uses to rate community water quality. For example, the Langelier Index (LI) is used to indicate the degree of saturation of calcium carbonate in water. A negative reading indicates that water will be corrosive to the distribution system; a positive reading means water will tend to deposit calcium carbonate in the distribution system; and a LI near zero means that the water will be neither corrosive nor calcium forming (Government of NL, 2014b). While there was little discussion of the LI index during the project's consultations, through surveys and consultations with municipalities and water experts, the researchers found that some indices are considered useful while others are of questionable utility. The Drinking Water Quality Index was one such contested tool.

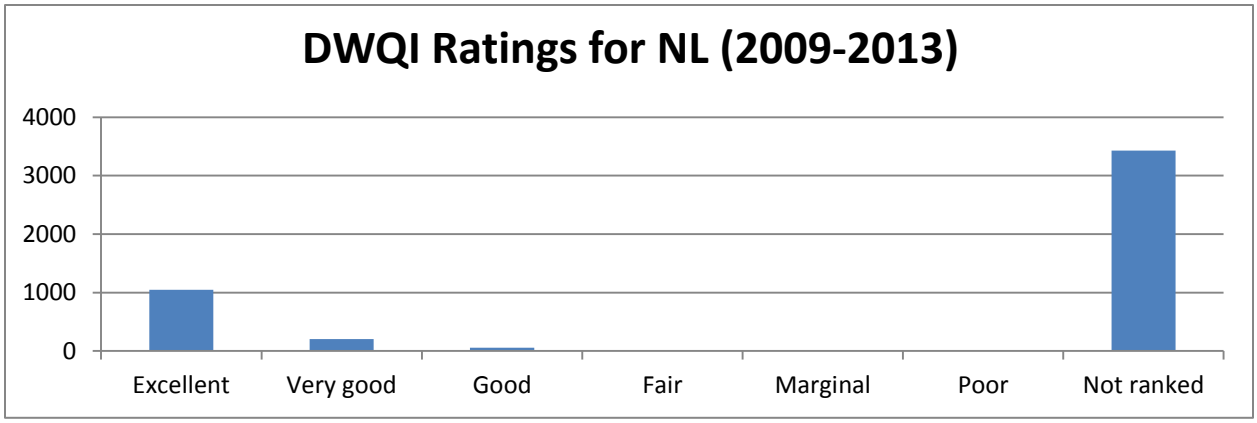
The Drinking Water Quality Index (DWQI) used by NL is a modification of the existing Canadian Council of the Ministers of the Environment Water Quality Index, and is a regular report released by the provincial government that rates NL communities' drinking water quality (Government of NL, 2013a). The DWQI is also based on the federal GCDWQ. Although its ratings range from 1 – 100, the provincial government only indicates which broad category or range a community's drinking water quality falls in, rather than being given an exact number. The DWQI categories are Excellent (DWQI Value 95-100), Very Good (DWQI Value 89-94), Good (DWQI Value 80-88), Fair (DWQI Value 65-79), Marginal (DWQI Value 45-64), and Poor (0-44) (Government of NL, 2013a).

The research team contends that the DWQI needs improvement, as it currently presents an overly positive view of the state of drinking water quality in the province. While most communities

with a DWQI rating are rated Excellent, 3431 of the 4740 water quality rankings between 2009 – 2012 were classified as "Not ranked, a fifth category (see Figure 3) (Government of NL, 2014c). This concern is further discussed in the Policy and Governance section below (see Section 7.1). Boil water advisories (BWAs) in NL are preventative measures to protect the public from contaminants that could be in their water (Government of NL, 2014a). BWAs can also be issued if water quality is threatened by "operational deficiencies (such as inadequate chlorine residual),

Figure 3: DWQI Ratings for NL (2009-2013)

Source: Government of NL, 2014c



no disinfection system or the water in a community's water system is contaminated with bacteriological indicators (such as total coliforms)" (Government of NL, 2014a, p. 4). Hence, BWAs can indicate a range of drinking water system problems, prompting headlines such as "Boiling Over" (Walsh, 2008) or "Badger Issues Boil Order" (Hickey, 2011) in local NL newspapers. The causes of these BWAs as of July 29, 2013 are displayed in Table 6 and Figure 4. The most common reason was lack of chlorine residual in the system, followed by absence of a disinfection system, and then by a disinfection system that was not operating due to maintenance or mechanical failure.

COTOLs are more likely to experience BWAs than communities of over 1,000 residents. Furthermore, BWAs last for longer periods of time in COTOLs. As of July 29, 2013, there were 256 BWAs affecting 184 NL communities. All but 7 of the 184 communities (and 8 of the 256 sources) with BWAs were COTOLs. Furthermore, out of the 248 BWAs issued for water sources serving COTOLs, over half of them (137) had been in place for five years or more as of July 29, 2013 (Government of NL, 2013b; Ramalho et al, 2014). Health Canada states that a "Long-Term Drinking Water Advisory" is a drinking water advisory that has been in place for more than one year (Health Canada, 2013). The research team created four different classifications of BWAs in NL, distinguishing long term from very long term BWAs:

- Short term BWA: Less than one month;
- Medium term BWA: Up to 364 days;
- Long term BWA: 1-5 years; and
- Very long term BWA: More than 5 years.

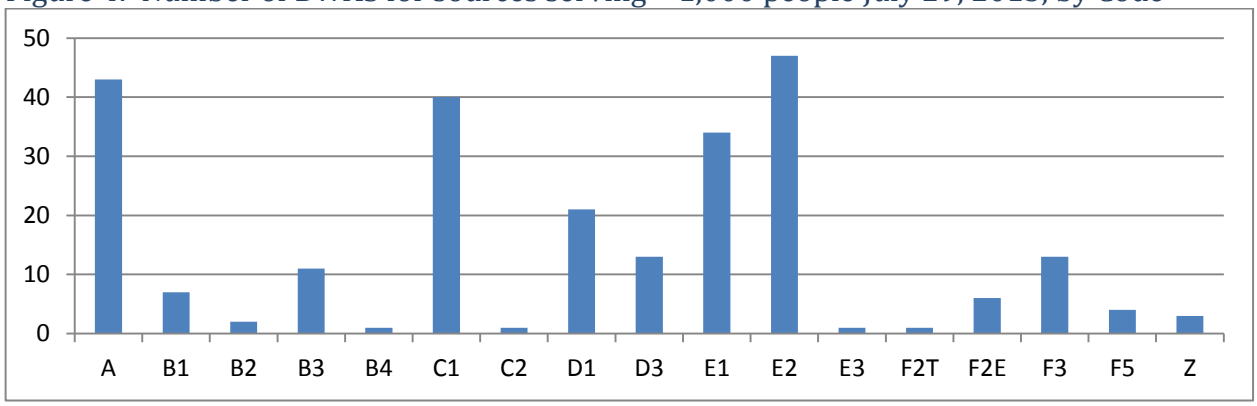
Additionally, according to community administrators survey results LSDs are more likely to experience lengthy BWAs (lasting more than one year) when compared to municipalities, which are more likely to report experiencing BWAs that lasted less than a week. Over half of the LSDs surveyed reported experiencing BWAs that lasted longer than a year (56%); comparatively, only 14% of the municipalities surveyed reported that they had experienced a long-term BWA. Examining the responses for MOTOLs reveals that 16% have had BWAs that lasted longer than 1 year in the last 4 years, whereas 10% of municipalities of over 1,000 noted having BWAs that lasted more than 1 year. This finding underscores the general finding that clear differences exist between the water quality of LSDs and municipalities, as well as between MOTOLs and municipalities of over 1,000 residents (Speed, 2014a).

Table 6: Reasons for BWAs for Sources Serving COTOLS, as of July 29, 2013

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
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 and confirmed in repeat sample.	F5	4
None listed	Z	3

(Government of NL, 2013b; Ramalho et al, 2014)

Figure 4: Number of BWAS for sources serving < 1,000 people July 29, 2013, by Code



(Government of NL, 2013b; Ramalho et al, 2014)

Finally, as noted in Table 5 above, there are 4 types of public reports that the DOEC releases each year. One of these is the exceedance report, which is issued when drinking water quality laboratory results indicate a contaminant parameter that exceeds the GCDWQ and therefore provides another indicator of water quality in the province (Government of NL, 2014a). The *Annual Drinking Water Safety in Newfoundland and Labrador: Annual Report 2013* indicates that many communities have had exceedances ranging from bacteriological, chemical and physical, DBPs and aesthetics. For example, the DOEC's annual report indicates that there were 147 HAA exceedances and 132 THM exceedances in the 2012-13 fiscal year (Government of NL, 2014a). An exceedance occurs when the THM or HAA levels are above the GCDWQ recommended levels, which are 80µg/L for HAAs and 100 µg/L for THMs (Health Canada, 2012). After analyzing the data on the Water Resource Portal it was found, out of the approximately 454 communities in NL, in 2013, 127 communities had at least one report of over the Health Canada Guidelines for THMs (28% of all of all municipalities and LSDs in NL) and 146 communities had at least one report of over the Health Canada Guidelines for HAAs (32% of all municipalities and LSDs in NL)[7]. Concerns regarding water quality measures are discussed further in section 7.1 below.

4. Source Water Quality and Quantity

Source water refers to the lakes, ponds, rivers, and underground aquifers that are used to supply drinking water to a residence or community. The project's main findings regarding source water quality and quantity are outlined below and relate to three key areas of concern: disinfectant by-products, aesthetics, quantity issues and source water protection. Though there are other source water contaminants that came up in the media scan as concerns in rural NL communities (e.g. arsenic in wells, e-coli and tailings from copper mines) the below subheadings represent the most prominent concerns evident from the research. More detail on these and other source water related findings can be found in other reports on the project's website (http://nlwater.ruralresilience.ca/?page_id=17).

[7] Data obtained April 25, 2014 from http://maps.gov.nl.ca/water/

4.1 Disinfectant By-Products (DBPs)

4.1.1 Findings

DBPs are created when chlorine used to disinfect drinking water reacts with the natural organic matter found in source water (Ling & Husain, 2014). During consultations, the research team found that many municipalities were very concerned about organics in their water and the potential effects of DBPs (Minnes, Collins, Will & Lightfoot, 2014). This concern was reflected in many of the project's case study communities. For example, Sunnyside, Greenspond, and Old Perlican all noted high DBPs as an issue (Daniels, 2014a; Daniels, 2014b; Daniels, 2014c; Lightfoot, 2014b). As noted above, in the 2012-13 fiscal year, there were 132 THM exceedances and 147 HAA exceedances in NL (Government of NL, 2014a).

The results of the administrators survey indicate a relationship between communities with DBP exceedances and communities that rely on surface water supplies (Speed, 2014a). This is understandable as more organics can be found in surface water supplies than ground water, leading to higher concentrations of DBPs (Kar, 2000). Surface water supplies are more prevalent in NL, with 299 surface water supplies compared to 179 groundwater supplies (Government of NL, 2014a).

Experts indicated that this problem is expected to be exacerbated by climate change due increased precipitation and extreme weather events, resulting in increased delivery of dissolved organic content (Dolter, 2014). During the Drinking Water Policy Workshop, it was explained that dissolved organic content in water can be especially challenging for small communities in NL, as it requires more costly and sophisticated filtration systems to remove organic matter prior to disinfection than the technology currently used by many communities. Currently, filtration is not mandatory in NL (CWWA, 2012). The Water Operator survey found that 93% of operators from LSDs and 46% of operators from MOTOLs operate public water systems that do not use filtration (Speed, 2014b). A NL government representative made the following comment during an interview:

"*And if you look at somewhere like Ontario where filtration is mandatory, we've got to have filtration. Most of ours is raw water, but it's being chlorinated. We would love to take the step but again the financial cost all of a sudden to put filtration into 400 systems is astronomical*."

-NL Government Representative

Further discussions on filtration were also prevalent in the case study interviews. As one interviewee in Sunnyside explained:

"*I am aware of the high THMs, and the HAAs. And that is a major concern for me. I've done the research on it and I just don't like what I'm reading about prolonged exposure. So what I have done to protect myself, I've gone and bought a device that reduces the THMs and the HAAs in the water, and have a separate little tap on my sink for just drinking water. That gives me some level of comfort, but then not totally, because apparently you can absorb these through your skin when you're having baths and so on…. So, a filtration system is my biggest priority. But if it comes to the point that [a filtration system] is too expensive to operate, well I guess the town will have to make a decision. The residents will have to decide, am I going to pay a dollar a day to*

make sure that I have pristine, safe, clean drinking water? Am I going to pay that price? Because it's going to cost a lot of money."

– Municipal government representative (Daniels, 2014a)

4.1.2 Discussion

Evidence from medical studies suggests that disinfectant by-products can lead to serious health problems (see Table 7). It is important to note, however, that the literature review conducted on the health impacts of contaminants in NL drinking water found that there is some conflicting evidence related to the health impacts of DBPs (Thomson, 2014). For example, some sources indicate that HAAs pose potential reproductive health risks, while others found no increased risk for pregnancy loss with elevated DBPs, including HAAs (Thomson, 2014). While resident and municipal concerns surrounding DBPs are significant, experts during the policy workshop indicated there is no baseline data for DBP-induced illness in the province (Dolter, 2014). As a result it is difficult to quantify the true impacts of DBPs when it is still largely unknown how DBPs have affected NL residents' health, representing an area where future research is needed.

Table 7: Toxicological Effects for DBPs

Class of DBPs	**Compounds**	**Health effects**
Trihalomethanes (THM)	Chloroform	Cancer, liver, kidney and reproductive effects
	Dibromochloromethane	Nervous system, liver, kidney and reproductive effects
	Bromodichloromethane	Cancer, liver, kidney and reproductive effects
	Bromoform	Cancer, liver, kidney and reproductive effects
Haloacetonitrile (HAN)	Trichloroacetonitrile	Cancer, mutagenic and clastogenic effects
Halogenated aldehydes and ketones	Formaldehyde	Mutagenic
Halophenol	2-Chlorophenol	Cancer and tumor promoter
Haloacetic acids (HAA)	Dichloroacetic acid	Cancer and reproductive and developmental effects
	Trichloroacetic acid	Liver, kidney, spleen and developmental effects

Source: Ling & Husain, 2014

4.1.3 Solutions and Future Directions

The Government of NL (2009) stresses that the risks of consuming untreated drinking water outweigh the possible risks associated with DBPs. Chlorine is the most commonly used disinfectant not only in NL but also across Canada (Ling & Husain, 2014). The current policy on public drinking water systems states- with the exception of potable water dispensing units (PWDUs)- that a chlorine residual of 0.3 mg/L with a 20 minute contact time (or equivalent CT)

is required entering the distribution system, and a detectable free chlorine residual must be maintained in all areas in the distribution system (Government of NL, 2012, p.1). However, provincial officials have confirmed this is evaluated on a case-by-case basis, depending what technologies are being used, so there is room for the potential of new technologies that do not use chlorine. Dunn and Ziegler (2009) also suggest that since higher chlorine concentrations lead to greater concentrations of THMs and HAAs maximum levels of chlorination for drinking water are also required. The authors recommend maximum levels of 3500 Mg/L but no such maximum is currently required by the Government of NL.

Given the concern about DBPs and high number of exceedances in COTOLs the research team explored alternatives to chlorine (for disinfection) as well as options for organics and DBP removal at both the municipal and household scale. Table 8 lists such technologies with associated prices, compared to chlorine disinfection prices. For more information on treatment and filtration technologies examined, as well as DBPs, visit the project website for the full report entitled, "Technologies to Remove DBPs in Drinking Water in Newfoundland and Labrador – A Review" (Ling & Husain, 2014).

The options for removal of organic matter and alternatives to chlorine for disinfection, including those provided in Table 8 (e.g. ozone, UV disinfection, nano-filtration, etc) should be examined further (see also CBCL Limited 2011 for a review of water treatment options for organic matter removal). A cost-benefit analysis of implementing filtration and/or other DBP reducing technologies for small-scale systems as well as at the household treatment level should be conducted. These analyses should be comprehensive and consider different conditions (e.g. raw water quality, combination of technology, and operational factors). More research is also needed into the necessity of using chlorine in combination with these technologies.

Table 8: Estimated Cost for Different Disinfection and Organic Removal Systems

1 MegaGallon/Day	**Capital costs**	**Operation and maintenance costs**	**Annual cost (Based on 10 Year Life Cycle)**
Chloramine	$ 62,608	$ 4,861	$ 11,122
Chlorine Dioxide	$ 47,531	$ 21,217	$ 25,970
UV Disinfection	$ 359,359	$ 10,855	$ 46,791
Ozone	$ 974,973	$ 91,862	$ 189,359
Granular Activated Carbon	$ 863,696	$ 61,531	$ 147,900
Nanofiltration	$ 1,057,344	$ 133,392	$ 239,126
Microfiltration/Ultrafiltration	$ 1,786,445	$ 78,573	$ 257,218

Source: Ling & Husain, 2014

Overall, more research is needed on the long-term health impacts of DBPs in drinking water in NL communities. Proactive research is needed to track possible correlations between cancer rates and high DBP levels. There also appears to be a need to share information on DBPs, potential health-related impacts, and both municipal and household treatment options with the public. Care is needed in communications related to THMs, however, so as not to increase the likelihood of

residents turning to untreated water sources (e.g. roadside springs). Also, there is a need to look at more household treatment options and increasing education efforts for residents about what they can do at home if they are concerned about DBPs. For example, it was found in the Ling & Husain (2014) review on DBP reducing technologies that boiling water can remove THMs. This information, as well as other home treatment options for eliminating THMs and HAAs (e.g. water purification systems and UV water disinfection systems), should be proliferated through pamphlets or other public outreach mechanisms in communities where DBPs are found to be over the GCDWQ limits. This could be done in collaboration with other public outreach efforts needed (see Section 6.1).

4.2 Aesthetics

4.2.1 Findings

Less than one-third (29%) of administrators from MOTOLs and 6% of administrators from LSDs who responded to the community administrators survey indicated that source water quality was a "challenge" for their drinking water system (Speed, 2014a). Among the water operator survey respondents, only 19% of MOTOLs' and 7% of LSDs' water operators said that source water quality was their "biggest water system concern other than financial constraints" (Speed, 2014b). Overall these results suggest that the majority of municipal staff with water-related responsibilities do not see source water issues as a concern.

Among those who did indicate source water-related issues, aesthetic considerations were a re-occurring theme. The results of the administrators survey show that 24% of MOTOLs and 18% of LSDs thought that improving aesthetics should be the highest priority for improving drinking water quality in their community (Speed, 2014a). Furthermore, aesthetic issues arose regularly throughout the case study research and in the regional workshop consultations, with representatives reporting that discolouration (see Figure 5) and chlorine taste discourage residents from drinking from municipal supplies. Chlorine taste may not be a source water issue but it is captured within the category of aesthetic concerns by community representatives who noted it as a concern along with issues such as discolouration and turbidity (Minnes et al, 2014). Though aesthetic issues do not always indicate contaminated water, residents often use it as an unofficial indicator of contamination or poor water quality. For example, in the Black Tickle case study the PWDU water had a high iron count, which made the water brown and unappealing for residents to drink (Hanrahan, 2014).

Figure 5: "Tea" Colour Bathtub water
(picture provided by a Northern Region community representative)

4.2.2 Discussion

During the regional workshop consultations, the research team heard that residents often turn to alternative drinking water sources, such as roadside springs or bottled water (Minnes et al., 2014). Roadside springs are a concern because these are unmonitored sources and could put residents at risk. It was found in another NL based study that residents often judge the safety of their drinking water based on aesthetics (e.g., colour, clarity, odour, taste) (Butt, 2010). While ensuring technically safe water should be a priority, aesthetics issues should not be dismissed as merely an issue of perception. If communities are not drinking from their monitored water sources, the benefits from the considerable funds being invested in water treatment are not being maximized. Additionally, residents may be putting themselves at risk by using unmonitored sources as a result of the poor aesthetics of community-provided drinking water (see Section 6.1 for more on this).

4.2.3 Solutions and Future Directions

Solutions to aesthetics-related issues are often expensive, with costs for measures such as reverse osmosis or in-home filters used at the residential level being incurred by individual residents. At the municipal level, there has been some success in the case study community of Sunnyside with using a MIOX (mixed oxidant) system, which creates a liquid chlorine oxidant on site (Daniels, 2014a). However, although the MIOX system has improved taste and colour of the water as well as helping to maintain consistent chlorination levels throughout the system, some residents are concerned that this is contributing to DBPs because the chlorine has a greater contact time with organics in the water (Daniels, 2014a).

To ensure residents are informed in their drinking water choices more education is needed on the impacts of water that is neither monitored nor chlorinated, as well as on why aesthetic parameters do not always indicate the actual safety of drinking water. Education may also be needed on simple ways to reduce chlorine taste, such as refrigerating water/letting water sit to allow the chlorine taste to dissipate, or the use of charcoal filters such as Brita filters. For example, the United States Environmental Protection Agency suggests that chlorine treated water can be kept in the refrigerator in an open container overnight to allow the chlorine taste to dissipate[8]. Furthermore, a maximum chlorine level for drinking water should be established within the province wide drinking water treatment standards so drinking water is not over chlorinated.

4.3 Quantity Issues

4.3.1 Findings

Not only is water quality a concern for some communities, but water quantity is also an issue for rural communities in NL, albeit to a lesser extent. The water operators survey indicated that 20% of water operators in LSDs see low water levels and even drought (i.e. an extended period of unusually dry weather due to lack of rain) as a threat to their drinking water system, and 13% of MOTOLs water operators see drought/low water levels as a threat (Speed, 2014b). In the community administrators survey, 62% of LSD administrators and 72% of MOTOL administrators who indicated they had imposed a water ban due to a water shortage, said that "drought" caused the water shortage in their community (Speed, 2014a). For example, in the project's case study community of Port au Port East, low water levels after long periods without rainfall were expressed as a concern. In fact, Port au Port East has stopped issuing new building permits due to water quantity issues, which is impacting economic growth (Lightfoot, 2014a).

A NL Provincial government representative explained,

"*We've had communities run out of water because their ponds just don't have the capacity. They're not recharging at a quicker rate than the water's being used. Any extreme in weather is really going to (have an) effect in a surface water supply."*

[8] More on US EPA filtration facts can be found at: http://water.epa.gov/drink/info/upload/2005_11_17_faq_fs_healthseries_filtration.pdf

-NL Provincial government representative

However, water quantity was not a concern in other communities like Sunnyside, Greenspond, and Old Perlican. In Greenspond, water quantity was a challenge in the past; however, this was alleviated after a causeway was built in 1982, providing a land link to a second water supply (Daniels, 2014c). Similarly, the Town of Old Perlican had to find a second water source in order to meet the town's demands when the fish plants are running.

4.3.2 Discussion

According to recent climate change projections, NL is at a low risk for droughts in the 21st century, with the majority of dry spells lasting approximately five days throughout the province, and with dry spells long enough to be a concern (i.e. 10 days or more) considered rare (Finnis, 2013). Finnis (2013) further "suggests that issues around drought driven water shortages … are not a growing concern for the province" (p. 5). Despite this, however, the data for this project indicated that some NL communities have experienced periods of water shortage. This may be largely due to geography, specific locations, water sources, leakages and/or the capacity of the water systems of these communities. Causes of water shortage require further investigation along with solutions to combat occurrences of low water availability.

4.3.3 Solutions and Future Directions

As seen in the case study communities, a common solution to low water level issues is to simply find a new water source. This is a good option when feasible, but water conservation education and the implementation of conservation practices on an institutional, industrial, and residential level can also be a useful tool in drought/low water mitigation (USEPA, 2013). The administrators survey found that the majority of "high water users[9]" were government buildings such as schools or hospitals (Speed, 2014a); therefore, it may be prudent for the provincial government to consider implementing water conservation strategies in these provincially funded institutions. Water conservation will be discussed in greater detail in section 6.3.

4.4 Source Water Protection

4.4.1 Findings

The first line of defense in the provincial government's MBSAP is source water protection (Government of NL, 2014a). In NL, source water protection is enacted through the *Water Resources Act*. Protected public water supply areas (PPWSAs) are protected under section 39 of the Act (Government of NL, 2014a). Development within PPWSAs is regulated using several different tools to monitor activities, including: referrals from the Interdepartmental Land Use Committee, Crowns Lands, Natural Resources, MIGA and other agencies; permits for development; watershed sensitivity classification system; watershed management plans; and watershed management committees (Government of NL, 2014a). Designation of a water supply as a PPWSA allows municipalities and LSDs to put up signage banning unpermitted activities such as swimming, boating and fishing within their drinking water supplies. As of the fiscal year

[9] There were no qualifying features given to the term "high water users"

2012-13, 256 of a possible 299 public surface water supplies were designated as PPWSAs, along with 59 of a possible 179 groundwater sources (Government of NL, 2014a).

As for source water threats, LSDs and MOTOLs most commonly answered that there were "no threats" on the community administrators survey (see section 6.2). For those LSD administrators who did indicate that there were threats to their drinking water source, the most common land use activity threats were: hunting and fishing (19%), domestic wooding cutting (16%), and recreational use (16%). MOTOLs administrators noted that the most common land use activity threats were: recreational use (25%), domestic wood cutting (23%) and hunting and fishing (18%) (Speed, 2014a).

Consultations revealed that many communities do not actually monitor their water supplies, even if they are designated as PPWSAs, due to insufficient human resource capacity (Minnes et al., 2014). This is despite the fact that, under the PPWSA regulations, operators of the water systems in municipalities and LSDs are responsible for monitoring their water supplies. In the community administrator survey, 43% of LSDs and 22% of MOTOLs indicated that they do not prohibit any of the banned activities under the PPWSA regulations (e.g., swimming, bathing, fishing) in their drinking water supply area. In contrast, only 2% of municipalities of more than 1,000 indicated that they did not prohibit these activities in their drinking water supply area. These statistics suggest that LSDs and MOTOLs are less strict in terms of source water protection than communities with populations over 1,000. It was also found that of the 25 communities that said they did not prohibit activities in their drinking water supply area nine of those communities did have PPWSAs recognized by the DOEC (Government of NL, 2014h). When asked if staff regularly monitored their drinking water supply area, only 15% of LSD administrators and 55% of MOTOLs said that monitoring by municipal staff occurred on a regular basis (Speed, 2014a). From this, it seems that leaving source water protection monitoring solely at the discretion of local governments may be inappropriate given the current capacity of many small communities, as well as conflicting values and cultural uses within source water areas. The main mechanism for source water protection under these circumstances is the permitting process, whereby individuals and organizations undertaking new development must seek a permit to conduct activities within a PPWSA (Government of NL, 2014a).

4.4.2 Discussion

While the provincial government strongly encourages communities to protect their water supplies, it is not mandatory to have a PPWSA (Government of NL, 2014a). This poses various problems, the first being that not all water supplies have a formal mechanism for protection. Communities themselves have to apply for PPWSA designation and it costs $100 to do so (Government of NL, 2013d). Although the program was seemingly designed in this fashion to ensure a community driven process, it seems that even when communities have PPWSAs, protection and enforcement does not always occur. Without sufficient monitoring and active implementation of the PPWSA, the usefulness of PPWSAs in achieving source water protection is questionable. Lack of capacity and understanding of the importance of source water protection can contribute to weak adherence to PPWSA regulations, especially when human and financial resources are limited. For example, when administrators were asked about current land use activity threats to their water supply, 59% of LSDs and 49% of MOTOLs indicated there were "no" threats (Speed, 2014a). Provincial government officials were surprised by this statistic,

especially for surface water supplies, as there are always potential threats to drinking water sources. Further information on administrators' awareness levels will be elaborated on below in Section 6.2.

Watershed planning has been employed as a source water protection tool in other jurisdictions (Ivey, de Loë, & Kreutzwiser, 2006), but this is not a common practice in NL. According to the *2013 Drinking Water Safety in Newfoundland and Labrador: Annual Report* there are only five watershed committees in the province, and only three watershed plans have resulted from these committees (Government of NL, 2014a). Of these, Steady Brook (population 408) is the only COTOL that has a watershed plan/committee. Furthermore, none of these watershed plans are inter-community or regional agreements, meaning they may reflect political rather than watershed boundaries. This is problematic for managing drinking water, as what happens upstream, outside of the political boundaries, impacts downstream communities but may be outside of the planning boundaries. Participants in the expert policy workshop explained, there is currently insufficient capacity at both the local and provincial levels for many NL communities to develop watershed management plans (Dolter, 2014).

4.4.3 Solutions and Future Directions

Source water protection in NL is a water quality and quantity issue, as well as a policy and governance issue. The lack of mandatory and enforceable source water protection regulations puts NL communities at risk. Even though source water protection is stated as an important part of the DOEC's "Multi-Barrier Strategic Action Plan" (Government of NL, 2014a), and researchers have identified source water contamination as a threat to drinking water in NL, little research has been done in the province on current and alternative source water management structures (Mitacs Workshop, 2009). Furthermore, in a summary report of NL water research it was stated that there is a, "...lack of information regarding the connectivity between landscape attributes, hydrology, water use and water quality" (Ziegler, Butt & Husain, 2009, p. 17). There is much potential for further research on source water protection planning in NL, including possible management and policy alternatives.

The findings of this study suggest that further research is needed on how to enhance source water protection in NL, as well as compliance with PPWSA regulations. Even if the PPWSA regulations are not enforced, making the designation of a PPWSA mandatory for all public drinking water systems may help to stress their importance and should be considered. Furthermore, source water protection should be context appropriate, which makes one size, fits all regulations problematic (Breen & Minnes, 2014). Though community driven regulations like the PPWSA process are often considered a best practice, our findings indicate they are not always being effectively executed in rural NL. One example of a context appropriate source water protection measure would be setting watershed specific buffer zones in PPWSAs, depending on the pressures or threats in the area. Considering the often limited capacity of small communities, alternatives such as community based education, stewardship and monitoring programs (e.g. citizen science) should also be explored, as well as the potential role of non-governmental organizations and public groups. Furthermore, watershed management plans should be created on a physical/ecological watershed basis, including inter-municipal agreements where water sources and watersheds are shared between communities. This is especially important for communities that share PPWSAs. These communities will need greater support

from the provincial government and/or organizations such as MNL to create regional water committees and to discuss source water protection and other drinking water related issues. However, no plans or committee decisions can work unless they are implemented. Further research is needed on how source water protection is being done in other rural areas and how NL can improve the implementation of current policies.

New policies or governance arrangements must be accompanied by efforts to improve awareness of the need for source water protection and the potential threats to community water supplies. This in itself may increase the number of communities engaging in source water monitoring and protection. Provincial wide organizations such as MNL and PMA can play a role in increasing awareness of the importance of source water protection.

5. Drinking Water Infrastructure and Operations

In this report, "infrastructure" refers to all infrastructure related to public drinking water systems, including water intakes and treatment plants, pump houses, and distribution lines. "Operations" refers to the operations and maintenance of drinking water systems, including daily procedures, operator training and certification, and proactive maintenance such as leak detection. The sub-headings below outline the project's main findings pertaining to water infrastructure and operations. More detail on these and other infrastructure and operations related findings can be found in other reports on the project's website: (http://nlwater.ruralresilience.ca/?page_id=17).

5.1 Aging and Degrading Infrastructure

5.1.1 Findings

Aging and degrading drinking water infrastructure was the most common challenge noted by communities in the water operator and administrator surveys, the case study community interviews, and the MNL consultations (Speed, 2014a; Speed, 2014b; Minnes et al., 2014). The community administrator survey results indicated that the majority of communities in NL (81% of LSDs and 65% of MOTOLs participating in the administrators survey) require repairs or upgrades to at least parts of their drinking water infrastructure. Of these communities, 88% of LSDs and 85% of MOTOLs indicated that they couldn't make required repairs or upgrades due to a lack of financial resources (Speed, 2014a). When water operators were asked what they thought were the biggest issues facing their communities' drinking water system other than financial constraints, 73% of LSD operators and 65% of operators from MOTOLs cited the age of their system (Speed, 2014b).

The need for infrastructure repairs or upgrades was also a prominent theme in the case study communities. For example, Woody Point's water supply system was installed in 1975, and while the system has undergone minor repairs, there have not been any system upgrades since installation (Will, 2014). A similar message was communicated to the research team during the MNL consultations, where many municipal decision makers noted aging or broken drinking water infrastructure as a concern in their communities (Minnes et al., 2014). Case study

communities such as Old Perlican and Greenspond noted dead-ends, leaks, and cross connections as other pressing infrastructure issues (Daniels, 2014c; Daniels, 2014d).

It was found in the community administrators survey that 16% of LSDs and 25% of MOTOLs had implemented new or innovative solutions locally in an attempt to address their drinking water issues. These attempts at innovation were in response to various challenges and issues faced by communities. In terms of how often these measures succeeded, 6% of LSD community administrators and 8% of MOTOL community administrators indicated that past actions undertaken by their community in an attempt to address their water challenges had either failed, or had not worked well. They described, in particular, a lack of local capacity to manage new technologies. It was noted by administrators that new drinking water treatment technologies are sometimes installed that are inappropriate for the community. For example, in some cases there was no one in the community with the necessary expertise to operate or repair the infrastructure. This resulted in expensive new infrastructure that was unusable and/or unsuitable (Speed, 2014a). It was explained in MNL consultations that outside engineers are required to consult on what new infrastructure is needed when communities are applying for federal or provincial funding. It was noted that these engineers often do not take into account the scale and human and financial capacity of the communities or may be unwilling to recommend solutions beyond standard approaches, resulting in the adoption of inappropriate technologies (Minnes et al., 2014).

However, provincial officials refuted this claim during interviews, indicating that MIGA does not fund any projects without assurance that someone in the community can operate the system. How they do this was not explained. The Province has also expressed a commitment to providing rural NL communities with context appropriate solutions. In 2008, for example, former Minister of Environment and Conservation, Charlene Johnson, spoke to the Province's commitment to context-specific drinking water solutions:

"*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, 2008).

A commitment to drinking water from the provincial government is evident with the funding provided from 2008-2014 from MIGA through their capital infrastructure program totalling $234,983,015 (an average of just over $39M per year) to specifically drinking water infrastructure projects and $132,037,213 (an average of just over $22M per year) to water and sewer joint projects (a total of $367,020,228). Out of the total funding for 2008-2014, $95,067,253 (40% of total funding and approximately $15.8M per year) was given to COTOLs for drinking water infrastructure projects, and $22,813,840 (17% of total funding and approximately $3.8M per year) was given to COTOLs for water and sewer joint projects.[10] A recent survey by MNL indicated that COTOLs anticipate spending over $280M (approximately

[10] These numbers were provided directly by MIGA.

$28M per year) over the next ten years on water related capital costs[11]. Thus previous levels of expenditure will need to increase significantly to meet anticipated needs of COTOLs. This will also place financial demands on local governments. It was mentioned by provincial and local government officials that even contributing 10% of a project's cost, a requirement for small communities under the Capital Works program, can be challenging for many communities, especially ones in which residents are on fixed incomes and/or populations are declining (Minnes et al, 2014).

5.1.2 Discussion

The findings on aging and degrading infrastructure in NL are not necessarily surprising. In a recent report on the subject it was stated that approximately, "43% of Water and Sewer assets have therefore been amortized and close to half the asset class is through its useful life" (Cooper, 2013, p. 32). Cooper speaks to the issues of aging and inadequately maintained infrastructure in NL and identifies measures, such as better asset management, that could be implemented to reduce known infrastructure risks. Furthermore, it was found in an MNL study that "more than 80 percent of all municipalities have water and sewer systems that are more than 20 years old" (Keenan and Whelan, 2010, p. 13). The life span of drinking water infrastructure varies greatly depending on the type, make, and the operation and maintenance it has received. For example, pipe life cycles can range from 15 to over 100 years depending on materials used, how they are maintained, and various environmental factors (USEPA, 2012a).

Asset management is a means of improving the lifespan of infrastructure. Asset management includes preventative maintenance, maintenance and operations plans, systematically tracking the details of infrastructure installations (e.g., dates and locations), and appropriate costing to operate and maintain infrastructure. Experts in the policy workshop, as well as in our literature review, describe these measures as essential best practices for sustainable drinking water infrastructure management (Bakker, 2007; Breen, 2013; CBCL Limited, 2012; Heare, 2007; Dolter, 2014). Indeed, throughout the project's data collection process, weak asset management was consistently found to be an issue at the local level. In the water operators survey, for example, 33% of water operators from LSDs and 29% of from MOTOLs indicated that a lack of maps, as-builts, and digitized mapping of community infrastructure was the biggest issue in their community (Speed, 2014b). The community administrators survey further indicated that many small communities were unlikely to have maps of their distribution infrastructure; 52% of LSDs and 16% MOTOLs claimed they had no maps or blueprints (Speed, 2014a). Knowledge gaps regarding fundamental infrastructure considerations, such as where it is in the ground and how long it has been there, represent serious barriers to effective management of water systems.

One provincial government representative explains the positive impact asset management can have on infrastructure and infrastructure funding:

"*...like a lift station I'll say and the lift station is 25 or 30 years old and obviously they've got reasonable life expectancy out of it, so we take all that into consideration, whereas if it failed after 5 or 6 years and they have no records, or there is no full time operator, then there may not be an infrastructure issue it may be more of an operational issue, so we have to take that into*

[11] These numbers were provided directly by MNL.

consideration. So our recommendations are based on information that we get, and again, some of it can be you know, I'll say word of mouth as opposed to actual documentation, and again I think that reflects on the improper I'll say maintenance records and that being kept on equipment of infrastructure. But now the department has been very active in developing as-builts. We have the GIS system, and we have been collecting as-built data present and previous and putting that [together]. So I mean if community X had an issue, I'm not saying that we would have the as-built data, but they should be coming to us and looking at the problem if they didn't have it."

-Provincial Government Representative

One feature of proactive asset management is having organized leak detection programs to reduce water leakage or loss, which reduces chlorine usage and results in fewer emergency repair-induced BWAs (Infrastructure Canada, 2011). In the water operator survey, only 17% of operators from LSDs and 8% from MOTOLs said they had an organized leak detection program. Yet from the same survey it was found, 20% of LSDs and 27% of MOTOLs had 5+ leaks in 2012 that required repairs. This suggests that COTOLs' proactive leak detection practices have much room for improvement (Speed, 2014b).

In addition to physical asset management, issues with human resources management, specifically around succession planning (or lack thereof) for experienced water operators, were raised during consultations with municipalities as well as in several case study communities. It was noted that when water operators leave, essential system knowledge, as well as critical administrative information are often lost (e.g., where as-builts of infrastructure are stored and current routines related to standard operating and infrastructure maintenance)(Daniels, 2014c). Collectively, the data suggests that both physical and human asset management are relatively ubiquitous challenges among rural communities in NL.

Regarding future management of drinking water assets, the administrators survey also asked whether "improving, repairing, or expanding upon water infrastructure" was part of communities' capital works plans. The responses to this question were mixed. Despite widespread need for repair or upgrades of water systems, just under half of LSDs (46%) indicated that there were plans to improve their water infrastructure system in their existing capital works plan; 31% indicated there were no plans to do so in their existing capital works plan, and 23% indicated that their community did not have a capital works plan. As for municipalities, 22% of MOTOLs indicated that there were no plans to improve or expand upon their water system as part of their existing capital works plan, whereas 2% of municipalities with over 1,000 residents did not include water infrastructure in their existing capital works plans.

One promising policy change highlighted in the Old Perlican case study was the reporting of Tangible Capital Assets (TCA). Starting in 2008, municipalities across Canada were required to account for their TCA in annual financial reporting, with the order from the Public Sector Accounting Board (PSAB) (MIGA, 2014). TCA for water infrastructure includes: dams and diversion structures, pipelines, reservoirs, tanks, wells, pumps, mechanical and electrical equipment, buildings, electric power and emergency equipment (CICA, 2007). This requires that municipalities pay closer attention to the value of their infrastructure over the course of these materials' useful life than in the past (Daniels, 2014d).

A final point on asset management relates to how local governments charge for drinking water services. In regards to infrastructure funding, one provincial government official explained:

"*There is a lot of money flowing through communities in our department alone that I know of. Again, it should be assisting them with operating and maintaining them and then charging reasonable levels so that they can do that.*"

-Provincial Government Representative

During a focus group in 2014 the following comments were made on the subject:

"Because you have some towns that legitimately cannot afford it but they're doing their best, and you have other towns that are, if your only charging 5 bucks a month for water then you know, I don't want to say I don't have any sympathy for you but your probably paying 30 a dollars a month for a cell phone bill or something or 100 dollars a month for cable"

- Municipal Government Representative

"People feel that these… any municipal service we shouldn't have to pay for them, and I'm not overly convinced of that. Cause again General Motors don't care, you know the car is the price of a car."

- Municipal Government Representative

Studies have shown that households on water meters (i.e. systems that measure how much water a consumer is using) use less water than households who are not (Hardie & Alasia, 2009). In the community administrators survey, it was found no LSDs and only 7% of MOTOLs use a metering fee-for-service set up. Many councillors and mayors also mentioned in consultations that their water and sewer taxes barely cover their water operations (Minnes et al., 2014). This suggests an overall lack of full cost accounting[12]. While water metering may not always make sense in small communities, there is a demonstrated need for proper operational management structures and proportional pricing in rural NL communities. A 2010 NL study found that the average water rate charged to residents was $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. In fact, a recent survey released by MNL on ten-year capital and operational cost estimates found that providing drinking water will place a heavy burden on smaller municipalities, especially in terms of capital costs (e.g. over one third of all capital expenditures expected for towns under 500 will be water related expenditures). Overall, the survey estimates almost 20% of municipal expenditures in NL in the next ten years will be spent on water capital costs and operations[13].

[12]Full cost accounting/pricing refers to accounting for the complete or true cost of drinking water systems, including all direct and indirect costs that are upfront, operational, and in the future (Roseland, 2012). Social and environmental costs are included, as are opportunity costs (i.e., the value of what is given up) (USEPA, 2012b). While accounting for costs that do not have an obvious value is challenging (e.g., environmental costs), at a minimum the money coming in needs to equal the money being spent. This includes not only basic operation and maintenance, but also the establishment of a reserve fund.

[13] These numbers were provided directly by MNL

Further study is needed to determine exactly how water rates are actually derived in NL. Though communities may think that they simply cannot afford to charge residents more for improved water systems, a recent study by Holisko et al. (2014) found that residents in Centreville-Wareham-Trinity and Indian Bay would be willing to pay more if water system improvements were made. Residents of other communities may well feel the same, particularly given the importance of drinking water to human health. The United Nations suggests that water costs should not exceed three percent of the household income (United Nations, 2013). This could be a useful metric to use when determining how much the tax base can afford to devote towards water-related costs.

5.1.3 Solutions and Future Directions

Rural NL could benefit from pilot metering programs aimed at promoting full cost accounting by building on previous experiences in the larger centres of Corner Brook, Mount Pearl, and St. John's (Murphy, Olson & Ramirez, 2010). Even if water metering is deemed inappropriate, further investigation into alternative methods of incorporating present and future costs into water fees is needed. Full cost accounting and better estimates of the true cost of drinking water systems' operations could be included in fiscal framework discussions between the provincial and local governments.

Overall, findings also suggest that asset management could be improved in rural NL. Better asset management could in turn improve the lifespan of water infrastructure and result in reduced funding requirements for aging and degrading infrastructure. During interviews with provincial officials, researchers were told that Capital Works funding can be used for asset management activities, but this is currently not widely utilized. The provincial government and organizations such as MNL and PMA should better promote this funding opportunity. Information should also be provided about the services of companies who can help digitize mapping resources and centralize drinking water related documents (see Daniels, 2014b). Also, sharing infrastructure, parts and tools with neighbours to make operations and maintenance more affordable should be considered more often, with the potential to formalize such arrangements in cases where this sharing is already taking place on an informal basis. Regional approaches are more fully explored in Section 5.2 and 7.5. For example, municipal officials from Greenspond and surrounding communities have collectively bought leak detection equipment, which makes the cost of the equipment more reasonable.

During a comparative research project associated with this project, researchers visited rural British Columbia to investigate innovative drinking water management programs there. One example is a program that is led by the Columbia Basin Trust (CBT) called the "Water Smart Program". Through this program, CBT helped communities evaluate their "leaks and peaks". The program raised awareness of water use in communities and demonstrated that preventative leak detection measures can reduce system demand and preserve community infrastructure. The program also included a strong educational component (Hamstead & Paré, 2014).

Addressing the issue of infrastructure deficit in rural NL communities is a priority for moving towards more sustainable drinking water systems. Providing communities with more funding for water infrastructure will help mitigate aging and degrading infrastructure, but this on its own is

not an economically or fiscally sustainable solution. It has been found that better maintenance and operations could improve the state of infrastructure in rural NL and extend the life of both existing and new infrastructure investments. To realize this potential, communities must focus on keeping better records including infrastructure maps and blueprints, conducting preventative maintenance, charging appropriate fees for water services, and considering regional programs.

5.2 Operator Education, Training, and Certification

5.2.1 Findings

In 2001, the Operator Education, Training and Certification (OETC) program was initiated in NL by the DOEC (Government of NL, 2014a). As of the 2012-13 fiscal year, there were 376 certified water and/or wastewater system operators in the province (Government of NL, 2014a). This may seem like an encouraging statistic, but the community administrator and water operator surveys found that uncertified water operators are prevalent in MOTOLs and LSDs. Indeed, the administrator survey indicated that 35% of LSD operators and 21% of MOTOLs have water operators with no certification.[14] Even though water operator certification is stipulated as a clause in the Permits to Operate (Government of NL, 2014a), it is evident that this clause is not always followed or enforced. According to some consultations with case study communities (e.g. Woody Point, Port au Port East, and Greenspond), if certification requirements were enforced for COTOL water operators it would be difficult for many COTOLS to comply. It is already difficult enough for these small communities to find and retain a water operator at all, let alone a certified one (Will, 2014; Lightfoot, 2014a; Daniels, 2014c). In contrast, there were no municipalities of over 1,000 who indicated they had an uncertified water operator (Speed, 2014a), illustrating a clear disparity by community size.

Along these lines, the project also explored the differences between certified and non-certified water operators. Unsurprisingly, the administrator survey indicated that certified operators were more likely to be in paid, full time positions, as opposed to volunteer positions (see Figure 6). As larger communities are more likely to have the tax base to hire a full time employee they are also more likely to have a certified operator. Also, during consultations with municipalities, it was evident that MOTOLs face significant human and financial resource shortages that make it difficult to find and retain certified water operators (Minnes et al., 2014).

[14] No certification was defined as no formal training recognized by the DOEC under the OETC program. The "Operator in Training" classification (under the OETC program) was treated as "certified" for the purposes of the certified versus not certified dichotomy.

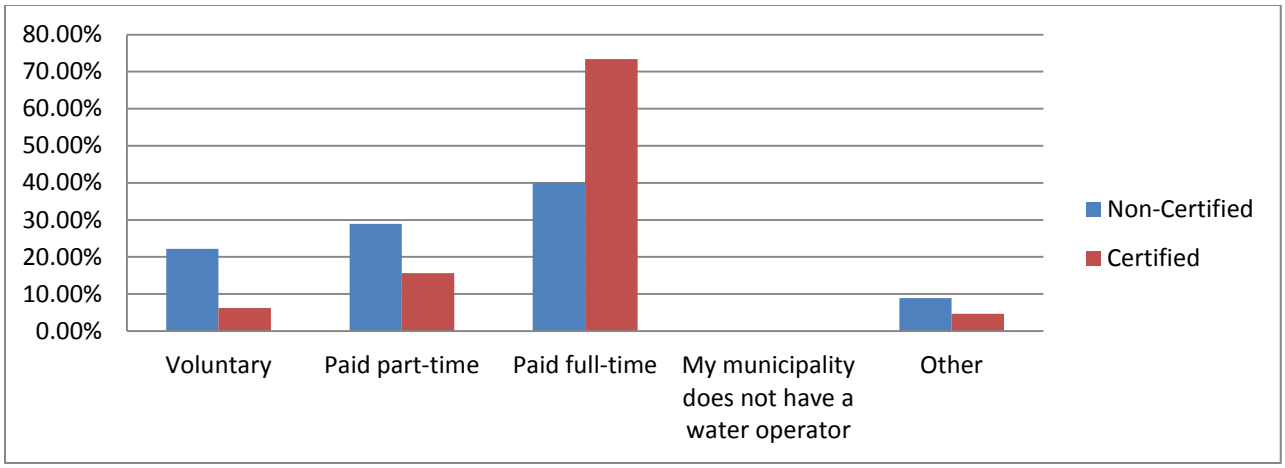


Figure 6: Certified/Non-Certified - Employment Type

The results of this study suggest a relationship between water operator certification and the prevalence of asset management, substantiating the aforementioned challenges associated with lack of asset management in small communities. In the community administrators survey, communities with certified water operators were found to be more likely to have a Capital Works Plan that focused on expanding, improving, repairing, or replacing the municipal water system (Speed, 2014a). Furthermore, in the water operators survey, certified water operators were found more likely to report that they had complete maps of pipe infrastructure, and were also more likely to report having a specific office or filing area for drinking water system information. While certified and non-certified operators were equally likely to have a written formal maintenance plan for water distribution infrastructure, certified water operators were more likely to have a maintenance plan for the water treatment system/plant operations than non-certified operators (Speed, 2014b). Another difference between certified and non-certified operators from the water operators survey was the frequency with which chlorine residual was checked (Speed, 2014b). This is important, as during interviews with provincial officials, it was stated that chlorine residual should be checked daily in two locations, as per best practices to ensure that no bacteriological contaminants enter the drinking water system (Government of NL, 2012). Certified operators were more likely to check for chlorine residual daily in two different locations, while non-certified operators were more likely to check only once a week (see Figure 7). As displayed in Table 6 (see Section 3.3), chlorine related issues contribute to 44% of BWAs (e.g. 47 BWAs were due to no chlorine residual being detected in the system and 63 other BWAs were due to chlorine related issues (Government of NL, 2013b; Ramalho et al., 2014).

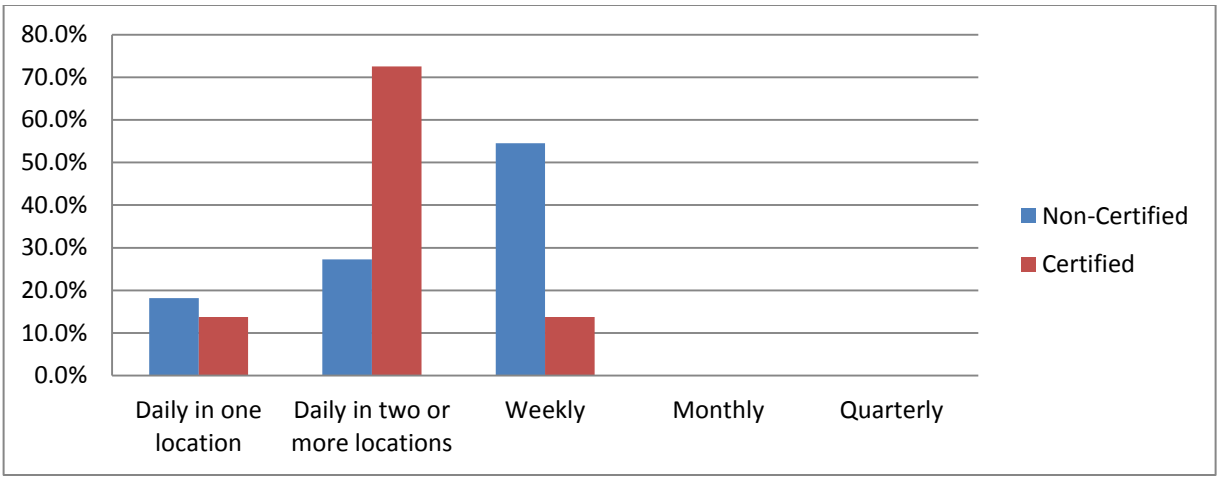


Figure 7: Non-Certified/Certified - Frequency of Checking Chlorine Residual

5.2.2 Discussion

Following the Walkerton Tragedy in Ontario, in which seven people died and thousands became seriously ill, an inquiry was commissioned (O'Connor, 2002). In this inquiry it was stated,

"Perhaps the most significant recommendations in this report address the need for quality management through mandatory accreditation and operational planning. Sound management and operating systems help prevent, not simply react to, the contamination of drinking water. In this vein, I recommend requiring all operating agencies to become accredited in accordance with a quality management standard – a standard that will be developed by the industry and others knowledgeable in the area and mandated by the [Ministry of Environment]. Accreditation is designed to ensure that operating agencies have systems in place at the organizational level that will enable them to deliver safe water. Also, as part of the quality management approach, I recommend that each municipality be required to have an operational plan for its water system. I anticipate that the accreditation standard and the requirement for operational plans can be tailored to accommodate systems of different sizes and complexity"

(O'Connor, 2002, p. 12).

Mandatory certification for all public water systems water operators is a laudable, if somewhat unrealistic, goal. As a provincial government representative explained during an interview:

"*I would love it if it were mandatory for everyone. But I understand the road blocks. If you've got a guy who's only getting paid, a lot of these guys who aren't getting paid. I know that these things are hard. I know fellas who have been out at 3 o'clock in the morning fixing a water leak, when the house with the leak wouldn't even get down to the pit to help the guy. So you've got to have realistic expectations. Say you're going to have a mandatory certified operator of your town of 50 people, then there's got to be something else in place for them to say hire an operator or pay him some money. Because that's the thing, the problem is with the volunteer organizations in the LSDs. That's where the biggest risk would be.*"

-Provincial Government Representative

Oftentimes in small communities, water operators are volunteers who are giving their time to do basic maintenance and operations work for their community's water system. But to what extent can, or should, these volunteers be relied upon to do the preventative maintenance and the technical operational tasks needed to keep these systems running? Indeed, many operators are nearing retirement or are already retired (Dolter, 2014). Furthermore, especially with volunteer operators, there is little succession planning for who will take over these positions when the current water operator leaves (Daniels, 2014c). At the same time, without training operators put themselves at greater risk should a health concern arise related to drinking water.

Based on the study's findings, the research team concludes that uncertified water operators are more prevalent in COTOLs, and that training (i.e. certification) enhances the sustainable operations and maintenance of water systems. Also, uncertified operators pose more than a health risk. Provincial officials suggest that uncertified operators are often the cause of operational and infrastructure problems.

5.2.3 Solutions and Future Directions

Though certification is mandatory for all water operators (and is a component of communities' Permits to Operate), our survey results have found that this clause in the Permit to Operate is often not enforced. Mandatory certification of water operators should be clearly stated in the Water Resources Act (not just buried in Permits to Operate that are not available to the public) to further emphasize the importance of certification. It may, however, be acceptable for uncertified employees/volunteers to conduct daily chlorine residual sampling and other smaller tasks for the water system if a qualified operator oversees them. Additionally, a qualified regional operator could also initiate asset management activities, as well as address infrastructure repairs and attend to other technical duties. Regional operator programs have been successful in the Northern Peninsula, notwithstanding some 'growing pains', and have been piloted in other areas (see Section 7.5). It should be recognized that as found in other Atlantic Canada studies on water operators, limited capacity and social capital, operator stress, and incorporation of current and upcoming regulations are all burdens for rural water systems (Kot, Castleden & Gagnon, 2012). The idea of regional water operators was noted during consultations with municipalities at the MNL regional workshops as well as in discussions with provincial officials and in the Centreville-Wareham-Trinity topic case study, as a solution to concerns surrounding the lack of certified water operators in COTOLs (Minnes et al., 2014; Dolter, 2014; Daniels, 2014b). Regional operator programs may not be feasible for some remote communities, but the results of this research suggest that further analysis should be done on the feasibility of these programs in other regions of NL. Based on these findings, the provincial government should consider further incentives to encourage regional operator programs. Further research into successes and challenges of regional water operators in NL and elsewhere could help shape the design of such incentives and other measures to support the success of these programs.

To complement this program, research into remote technologies should be applied where feasible. For example, if the chlorine residual was monitored in communities automatically and the residual levels were available online or via cell phone, then this would save a regional water operator from having to check the residual daily in two locations in each town. Chlorine analyzers may also save a water operator (regional or local) from having to go into the pump house/water treatment plant every day (USEPA, 2009).

The NL Government has an innovative asset in the Mobile Training Unit; however, many municipalities expressed interest in learning more about this program during the MNL regional workshops, which suggests that more education and awareness is needed about this service (Minnes et al., 2014). It was also suggested at consultations that more regional training opportunities should be provided and that other towns should be notified if a training opportunity is taking place in their region (Minnes et al., 2014). Furthermore, COTOLs must ensure that a back up water operator and plans for succession of water operators are in place.

5.3 Potable Water Dispensing Units

5.3.1 Findings

PWDUs have been separated here from the general discussion on aging and degrading infrastructure above, as they have been highlighted by provincial representatives and some towns as a solution in rural NL and therefore warrant special attention. PWDUs are small-scale water systems that treat water for drinking water purposes only (i.e. not for other household purposes such as showering or laundry). Water is stored at a central location, where it is manually collected by users (Miller et al., 2009). Therefore, residents must go to the PWDU location with water containers and transport the water back to their homes. PWDUs use a combination of different water treatment processes that are also used in large-scale water treatment plants, but at a smaller scale (Miller et al., 2009). These systems include a combination of multimedia filtration, activated carbon filtration, ozonation, reverse osmosis, and UV disinfection (Government of NL, 2009). These systems are very sophisticated compared to the typical drinking water treatment and filtration infrastructure in COTOLs in NL (Speed, 2014b).

According to the community administrators survey, the most common reasons for installing a PWDU are chronic BWAs on the existing drinking water system, a lack of financial resources for household hook-ups, and health concerns surrounding drinking water (see Table 9).

Table 9: Why a Community Uses a PWDU

	Do you operate a PWDU?	
	Yes, the entire municipality/LSD	Yes, part of the municipality/ LSD
Municipality cannot afford to install/maintain direct-to-home water system	3	1
Province would not fund direct-to-home water supply	1	0
Chronic boil water advisories under old system	4	0
Reported ease of maintaining PWDU	0	0
Residents demanded municipal drinking water system	0	0
Health concerns related to not providing local, clean drinking water	2	0
Lack of regional option	0	0

Source: Speed, 2014a

The community administrator survey indicated that in 100% of PWDU operating LSDs, the PWDUs were working properly; 82% of MOTOLs indicated their PWDU was working properly. For some communities surveyed, it is clear that PWDUs are seen as a solution to their drinking water challenges. Six communities indicated that installing a PWDU was a new or innovative solution they had tried with their drinking water system. Overall, however, research reveals mixed opinions regarding the success and potential of PWDUs. In the case study community of Black Tickle-Domino, for example, residents complained that the PWDU was not placed in an optimal location for all residents to conveniently access it. This results in the added costs of having to pay for gas to retrieve the water from the PWDU location via snowmobile in the winter and automobile or ATV in the summer. Furthermore, the community's PWDU is inconsistently functional and is open at inconvenient times. PWDU usage was limited due to frequent malfunctions. A further problem identified was the physical difficulty of carrying the water containers from the PWDU location to a vehicle and from vehicles to homes, especially considering aging demographics. Furthermore, possible contamination of water storage containers due to containers not being cleaned properly has been noted as a health risk (Hanrahan, 2014).

During consultations with municipalities, PWDUs were sometimes noted as a step backwards in terms of water systems, or as a "band-aid" solution (Minnes et al., 2014). Concerns were also noted about the rising costs of the units and of the costs of operations. One water operator spoke about PWDUs in the following manner:

"*Well, first time they were brought up in Gander, they cost $50-$60,000. The last quote I heard was over $400,000 to install. So that's one thing and after people got them in the operation costs, they need an everyday operator for so many hours; otherwise they just won't run properly. Not something an operator can do once or twice a week, there are things that need to be cleaned and flushed everyday*."

-Water Operator

It is evident that there are some concerns about PWDUs from municipal officials and water operators alike that warrant further investigation.

5.3.2 Discussion

PWDUs have been actively encouraged in small communities by MIGA due to their ease of use and effectiveness in delivering clean and safe drinking water. In 2013, six new PWDUs were installed (Government of NL, 2014a). Provincial officials and some communities have noted PWDUs as an appropriate solution for small, rural communities because they require operators to have limited technical expertise, and are inexpensive compared to treating water for household distribution (Miller et al., 2009; Miller et al., 2014a). In practice, however, some rural communities like Black Tickle-Domino have not found the units inexpensive or easy to operate. Furthermore, for communities such as Makkovik, who have chosen a PWDU because of concerns about DBPs in their water (Lightfoot, 2014b), studies have shown that DBPs still can be absorbed through skin contact when bathing (Thomson, 2014).

The research team understands that PWDUs can be a feasible option for communities with chronic BWAs, as it can provide an alternative source for safe drinking water. Serious consideration should be given, however, to PWDUs as a permanent solution to poor drinking water quality versus as an increasingly expensive temporary solution while waiting for funding and/or appropriate technology for a better treatment and water distribution system.

5.3.3 Solutions and Future Directions

A speech from the Minister responsible for MIGA at the most recent MNL Symposium made it clear to rural communities that the province is encouraging communities to consider PWDUs as a solution to their drinking water challenges. It should be recognized that communities have mixed feelings about these systems. Further research and public education on the benefits and costs of PWDUs is needed. PWDUs could very well be the answer to some rural NL communities' water system problems, but not all communities have reached this conclusion. A credible and trusted organization, such as MNL or PMA, would be an appropriate entity to commission research into the successes and challenges of PWDUs thus far in rural NL communities. Furthermore, comprehensive studies on optimizing the design and improving the performance of PWDUs under different environmental and operational conditions as well as more demonstrational tests in the field could be beneficial.

6. Public Perception, Awareness and Demand

Public perception, awareness, and demand in this study refers to residents' attitudes and behaviours in relation to their drinking water. Perception is defined as a way to become aware of something through the senses, or of regarding, understanding or interpreting something.[15] Though public perceptions of drinking water do not always coincide with provincial and federal data on water quality, it is one indicator of water quality. Public awareness is further discussed in this section in terms of how community administrators view drinking water quality and the ways in which NL residents' use publically supplied drinking water.

6.1 Residents' Perceptions of Drinking Water

6.1.1 Findings

This research project did not collect primary data on general perceptions of residents, with the exception of resident interviews in case study communities. Instead the research team relied on existing reports pertaining to public perception, a media scan, and municipal opinions and evidence (e.g. complaints) related to resident perception. The media scan was used not as a representation of public opinion, but a means of getting a general sense of what non-experts (i.e. media) in NL were saying about drinking water and what kind of information residents have been exposed to by the media. The media scan on COTOLs found that out of the 94 articles examined in depth, 16 related to frequent or long term BWAs, and 10 were about a drinking water contaminations such as high DBPs, e-coli, and arsenic. This suggests that drinking water issues are mainstream issues, as indicated by story headlines such as, "Don't Drink the Water"

[15] Oxford dictionary definition

(Morrissey, 2005) and "Resident Starts Petition For Better Water" (Clarkson, 2011). However, not all headlines were negative. The greatest proportion of articles (23), were related to water treatment facility upgrades and the provision of funding for drinking water related expenses. This is encouraging and demonstrates to the public that investments are being made to improve drinking water conditions in their communities.

Figure 8: Roadside spring in Gambo

In the community administrators survey, 62% of LSD administrators and 69% of MOTOLs perceive their communities' public drinking water supply is drinkable directly from the tap. Additionally, very few administrators (only 10% from LSDs and 11% of MOTOLs) indicated that residents' perceptions of drinking water in their community were either somewhat or very negative. Nevertheless, 16% of LSD administrators and 17% of MOTOLs revealed they receive complaints about their water systems every 1-7 days (Speed, 2014a). This suggests that community administrators may have presented overly positive interpretations of their residents' perceptions of drinking water supplies. Again, as with all of the survey results, the research team assumes that those communities with the lowest financial and human capacity were less likely to answer the survey, which further suggests that the results from the community administrator and water operators surveys may portray an overly positive picture of drinking water systems in rural NL.

Even though residents may not be aware that their drinking water contains DBPs, concerns about DBPs in NL were raised by the elected officials that were consulted during the MNL regional workshops, as well as in case study communities, particularly in Sunnyside (Daniels, 2014a). Health concerns mainly stem from fears of carcinogen exposure, but government reports also outline other DBP health risks including but not limited to: liver cancer, kidney damage, reproductive effects, and developmental effects (Government of NL, 2009). As a result of one or more of these concerns, residents may feel that roadside springs, which are not chlorinated, are free of THMs and HAAs and are therefore perceived to be safer. Alternatively, they may be turning to commercially purchased bottled water as an alternative (Daniels, 2014a).

In consultations with municipalities, as well as in case studies, it was revealed that many residents do not like the taste of chlorine. The clear colour of spring water vs. discoloured surface water in community systems was also cited as a factor leading to roadside spring water collection. During the drinking water policy workshop, the issue of chlorination was linked back to operations and management. It was expressed in the MNL regional workshop consultations

that “end of the line” issues are prevalent in rural communities (Minnes et al., 2014). This refers to situations in which chlorine residual levels meet the minimum level at samples taken halfway through the distribution line, but do not meet the minimum level at houses at the end of the distribution line. To remedy this problem, water operators occasionally use large amounts of chlorine so residual levels meet standards throughout the water distribution line. This results in chlorine taste at the beginning of the line that may be overwhelming for residents, further inducing roadside spring collection or the use of bottled water. Residents’ preferences for water sources other than publically supplied water due to aesthetics (e.g. chlorine taste and/or colour), as well as the aforementioned concerns about DBPs were found in the Greenspond, Old Perlican, Port au Port East, Makkovik, and Woody Point case studies (Daniels, 2014c; Daniels, 2014d; Lightfoot, 2014a; Lightfoot, 2014b; Will, 2014).

During consultations with municipalities, many elected officials did not see collecting drinking water from roadside springs as an issue, as this is a common practice in NL (Minnes et al., 2014; Nicol, 2009). However, based on previous studies and after consultation with health officials and provincial representatives, it is clear that roadside springs are an unmonitored source of drinking water that pose a risk of contamination. A recent study conducted in Indian Bay, NL in 2013 discovered, for example, that E. Coli was found in a water sample from a roadside spring (Holisko et al., 2014). Similarly, in a study done in 2009 on the use of springs for drinking water in Western and Central Newfoundland, it was found that roadside springs used for drinking water contained E.coli and/or coliforms 43% of the time (Nicol, 2009).

Provincial government representatives acknowledged roadside springs as a risk:

“*Oh I totally agree. And one, you definitely don’t know what’s happening in the spring, you don’t know what’s happening upstream. I mean, again, it’s a risk, and a percentage of the people believe it’s safe and reliable.”*

-Provincial Government Representative

Clearly, the provincial government considers roadside springs to be a concern. However, very little public education on the dangers of roadside springs has been coordinated as roadside springs fall out of the jurisdiction of the province, and local governments are often not aware they are an issue or do not wish to be seen as taking responsibility for these unmonitored and unregulated sources. Overall, residents’ use of potentially dangerous roadside springs due to mistrust or distaste for the public water system is an important issue in rural NL.

6.1.2 Discussion

During consultations with municipalities and through the expert policy workshop, it became evident that the public, and even municipal elected officials need more education on drinking water-related concerns and water conservation. The research team felt that elected officials benefitted from consultation sessions and presentations on the research project. For example, during the Northern Regional MNL workshop, a research team member’s simple suggestion of refrigerating a water jug overnight to allow the chlorine in the water to dissipate was noted as very useful information by participating municipal officials. While not a focus of this study concerns about the safety and sustainability of bottled water have also been raised.

Municipalities and the provincial government have taken a non-interventionist approach regarding the use of roadside springs, in part due to liability concerns. This is potentially putting the public at risk. It was recommended in a 2003 study that, "efforts to discourage the use of roadside spring water should be strengthened" (Howse, 2003, p.5). The report goes later to say that municipalities should post warning signs at roadside springs and that springs outside municipal boundaries should be dealt with "similarly" by the provincial government (Howse, 2003). Clearly, some ownership needs to be taken to educate the public on the potential dangers related to roadside springs.

6.1.3 Solutions and Future Directions

More education is needed to change public perceptions about drinking water, as well as raise awareness levels on the importance of drinking water treatment. To start, more emphasis on chlorine management is required within the DOEC's OETC program. Though this will not impact those operators who are not certified, operators need to know the importance of appropriate levels of chlorine in public systems. To combat the aforementioned "end of the line issues", greater consultation could also be undertaken with communities regarding chlorine boosters to reduce over chlorination of drinking water. Please see Section 4.1 for more on DBP reducing technologies and the need for provincial standards on maximum chlorine levels. More information also needs to be communicated to community officials and the general public on the risks of DBPs. As mentioned previously, more research on the long-term impacts of DBPs would complement the needed public education on the subject in NL. Perpetuating even simple information, such as how to reduce the taste of chlorine in water with home filtration and treatment, is needed.

Ultimately, it is residents who must decide what water sources they use; however, when municipalities or the Province discover commonly used roadside springs, it would be beneficial to make some attempt to educate the public on the potential risks. Experts at the Drinking Water Policy workshop mentioned that literacy levels should be considered when educating the public. A mixed methods approach should be employed using channels such as local newspapers, mail outs or inserts with tax bills, social media, and public service announcements on the television and the internet. However, the internet should not be relied upon as the sole method for communication, as some areas of rural NL have poor connectivity and residents who do not use the internet regularly. Ultimately, context matters in education efforts; messages must be tailored to individual communities' circumstances, languages, and available media (Dolter, 2014).

6.2 Level of Administrators Awareness

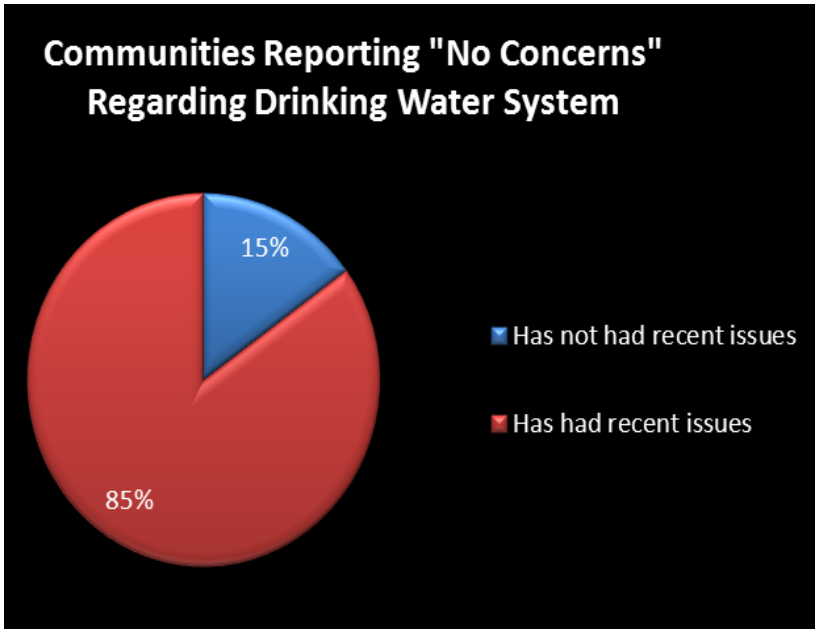
6.2.1 Findings

During the analysis of the community administrators survey, the research team was perplexed by how many administrators indicated in a multitude of questions that they had "no concerns" related to their drinking water system. This was especially curious given the prevalent challenges that were mentioned during consultations, as well as those challenges found during the team's secondary source review. As a result, researchers took the level of administrators' awareness of

threats to their drinking water systems as a form of public perception that required further investigation.

The research team compared the answers given in the community administrators survey to data provided on the DOEC's Water Resources Portal (http://maps.gov.nl.ca/water/mapservices.htm) to see whether respondents' answers coincided with available provincial data. This comparison found that out of the 40 administrator respondents that indicated they did not have any concerns regarding their municipal/LSD water supply, 85% of those communities had experienced recent issues (as of 2010) with their drinking water system according to provincial data (see Figure 8).

Figure 8: Communities Reporting No Concerns vs. DOEC Data



(Speed, 2014a)

For example 27/40 communities that said they had "no concerns with their drinking water system" had no current DWQI ranking in Winter 2014 due to THMs/HAAs that exceeded federal guidelines or the presence of a BWA. Furthermore, 14/40 communities who said they had no concerns about their drinking water system had noted aesthetics issues in the last three years according to the DOEC data (Speed, 2014a). Despite the concern expressed by elected officials regarding DBPs (Minnes et al., 2014), 59% of administrator respondents who indicated that they had not had any issues with THMs/HAAs in the last four years had in fact exceeded the GCDWQ standards at least once in the last four years according to DOEC data (Speed, 2014a; Government of NL, 2013e).

More generally, it was found that 35% of administrators in LSDs and 33% in MOTOLs did not know or were unsure of the level of water operator certification their water operators held (Speed, 2014a). This suggests a lack of awareness amongst administrators regarding their communities' water operations. Given the overall responsibility these individual have for managing their municipalities this apparent lack of awareness is a major concern.

6.2.2 Discussion

It seems that the respondents to the community administrators survey were often unfamiliar with the specifics of their drinking water quality data. Although respondents were asked to have their most recent drinking water quality report out while completing the survey, this data does not appear to be wholly understood by municipal staff/elected officials. It should be noted that rural NL has never experienced a major drinking water crisis like the one that occurred in Walkerton, Ontario in 2000, so water contamination may not seem like a pressing issue for many stakeholders. When interviewed by the research team, town officials suggested that if nothing has happened, then to many, it seems like nothing is wrong. Furthermore, as NL does not have the same level of agricultural or development pressures as other provinces, which was one critical factor in the Walkerton crisis, there is less of a perceived risk to drinking water. However, that does not mean there are no risks when public water systems are not meeting mandatory requirements (e.g. proper chlorination levels) or when residents are drinking from unmonitored sources.

Administrators and other key municipal decision makers need to be better educated regarding their drinking water systems and drinking water-related issues so that they can make more informed decisions. Due to a noted lack of personnel at the provincial government level (Dolter, 2014) if the fiscal and human capacity cannot be found within the provincial government to adequately educate administrators and town staff, then professional associations and/or non-governmental should be engaged to fill this gap. In either case, partnerships between the Province and associations such as PMA, MNL, and the Atlantic Canada Water and Wastewater Association could lead to more effective education and awareness-raising efforts.

6.2.3 Solutions and Future Directions

As mentioned previously, public education is a critical component of safe, healthy drinking water. Training sessions and courses on drinking water management should be mandatory for community leaders and staff, as it is an important part of their job. Organizations such as MNL and PMA could fill this gap through mandatory education sessions at annual meetings and regional workshops. As will be mentioned below in the regional approaches section, regional water committees can also play an important role in sharing information and best practices.

6.3 Water Use and Conservation Efforts

6.3.1 Findings

According to the community administrator's survey, 23% of LSD respondents suggested that they have local regulations addressing water conservation (e.g. times of day watering grass was allowed). In relation to conservation, only 9% of MOTOLs indicated that their municipalities had water conservation bylaws in place. Additionally, only 19% of the LSDs and 37% of MOTOLs who noted having water shortage issues indicated that a water ban had been put in place to combat these shortages (Speed, 2014a). Also from the community administrators survey, 53% of respondents in MOTOLs indicated that there were high water users in their municipalities. Among these municipalities, the most commonly identified high water users were

schools and fish plants (Speed, 2014a). Among MOTOLs who indicated that they had high water users, 42% had attempted to discuss drinking water issues with these facilities' owners/operators. Only 9% of LSDs indicated that there were high water users in their areas. This was not a surprise to the research team as none of the common high water users noted were expected to be numerous in LSDs. Among LSDs who indicated that they had high water users, only one had attempted to discuss drinking water issues with these facilities' owners/operators. Moreover, 81% of LSDs indicated that the water needs of industry and government did not adversely affect water quality or pressure for their residents. Overall, high water users were not perceived to be a major problem within LSDs, but were relevant for the majority of participating municipalities.

When asked how high users are charged for water, 80% of LSDs and 57% of MOTOLs responded that these users pay a lump sum payment. This suggests that high water users may not be paying rates that are commensurate with their usage, however this requires further investigation in relation to full cost accounting in order to confirm. During the Drinking Water Policy workshop, participants acknowledged that residential metering could help induce conservation; however, it is generally not used in rural NL (Dolter, 2014) (see Section 5.1). However, as mentioned, public buildings such as schools and hospitals, as well as commercial/ industrial ones like fish plants, are the greatest water users in the province (Speed, 2014a). The seasonal impact of fish plants on water supplies was also noted in the case study communities of Old Perlican and Woody Point (Daniels, 2014d; Will, 2014). In the Old Perlican case study, the fish plant is metered and has extremely high rates of water use. The fish plant's water tax contributes significantly to the cost of operating the drinking water system in the community (Daniels, 2014d).

Inadequate or degrading infrastructure also contributes to excess water use in many communities. The issue of leakage has been discussed above. In the Makkovik case study, to stop water lines from freezing during the winter months, as with other areas in NL (Dolter, 2014), Makkovik asks residents to continually run their water during the winter (Lightfoot, 2014b). This community-level policy is not only merely a temporary solution to the larger issue of inadequate infrastructure, but it is also a misuse of treated water.

6.3.2 Discussion

It is very interesting that a greater percentage of LSDs than MOTOLs reported that they have enacted conservation bylaws given that the latter have the legitimate authority to do so while the former do not (see Section 3.1). It is evident that proactive conservation bylaws at the local level are not common practice in rural NL. At MNL regional consultations, it was suggested that water is commonly perceived to be abundant in NL, and since it is not a pay-per-use utility, water is undervalued (Dolter, 2014; Minnes et al., 2014). The connections between conserving water, preserving infrastructure, and saving on operational costs associated with having to treat less water do not appear to be well understood in the province. Studies by Hardie & Alasia (2009) and Environment Canada (2011) outline a higher per capita use of water by residential users in rural areas. Furthermore, NL is estimated to have the second highest per capita water usage rate of all Canadian provinces and territories: approximately 804 litres per capita per day (Environment Canada, 2011).

Yet residential metering is not necessarily a comprehensive solution. As one provincial representative explained:

"*I mean the meters require someone regularly checking them and the time that's required for replacement and you know the province needs to look at that and say if your thinking about going into metering then this is going to be a capital eligible category down the road. Then again, we've had requests for individual systems, residential systems, it's not something that we have as a policy as of right now.*"

-Provincial Government Representative

6.3.3 Solutions and Future Directions

There is currently no water metering policy at the provincial level, which is understandable given the capital investment and expertise needed for metering, especially at the residential level. However, better metering or at least an understanding of usage, for industrial and commercial users, such as fish plants, is required, as well as for high users of water that are public facilities. Installation of meters at every residence would be difficult and costly, but if the biggest water users were targeted this could be a feasible start for metering in rural NL communities, where this kind of metering does not already exist.

Secondly, further clarification of the *Municipalities Act, 1999* should be considered regarding giving LSDs the authority to enact bylaws related to conservation of water, as this could have a positive impact on their water supply. Overall, there is a need for more proactive water conservation policies and programs (e.g. education) at local and provincial levels. This includes conservation campaigns in communities. Both decision makers and the public must understand that distributing water within their communities entails significant costs and that misusing treated water is expensive – a cost which residents bear (Dolter, 2014). As evidenced by policies on running water all winter instead of fixing or replacing pipes, this water-wasting culture seems to be engrained at the community as well as the household level. More financial support could be provided to communities to replace pipes that do not have proper insulation or were not installed deep enough into the ground, resulting in frozen pipes during the winter. This would eliminate the need for residents to run their water all winter.

The case study community of Port au Port East provides an example of a simple but effective conservation strategy. A community building in their town had continually flowing urinals that put an unnecessary demand on the water system. Flushes were installed on these urinals to prevent continuous running (Lightfoot, 2014a). Combining programs that increase awareness of the need to conserve with incentives to encourage water conservation such as funding support for such water conserving devices could significantly enhance water conservation efforts in the province.

Public outreach programs concerning drinking water and water conservation in other provinces, such as Ontario, have been spearheaded and delivered by entities such as conservation authorities and environmental non-governmental organizations. In NL, these bodies do not exist in most communities, and it is clear from interviews with provincial representatives that, like local governments, the Province also lacks human and financial capacity. Maximising the capacity of already existing programs and actors, such as non-governmental organizations who may be

involved in community based monitoring or public education, could be explored. Potential partners include the Atlantic Coastal Action Program (ACAP) and Ducks Unlimited. Modelling a province-wide water education program on existing examples, such as the provincial government's "Turn Back the Tide" climate change awareness campaign (http://www.turnbackthetide.ca), may also be appropriate. Furthermore, government resources, such as those within the Office of Public Engagement, should be utilized to assist with community education. Lastly, policymakers, educators, and scholars should all consider how academia and other educational institutions at all levels can help in mobilize knowledge and facilitate public outreach and education.

7. Policy and Governance

Though background regarding water policy and governance in NL was provided in Section 3, research findings related to policy and governance are presented in this section. Policy and governance issues relating to specific drinking water system components have been discussed in their respective sections. In this section governance refers to the set of actors (government and non-government), structures and processes in place to direct and manage drinking water in rural NL. The following discussion on policy and governance includes legislation, guidelines, programs and decision-making tools that emerged as specific points of interest in the research findings. Suggestions are also made for how governance tools, structures and processes may be improved. For more on specific NL water policies, see the DPSIR Scoping Document located on the project website (http://nlwater.ruralresilience.ca/?page_id=17).

7.1 Concerns Regarding Water Quality Measures

7.1.1 Findings

The NL Water Resources Portal is an excellent tool managed by the DOEC, providing the public with important provincially derived drinking water data[16]. Information regarding public water supplies, drinking water reports, BWAs, and drinking water quality is provided on the site. When querying community reports, eleven different reports can be generated. Research team members used the Portal extensively in their analysis. Additionally, while the research team did not receive a great deal of feedback on the Water Resources Portal specifically, feedback was received on the DWQI during the Drinking Water Policy Workshop (Dolter, 2014). The DWQI is intended to be a simple tool for reporting on drinking water quality in the province based on the GCDWQ (Tobin, 2010). However, the research team found that many communities do not receive DWQI scores (see Section 3.3.). In fact, whenever communities exceed GCDWQ recommended limits for THM or HAAs, or are on a BWA, they do not receive DWQI ratings (Speed, 2014a). It was found that out of the 4,740 water quality rankings between 2009 and 2012, 3,431 were "Not ranked". In other words, 72% of community rankings in this three year time period did not provide a meaningful DWQI score (Speed, 2014a). In addition, there were no DWQI scores lower than "Fair" in this period. Therefore, no water sources in NL were ranked as either "Marginal" or "Poor" despite the challenges outlined throughout this report (see Figure 3

[16] For more information on the Water Resource Portal visit: http://maps.gov.nl.ca/water/

in section 3.3) (Government of NL, 2014c). This was curious to researchers considering, for example, the large number of communities on long term BWAs. Further, 10% of LSDs and 4% of MOTOLs self reported in the community administrator survey that the drinking water in their community was "Not suitable for drinking, but suitable for other home uses" (Speed, 2014a).

7.1.2 Discussion

Having a rating system that does not provide a meaningful indication of drinking water quality in over 70% of water sources does not serve the public good. Given that most communities that have a DWQI ranking are labelled as excellent or very good (Speed, 2014a), it seems likely that the DWQI misrepresents the drinking water reality in many NL communities. Excluding those communities who are on BWAs and have high THMs or HAAs skews the overall picture. Accordingly, communities, researchers, or governments cannot use the DWQI as a baseline metric of drinking water quality or the effectiveness of drinking water systems in NL, and as a result the index has limited utility for policy development, implementation, and evaluation. Furthermore, the DWQI is a poor communication tool that is inherently biased by the way it selects which public water supplies get rankings.

Experts at the Drinking Water Policy Workshop viewed the DWQI as an inappropriate ranking system. It was explained by workshop attendees that the DWQI system is not designed to consider annual averages or adequately incorporate THMs or HAAs (Dolter, 2014). However, simply giving all communities with BWAs, or those with high THMs and HAAs, a poor rating would also not accurately reflect the quality of community water supplies. This is because many BWAs are issued for precautionary reasons, such as when maintenance is occurring (Dolter, 2014). Therefore, a BWA at the time of ranking may not actually mean that the drinking water quality is poor on average. While the current DWQI ranking system is inadequate, appropriately integrating BWAs as well as THM and HAA measurements into this metric is no easy task.

7.1.3 Solutions and Future Directions

The DWQI should be amended to better serve communities with concerns such as high THM/HAAs and BWAs. Further research is needed as to how to improve the DWQI so it can be used as an accurate baseline metric, as well as an easy to understand communication tool. This should include examination of drinking water quality monitoring and reporting mechanisms in other jurisdictions. Furthermore, performance indicators related not only to drinking water quality, but also to water infrastructure maintenance and operations should be employed in community drinking water reports. For example, in a 2011 report on Municipal Fiscal Sustainability, several performance indicators employed by the Government of Nova Scotia are suggested: water treatment and distribution; water tests; and water main breaks (Locke, 2011). These indicators measure the effectiveness of water infrastructure and the quality of drinking water. Particularly useful in relation to improving the DWQI, it is explained that water tests, "would measure the percentage of water test results that showed adverse water quality or exceeded maximum concentrations as prescribed" (Locke, 2011, p. 497). The performance indicator system used by the Government of Nova Scotia may be a valuable example for NL communities. It is likely that the Government of NL already has the necessary data to create such a system.

7.2 Managing Boil Water Advisories

7.2.1 Findings

During the expert policy workshop, as well as during the consultations with municipalities during the MNL regional workshops, concerns were raised about the validity of BWAs as an indicator of risk (Dolter, 2014; Minnes et al., 2014). As mentioned above, BWAs can be precautionary in nature. It was determined that some communities are more cautious than others (e.g. calling a BWA when flushing lines or doing short term maintenance); therefore, it may appear as though these communities have lower water quality than others simply because they issue BWAs more frequently. Furthermore, sometimes BWAs are extended longer than necessary due to liability concerns (Dolter, 2014). As one Provincial Government representative explained:

"*A lot of the time people have… looked at the boil water advisories, and they use that as their measuring stick. And it's unfair because ten years ago towns weren't putting on boil water advisories for something like that. Or if we're doing maintenance. They're going to be flushing the system and that's going to introduce more dirt to the system, the chlorine demand is going to go up so we're going to put on a boil water advisory for a couple of weeks while we're doing maintenance. That's completely pro-active and safe, smart. If someone had done that in Walkerton, we would have never heard of it. And so we don't like to use the boil water advisories. Unfortunately a lot of LSDs, it's just less stress that they just remain on it. We've got a lot of them still chlorinating it and inspecting their water but they'll remain on it just to take the stress out of their lives because they can kind of play (auto) pilot and wash their hands of it because we told them to boil the water, which is not the purpose of the boil water advisory."*

- Provincial Government Representative

It was noted at the MNL regional consultations that BWAs cause residents to lose confidence in their water system, leading them to choose other drinking water sources, especially when BWAs are frequent or in place for long periods of time (Minnes et al., 2014). Therefore, reducing the number and length of BWAs is seen as necessary to improve residents' perception and use of public drinking water systems. Overall, clearer guidelines about issuing BWAs are needed, as those currently in place are largely subjective and often left at the community's discretion. This sometimes makes it difficult to differentiate between precautionary BWAs and advisories issued for more serious reasons (Dolter, 2014). Additionally, when there is a long-term (and very long-term) BWA, communities sometimes stop communicating these advisories to residents (Dolter, 2014). Furthermore, residents may not be aware that their water is no longer being chlorinated (or is being chlorinated at inadequate levels) during a BWA (which researchers heard is sometimes the case in NL communities) (Minnes et al., 2014). This puts old and new residents at risk, as old residents may believe their water is still being adequately chlorinated and new residents may not even be aware of the BWA. The results of this research suggest that better communication with residents about how and why BWAs are issued is needed.

Furthermore, the process for terminating BWAs needs to be streamlined, especially in rural areas with limited access to Service NL labs (Minnes et al., 2014). Some remote communities are given the responsibility of taking and delivering their own drinking water samples (Government of NL, 2014a), however this does come with related cost concerns. On the other hand rural

communities often experience time lags between Environment Health Officer visits, when they are waiting on NL Services to perform tests for the required two clean drinking water samples. As explained in the Woody Point case study:

"*Our boil orders would normally be a lot shorter if the provincial government had the resources to get people down when we needed them down here. They only come down when they're available to come down. So we could be working on a plan to get the boil order removed and we'd lose that opportunity because the provincial health staff doesn't come down to check, because ultimately they're the ones who can take it off. We can put it on – but they have to take it off. So there's a capacity issue there with the [provincial] government.* "

- Municipal Government Respondent (Will, 2014)

The considerable number of BWAs issued in NL is disproportionately impacting COTOLs (see Section 3.3) (Ramalho et al., 2014). Though some communities, such as Greenspond, have relatively few BWAs of short durations (Daniels, 2014c), there are many communities that have been impacted by long term BWAs. In the administrators survey, 56% of LSD administrators and 16% of MOTOL administrators indicated that they have been on a BWA that has lasted one year or longer (Speed, 2014a). According to the DPSIR scoping document, of the 248 BWAs issued for water sources serving less than 1,000 persons on April 23, 2013, over half of them (n=137) were long-term BWAs that had been in place since 2008 or earlier (Ramlho et al., 2014). This indicates long term and even very long-term BWAs are prevalent in rural NL. Some examples of very long-term boil water advisories in NL include Portugal Cove South - BWA since 1984, Pollard Point - BWA since 1987 and St. Brides, Point Lance, Branch and Chanceport - all on BWA since 1989 (Government of NL, 2014i).

7.2.2 Discussion

The BWA system in NL was designed to protect the public. Unfortunately, in some ways, it is being used as a temporary, or worse yet a long-term, solution when the funds or expertise are not available to solve a problem. Furthermore, the BWA rationales are not being adequately communicated to residents, making it difficult to determine whether they are issued for precautionary reasons or as a result of a contamination in the system. This is eroding residents' trust in public drinking water systems (Minnes et al., 2014). While BWAs alone should not be used to determine water quality, unfortunately, the public often view BWAs as indicating an issue with their water. It was found in Butt (2010), similar to the project's findings, that there is low compliance with provincial recommendations for safe public water use during BWAs in NL. Improved communication and education about BWAs and implications for water use practices are needed.

7.2.3 Solutions and Future Directions

Overall, BWAs are not always a problem; BWAs are sometimes a very proactive and useful tool for ensuring drinking water safety. However, clearer communication to the public is needed about why a water system is on a BWA, along with better communication about the expected length of these advisories. Simply advertising a BWA when it is initiated is insufficient. It should also be clearly communicated when on a BWA, if towns are no longer chlorinating the water or not chlorinating to adequate levels – so the public knows the potential consequences of drinking the water may extend beyond the issue that prompted the advisory. Further, during extended BWAs residents require reminders of the BWA. In short, more information and education for residents about BWAs is needed.

Not all BWAs are equal. Those communities on long-term (and very long-term) BWAs should be ranked differently, as long term BWAs and residents' inability to drink the town water for long periods of time should be seen as a more severe problem by provincial and local governments. Long-term BWAs reflect a serious breakdown in a public water system and an inability to provide safe drinking water supply to residents. Greater attention is needed to examine the causes of long-term BWAs and explore solutions to address related deficiencies in the water systems of these communities. With programs such as the OETC training, the Province does try to prioritize operators that are new or in communities on long term BWAs. However, evidently a strategy is needed to better address remaining long- term and very-long term BWAs in NL.

Furthermore, rural areas need assistance to get off BWAs in a timelier manner once the issue of concern has been addressed. For example, we suggest that rural communities, like remote communities, be given the authority to have the option to take their own samples when on a BWA, for at least one of the two of the required clean samples to remove the BWA (Government of NL, 2012). This would result in reduced reliance on provincial inspectors to travel to these communities, and potentially would result in BWAs being removed more quickly. In this case, all testing of the water would still occur at the NL Services lab, therefore the time delays due to a lack of human resources at the lab could still be an issue. One expert suggested that if a BWA is issued for preventative mechanical reasons (e.g. flushing of lines or small repairs on a water distribution pipe) the community should only need one clean water test to have the BWA designation lifted. This would be a useful step towards separating preventative BWAs from those that are issued due to demonstrated risks (e.g. bacteriological contamination) found in the water supply (Dolter, 2014; Minnes et al., 2014). Another drinking water expert suggested that a possible rating system to measure the risk posed by different BWA codes (or alternate codes) could be created to help better explain to the public what kind of BWA their water system is on.

The proposed rating system was simply:

- Red (a true public health risk was found in the water)
- Amber (there is a possible risk)

(Dolter, 2014)

Other ranking systems used by Health Canada differentiate between a Boil Water Advisory; Do Not Consume Advisory: and a Do Not Use Advisory (Health Canada, 2013). The definitions for these rankings are below:

*"**Boil Water Advisory (BWA):** An advisory issued to the public when the water in a community's water system is contaminated with faecal pollution indicator organisms (such as Escherichia coli) or when water quality is questionable due to operational deficiencies (such as inadequate chlorine residual). Under these circumstances, bringing the water to a rolling boil for at least one minute will render it safe for human consumption.*

***Do Not Consume Advisory:** An advisory issued to the public when the water in a community's water system contains a contaminant, such as a chemical, that cannot be removed from the water by boiling.*

***Do Not Use Advisory**: An advisory issued to the public when the contaminant that poses a health risk cannot be removed from the water by boiling and exposure to the water could cause skin, eye, and/or nose irritations or when an unknown contaminant has polluted the drinking water supply (e.g. a chemical spill).*

***Drinking Water Advisory (DWA):** Preventive measures to protect public health from confirmed or suspected microbiological and/or chemical contamination in drinking water. They include "Boil Water", "Do Not Consume," and "Do Not Use" advisories"*

(Health Canada, 2013, pg.vi)

Another alternative to the current BWA system in NL is the *Quantitative microbial risk assessment* (QMRA) tool, which is used to more clearly communicate health risks associated with water systems by using source water quality data, treatment barrier information, and pathogen specific characteristics to estimate safety risks associated with the water (Dawe, 2013). The QMRA moves from a zero risk model for BWAs that NL currently uses, and adopts the Health Canada risk target of 10^{-6} DALYs per person per year for individual pathogens as a guideline or standard for drinking water safety. Use of the QMRA risk rating for determining when a BWA should be put in place could reduce the number of BWAs, and would mean BWAs are actually indicating a health risk. This could then increase compliance with BWAs (see Dawe, 2013 for more on the use of QMRA for assessing risk in NL). If this system is considered, we suggest it that it should be carefully examined for a rural NL context. Evidently, more research is needed to determine an appropriate ranking system for drinking water quality advisories in NL. Lastly, future research is needed in relation to understanding the true health risks of unsafe drinking water in rural NL. This could include looking at gastrointestinal illnesses in communities with long-term BWAs versus short-term BWAs and those not on a BWA, to compare probability, incidence rates, and length of illness (Dawe, 2013).

7.3 Integration and Coordination

7.3.1 Findings

During the research an overarching theme emerged regarding a lack of integration and coordination amongst the provincial and local governments. There were many situations where local government believed that the Province could be doing more for local water systems, and vice versa. There was also some confusion on the part of local government officials over their role in managing drinking water systems. Local governments also sometimes felt there was not enough communication amongst provincial actors. Furthermore, it can often be a lengthy process to get provincial and municipal officials to reach mutually acceptable solutions on issues like funding proposals and BWAs (Minnes et al., 2014). In the case study community of Old Perlican, for example, it was felt that MIGA should provide greater support in the application process for Capital Works funding (Daniels, 2014d).

Some communities also felt that the provincial government was not listening or simply has not prioritized drinking water issues (Minnes et al., 2014). The research has found this perception does need to be clarified, as it has been made clear by several throne speeches as well as speeches from DOEC and MIGA Ministers that drinking water is very much a priority of the provincial government (Ramalho et al., 2014). Also, through the MBSAP, provincial government actors seemingly seek to coordinate efforts amongst various provincial departments. For example, one provincial government official said the following regarding working with colleagues in other departments,

"*I think it's very good, and the longer we work together the more we get to know each other. And everyone understands what our roles are and what we're trying to do. Sometimes a line is drawn, sometimes our role as trainers, a lot of times the phone calls I get is people saying hey, can you come out and do training for me. It's really a service call and they want us to go out and repair something for them. If there are ways that we can do that and still make it training...*"

- Provincial Government Representative

It seems that when they can, the provincial government, especially the DOEC, is willing to accommodate communities when requests are made. However, there are few formal channels for local government to voice their concerns to the provincial government or strategically work with provincial actors in a true multi-level governance arrangement. Also, the provincial government often lacks in human resources to properly manage the very large regions they are responsible for and to meet all requests that are made of them (e.g. getting off BWAs faster). According to the MBSAP, everyone has their role in the water system, including LSDs and municipalities. Another provincial government employee explained this dynamic as:

"*I think it's more a collective thing in my opinion. The province takes it's ownership and responsibility and the town needs to take their ownership and responsibility and ensuring the proper resources are there to operate and maintain it and ensuring the people that were going to operate and maintain it were properly trained and (this) may not have been as well defined in the contract as it should have been*."

- Provincial Government Representative

As seen in the regional workshops, there is some confusion about the responsibilities of municipalities in the MBSAP, especially concerning source water protection efforts (Minnes et al., 2014). Furthermore, during consultations, municipal representatives vocalized a sense of mistrust of the provincial government, especially concerning issues such as DBPs. One focus group respondent said:

"We met with the Department of Environment about a week ago, and they know the situation with THM's, alright I don't trust government [Same here, same here.] Because they say that well, don't go talking about that and let everybody in Newfoundland know about THM's and HAA's because we are going to be in serious trouble, we can't afford what we're doing now."

- Municipal Government Representative

On another note, one councillor from Centreville-Wareham-Trinity explained:

"*There is a lot of documentation related to our water, from the government, out there, and a lot of it that we don't really know about. And if that could be presented in some way, integrated together, that would be very helpful*."

– Councillor (Daniels, 2014b).

Data management requires better integration between local and provincial levels. All municipalities should readily know about and be familiar with the Water Resources Portal. Furthermore, a more integrated system where municipalities have electronic access to the as-builts and maps of their infrastructure available not only in their own town offices but also at provincial regional offices (e.g. regional offices of MIGA), would facilitate discussions between officials from both levels of government and provide back-up copies of key documents.

7.3.2 Discussion

Though it does seem through the MBSAP that the provincial departments involved in drinking water governance have generally good coordination, there is clearly some miscommunication and room for improvement in terms of multi-level governance relationships related to drinking water management. There is currently an interdepartmental working group at the provincial level that leads work on the development of policy and guidelines relating to drinking water safety (Government of NL, 2014a); however, despite their critical role, local government and non-governmental organizations are not invited to these meetings (Government of NL, 2014a). More communication in a formalized venue, such as an inter-governmental working group, could enhance communication between various levels of government and contribute to a better understanding of roles, responsibilities, challenges and opportunities for innovation and improvement. Furthermore, if these already existing interdepartmental meetings happen on a regional scale, it could be an opportunity for provincial government to share the information they have with communities and develop better ways to coordinate and integrate data as well as responsibilities. As was stated in a 2003 study conducted by the DOHCS, "…more frequent discussion between the provincial government and municipal governments is needed to ensure that they recognize their responsibility in delivering information to their residents about their local drinking water supplies, particularly during BWAs" (Howse, 2003).

7.3.3 Solutions and Future Directions

Opportunities, such as the one provided through the project's policy workshop that brought together various drinking water actors, including federal, provincial, local government and non-governmental actors, offer the potential to improve integration and successful policy implementation (Dolter, 2014). Existing provincial interdepartmental working groups are one example of a venue that could be used to increase communication and coordination on water systems management between municipal and provincial governments by inviting non-provincial actors (e.g. local government actors) to meet with the working groups. Also, this could be a time where community leaders could receive further instruction on how to use the Water Resource Portal. Software programs where water system related data, as-builts and maps could be digitized could also be used to integrate and visualize information about water systems at the municipal and provincial levels (see Daniels, 2014b for an example).

7.4 Implementation Gap

7.4.1 Findings

Overall, as described in Section 3.1, municipalities/LSDs are largely satisfied with provincial policies. However, some findings suggest that implementation of provincial level policies are lacking. First, each operator (or town) of a public water system receives a permits to operate where stipulations regarding things like mandatory chlorine residual levels and level of operator training/certification are outlined (Government of NL, 2014d). Performance evaluations are occurring to some extent with the Permit to Operate Drinking Water Inspection Program (Government of NL, 2014a). However, this program is still in its infancy and had only provided ratings for ten systems in the 2012-2014 time span (Dawe, 2014). As discussed in the previous sections of this report, some clauses such as required water operator certification are not being achieved in all communities (Speed, 2014a).

Further, in regards to the PPWSA designation, it was found that many communities do not enforce the banning of activities in their PPWSA area (Minnes et al., 2014). As explained in Section 4.4 source water protection under the PPWSA regulation is up to the municipality to monitor, and is a voluntary designation. The idea behind making the PPWSA designation voluntary was explained by one provincial government representative:

"*I suspect that that's why it was a community-based program in the beginning and that communities had to be okay with their watershed areas being protected and having these duties to their water supply area because it helps to get that idea out there that "this is our water supply area and we need to watch what we're doing in there because this water supply area needs to still be there a hundred years down the road for our children's children". A community program fosters that outreach of knowledge better than a top-down."*

-Provincial Government Representative

It seems in our discussions with municipalities that having the PPWSA designation does not always foster more outreach or resident knowledge regarding related restrictions, other than signs being posted about the presence of PPWSAs (Minnes et al., 2014). For example, in the case

study community of Old Perlican interviewees said even though there are signs posted indicating that the source water ponds are protected water supplies, residents often skidoo over the source. Town representatives indicated it would be impossible to prevent all recreational use of ponds (Daniels, 2014d). Mechanisms are needed to ensure more involvement of local governments and residents in protecting their drinking water supplies while recognizing the realities of multiple uses in many, particularly larger, rural watersheds.

During the policy workshop, experts said that watershed plans could be a good tool for water resource management; however planning and implementation would be difficult in many cases, as it requires significant resources that towns do not have. Furthermore, if every town created a watershed plan, there is insufficient capacity at the provincial level to assist with this venture (Dolter, 2014).

Lastly, insufficient financial resources to support provincial programs and policies were reported as an issue. It was found in the DPSIR Scoping Document that most NL drinking water related policies have an underrepresentation of economic instruments to support them (Ramalho et al., 2014). For example, the OETC program is said to be an important part of the MBSAP (Government of NL, 2014a), however, attracting and retaining qualified operators can be a problem as there is often inadequate funding there to make these positions attractive to qualified candidates. One full time regional water operator explained in relation to the water operator job,

"*No retirement benefits, there is no medical or benefits of any kind, nothing in that department. That is one thing they could look at is putting some sort of funding in place so that you can use it to make benefits. You go to work with other companies you start with benefits even pension benefits.*"

-Regional Water Operator

7.4.2 Discussion

There is a clear need for more provincial support and human capacity to ensure provincial policies are being implemented. There are many provincial policies but few regulations that have meaningful mechanisms for enforcement. Furthermore, there are very few institutions/ organizations to help fill the capacity gap. In places such as Ontario, there are conservation authorities that act as the coordinators between the government and the public (Dolter, 2014). As funding for bodies such as Conservation Authorities seems unlikely in NL, efforts need to be better coordinated between provincial governments, local governments and even non-governmental organizations to enhance compliance with provincial policies and regulations.

An encouraging program that already exists in coordination with MIGA and the DOEC is the Maintenance Assurance Manual (MAM[17]) designed for local governments. The MAM program supports MIGA's strategic direction of "appropriate infrastructure investment" (Government of NL, 2014g, p. 11). In the most recent 2012-2013 MIGA Annual report it was said that out of the municipalities that piloted the MAM program from January to December 2011, that better maintenance records and practices improved municipal councils knowledge of their water system

[17] For more on the MAM program see: http://www.env.gov.nl.ca/env/waterres/training/adww/2012/13_Alan_Kirby_MAM.pdf

operations. MIGA has also committed to creating a MAM program specific to communities of 500 residents or less (Government of NL, 2014g). This seems like a very promising program that should be expanded and made mandatory, as it helps to ensure water operators and local governments know what is expected of them regarding the maintenance of their water system.

7.4.3 Solutions and Future Directions

More monitoring and mechanisms for enforcement are needed for drinking water guidelines, policies and regulations related to drinking water in rural NL. The best candidates for monitoring efforts are those at the local level (Dolter, 2014). However, local actors require more education about the need for monitoring as well as support for monitoring activities in the form of financial and human resources. Furthermore, greater enforcement by the provincial government is required. This would include expanding the Permit to Operate Drinking Water System Inspection Program so that communities are inspected at least once a year and the results are posted on the Water Resources Portal and in public areas. Further to this, to encourage transparency and residents' awareness levels Permits to Operate should be publicly available on the Water Resources Portal. Expansion of the MAM program to be part of regular operations of water and waste water systems in all NL communities offers promise for increasing the effectiveness and longevity of new and existing water systems. Lastly, considerations should be given to making source water protection mandatory, so that even if compliance is not 100%, responsible use of drinking water supply watersheds is on the radar of residents and local water operators and town staff. In any case, better implementation of source water monitoring requirements under the PPWSA regulations is needed at the local level, along with effective enforcement of PPWSA regulations by the province when local governments report violations. Capacity building so local governments are better equipped to monitor their own water supplies should be accompanied by expanded and more stringent self reporting requirements.

7.5 Regional Approaches

7.5.1 Findings

In this report regional approaches have been noted as one type of solution to the issues experienced in rural NL related to limited finances and human resource capacity. Many of the solutions proposed in this report, such as better filtration for some surface water fed public water systems, will lead to increased financial burdens for municipalities and LSDs (Cooper, 2013). Managing rural drinking water systems better without the certainty of sustained funding for the changes that are required, will mean rural NL communities must be very efficient with limited financial and human resources. We heard in multiple consultations, at both municipal and provincial levels, that when geographically feasible, regional approaches must be part of drinking water systems of the future. Experts expressed during the Drinking Water Policy Workshop that there is a lack of regionalization in the province (Dolter, 2014). Municipalities further elaborated on this sentiment during the focus group on regional approaches at the MNL Symposium in May 2014 and the MNL regional workshops. One provincial government representative explained:

"*And we are seeing more regionalization and there is even discussion about full amalgamation too right, and the Department recognizes that, and we've been involved with that… one of our mandates is sustainable communities and if it's regionalization or amalgamation type initiatives that help establish that then we're involved outside the regulatory side or infrastructure side… we're looking at it from a local governance perspective as well, not just from the infrastructure, and the way they govern and operate and there is initiatives there and there is work being done in those areas which would impact on the infrastructure side*."

-Provincial Government Representative

It seems there are encouraging examples where regionalization is occurring organically with the help of the provincial government. Examples discussed earlier in this report include regional water operators and sharing of parts and equipment. In other cases multiple communities share a water supply. Multi-community watershed planning and increased regional training opportunities have also been suggested.

While there have been successes with regional approaches in NL there is room for their improvement and expansion. One provincial government representative commented on the current system of local governance in NL as limiting regional collaboration:

"*Yes it needs to be like a county system that Nova Scotia has, for example. Where communities that are neighbouring communities and are close in vicinity come together on things like their water systems. There is none of that in Newfoundland right now. If you are a local service district or a municipality and you border another town and you are not amalgamated, you are completely separate entities. It just doesn't work. You're not sharing with your region. Funding opportunities would become more available if you amalgamate. Tax bases would become larger and there would just be more things available. But people just don't seem to be keen to that idea*"

-Provincial Government Representative

There was also concern raised by municipalities that LSDs often do not pay equitable amounts in current regional arrangements (Minnes et al., 2014). Furthermore, during the regional approaches focus group it was stated that a great deal "needs to be in place" before regional activities can occur. This includes arrangements set up to manage regional operations, such as meeting venues, decision-making structures and formal agreements. One regional water operator explained in relation to addressing conflicts between the communities when sharing a water operator:

"*Well, basically you have a meeting and you sit down and you talk about it. Sometimes it gets resolved in one meeting sometimes it takes 10 but you know you have to have that ability to sit down and talk about it and look at what you need to do*."

-Regional Water Operator

7.5.2 Discussion

The current literature on rural water management suggests regional approaches such as shared infrastructure between small communities, is a way to decrease costs for communities and aid in overall sustainability (Maxwell, 2008). Many argue that to achieve sustainability generally there needs to be a change in the decision-making and overall governance of infrastructure, including water infrastructure (Breen & Minnes, 2014; Connelly, Markey, & Roseland, 2009; Santora &

Wilson, 2008). This approach includes using watersheds as the geographic basis for water management (Rothwell, 2006) and taking an integrated approach that recognizes the interrelationships between water, humans, and the environment (Bakker, 2007).

To support a more integrated regional approach to water management, more research is needed on the possibilities of collaboration at the regional level in NL as well as the interrelationships between water, humans and the environment. On the DOEC's website there are several "Regional Water Resource Studies", with the oldest being from 1968 and the most recent being 1993 (Government of NL, 2014f). MNL's Community Cooperation Resource Centre (now Community Cooperation Office) conducted case studies of regional service sharing arrangements in 2005, including several drinking water-related examples (Vodden 2005a, b, c, 2007). The cases were part of MNL's ongoing effort to encourage greater regional cooperation as a means of making municipalities more sustainable. There may be more recent studies related to regional approaches and possible areas ideal for regional collaboration, however if there are these have not been identified and may not be publically available. For example, the research team was provided with a study that assessed the feasibility of a regional maintenance program between the towns of Rose Blanche-Harbour Le Cou, Burnt Islands, Isle Aux Morts, and Fox Roost & Margaree. This study found in 2006 that it would be viable to implement a Regional Maintenance Program in the region, however in 2014 it seems nothing has been done to follow up or act on this finding (Atlantic Engineering Consultants Ltd., 2006). Further investigation is needed into not only existing options, but barriers to implementation of such approaches.

With the example of regional operators, this also provides an opportunity for highly qualified people to stay in the province. For example, graduates from the Marine Institute's Advanced Diploma in Water Quality[18] would be perfect candidates for a regional operator position. This would require a commitment from local and provincial governments to provide a reasonable salary for these positions; however in the long term as seen in Section 5.2, having qualified people looking after the drinking water systems of rural NL could improve the longevity of infrastructure and help to ensure drinking water safety.

MIGA has identified community cooperation as a component of their strategic direction of "local government sustainability" (Government of NL, 2014g, p. 9). MIGA describes regional cooperation as activities such as pooling of resources, cost sharing agreements, amalgamation or regionalization. It was stated in MIGA's 2012-2013 Annual report that the department facilitated discussion related to regional approaches with six different groups, representing fifteen communities and including feasibility studies undertaken to examine new local government structures (Government of NL, 2014g). Evidently, both the provincial government and provincial organizations such as MNL are very much in support of regional approaches. However, at the local level, regional approaches are still often met with suspicion and equated with fears of amalgamation and losing individual community identities. More work is needed to demonstrate to local governments how, if done properly, collaborative and regional approaches can result in net benefits for all (Hardy & Koontz, 2009; NRTEE, 2011). Concrete illustrations from other locations are particularly valuable. It was found in a recent comparative study between the Kootenays region of British Columbia (BC) and the Kittiwake region of NL, for example, that the Kittiwake region could benefit from greater involvement of non-governmental regional

[18] http://www.mi.mun.ca/programsandcourses/programs/waterquality/

actors such as the Columbia Basin Trust in BC, sponsor of the "Water Smart Program". Furthermore, the Kootenay Conservation Program and the Columbia Basin Watershed Network are playing key roles in integrating water data for communities. This could be something to be explored for non-governmental organizations like the NL's Nature Conservancy of Canada chapter, which is already involved in data management and integration efforts in NL (Breen & Minnes, 2014).

7.5.3 Solutions and Future Directions

Overall, venues are needed where inevitable conflicts between communities involved in regional approaches can be resolved. MNL's Community Cooperation Office, as well as MIGA staff can play an expanded role in assisting groups of communities to work collaboratively on water-related issues. There is also a need for updated information regarding the feasibility of regional approaches to water delivery and management in rural NL and the connection between sustainability and such approaches, including case studies that are relevant to the NL context. It must be clear to local governments that regional approaches can be a viable option for the sustainable management of their water systems and that regional approaches do not have to mean amalgamation if support is to be gained for such approaches.

In any collaboration there is the potential for winners and losers and investments required in relationship building and maintenance, however with supporting governance structures for regional initiatives these transaction costs can be mitigated (Fish, Ioris & Watson, 2010). Regional activities that should be considered in relation to drinking water systems include: multi stakeholder regional water committees, regional water operators/maintenance programs, source water protection committees when drinking water sources are derived from shared watersheds, and knowledge sharing venues such as regional drinking water workshops. Support for these regional activities may have to mean restructuring of local government. However, already existing joint councils throughout the province can also play a role. At these meetings, representatives from each town could bring forward their drinking water concerns and, where possible, share strategies for addressing these concerns with neighbouring communities. Joint Councils may also choose to establish drinking water committees. Though forced collaboration can have it problems, provincial incentives for regionalization has also been seen as best practice (Mckinney & Johnson, 2009). Further research is needed on regional solutions for rural drinking water systems in NL and the incentives that can be provided to move towards these solutions. For more on regional approaches to drinking water management, please see the report entitled, *Regional Approaches to Drinking Water Management: NL-BC Comparative Study*, which will be made available in late Fall 2014 on the project website:
http://nlwater.ruralresilience.ca/?page_id=17

8. Conclusions and Future Directions

8.1 Conclusions and Policy Recommendations

Overall, the state of drinking water systems in rural NL is mixed. There are many communities that the research team spoke with during consultations that were very happy with their drinking water. Unfortunately this was not always the picture presented. On a survey directed towards community administrators 62% of administrators from LSDs and 69% of MOTOLs administrators said their town drinking water was "drinkable directly from the tap" (Speed, 2014a). However, there are many COTOLs in rural NL that are either on a BWA or have some part of their drinking water system in disrepair. Our research clearly demonstrates that changes are needed when it comes to the management and operations of public drinking water systems in rural NL, including everything from enhanced source water protection to infrastructure improvements, operator training, and conservation. With the lack of any true enforcement of source water protection measures, the prevalence of uncertified operators in LSDs and MOTOLs, and the mismanagement of aging infrastructure, at best, rural NL drinking water systems cannot be considered sustainable on the whole. At worst many of these systems are at true risk of falling into complete disrepair and exposing the public to serious health risks.

Though this project was focused on four main components of the drinking water system (i.e. source water; infrastructure and operations; policy and governance; and public perceptions, awareness and demand) the problems faced by rural communities are often not specific to one component but rather overlap. Drinking water problems are interconnected, cumulative and complex, interacting in sometimes unexpected ways. This means effective solutions must also be multifaceted and integrated, taking these interactions into account. As with many other rural sustainability issues, there is no "magic bullet" to address rural NL's suite of drinking water issues. There are, however, a number of steps that can be taken to move toward a more sustainable situation.

First, capacity needs to be fostered at the local level. A great deal of responsibility is given to local governments in NL, often times without proper technical, financial, or human capacity to match. Due to a lack of capacity at both the provincial and local level, implementation of existing policies and programs is inadequate. Greater monitoring and enforcement is needed, particularly when it comes to permits to operate and PPWSAs. Education programs are also needed, first targeting community decision-makers such as councillors, mayors and administrators. Decision makers often expressed during this research that they felt uneducated on important drinking water related subjects impacting their towns, especially regarding health concerns such as DBPs. More informed decision makers make better decisions. In turn, more education and technical capacity at the local level could also help in informing the general public about drinking water related issues, such as the need for source water protection. Issues related to public perception and public consumption patterns also require resources and attention. This would include more general public education and outreach.

Second, improved tools are needed for monitoring and reporting on the state of drinking water systems in the province. For example, a better system than the current BWA mechanism is required for communicating risks associated with drinking water. It has been found, "in NL small drinking water systems without certified operators, mostly in LSDs with low economic capacity,

are more likely to be on BWAs" (Dawe, 2013, p.89). The province might look at programs elsewhere such as British Columbia Interior Health Authority's (IHA) Boil Water Notice Remediation Program[19]. This program found similar struggles with human and financial capacity issues. When the IHA investigated further how they could change their management structure to better serve small systems they found that meaningful consultation with stakeholders and public education could reduce risks in small drinking water systems (Norlin, 2014). Though meaningful consultation and outreach is important, the Province of NL also needs to focus energies towards a strategic program designed to reduce long-term (and very long-term) BWAs in the province.

Another measure to reduce BWAs as well as preserve already degrading infrastructure is asset management. For asset management to be successful qualified personnel are required to lead these efforts. In rural areas certified regional water operators, when feasible, appear to be a viable option. We recommend that municipalities and LSDs investigate further how regional operations could assist them in addressing their drinking water challenges. Though there will be growing pains and inevitably conflict between communities over shared resources, we suggest that rural NL cannot afford the risk of having uncertified operators managing their drinking water systems. A higher level of oversight of these water systems on a regular basis is needed and regional water operators could provide the expertise that is currently lacking in many rural NL communities.

In conclusion, access to safe, acceptable, affordable, and physically accessible water is a basic human right, recognized by the United Nations (2013). However, it should be acknowledged that though this is a human right, drinking water services do not come for free. There are significant costs in distributing clean drinking water. NL is a large province, with many small, spread out communities, often with declining populations and limited tax bases. Many of the recommendations throughout this report outline that more funding is needed for drinking water related solutions. Where this funding can and should come from is a topic that requires further dialogue and critically examination. Water services must be considered in fiscal framework discussions and the true costs of water supply and distribution should be accounted for in municipal and LSD budgets and reflected accurately in water and sewer rates, while keeping in mind equity concerns. An emphasis should be put on investing money strategically and efficiently, with the utilization of regional approaches and investments in long-term planning and asset management activities.

All NL drinking water stakeholders (e.g. local, provincial and federal governments as well as academics, non-governmental organizations, industry and the general public) have a role to play in improving drinking water systems to ensure that this right is satisfied in NL. This web of actors must better align and coordinate their efforts in more integrated and multi-level governance collaborations to achieve sustainable rural drinking water systems in rural NL.

[19] More information on this program can be found at: http://www.creston.ca/files/File/AKBLG2014/SWS%20strategic%20plan%20AKBLG%20%28April%202014%29.pdf

8.2 Recommendations

Below is a list of recommendations for policy and practice related to drinking water policies, programs, operations and infrastructure in rural NL. These recommendations are intended to identify areas where greater efforts are needed, as opposed to prescribing specific actions. The creation of action plans for addressing these recommendations should be a coordinated effort between all stakeholders involved in the process. Recommendations are intended to be both pragmatic and achievable, however the research team understands that what is ideal may not be feasible given the current political and economic realities of rural NL due to capacity issues at all levels of government. The following recommendations are grouped in three categories (Policy, Regulations and Governance; Education and Training; and Infrastructure and Operations) and are listed in no particular order:

Policy, Regulations and Governance

1. Enhance stewardship of PPWSAs by local governments.
    1.1. Include PPWSA monitoring requirements and efforts taken to protect drinking water supplies in local level self-reporting.
    1.2. Encourage towns with supplies that are not designated as a PPWSA to do so.
    1.3. Provide outreach and education on the importance of and measures for protecting PPWSAs (see also recommendations for Education and Training below). Towns should explore potentials for partnerships with non-governmental groups to undertake these activities.
2. Improve water conservation programs and policies.
3. Develop more functional and user-friendly tools for assessing the state and vulnerability of drinking water systems (e.g. water quality, infrastructure and operations).
4. Create a more effective advisory system for managing and communicating risks than the current BWA approach.
    4.1. Develop more descriptive advisories (e.g. a ranking system to differentiate between different types of advisories).
    4.2. Develop strategies to remove BWAs in a more timely manner once the issue of concern has been addressed, including considering allowing communities to bring in at least one of the two samples required themselves to a NL Services lab, and only requiring one clean sample for those communities who put a BWA on due to low risk preventative mechanical reasons (e.g. flushing lines, small repairs, etc.).
5. Develop and implement a strategy to address remaining long term and very long term boil water advisories.
6. Foster enhanced compliance with provincial drinking water policies and regulations. For example:
    6.1. Expand the Permit to Operate Drinking Water Inspection Program and make Permits to Operate publicly available on the Water Resources Portal.
    6.2. Provide more capacity (financial, human and technical) and opportunities for capacity building at all levels specific to enhancing compliance with water policies and regulations (see also recommendations for Education and Training below).
    6.3. Make self-reporting mandatory for public water system operators, so requirements under policies and regulations are clear.

7. Increase opportunities for multi-level governance and dialogue at the local, regional and provincial scale, bringing together all levels of government as well as representation from other stakeholders such as non-governmental and industry groups. This would involve creating venues for integration, coordination and sharing information concerning water related matters.
8. Provide further incentives and sustained support for regional operators and other regional service sharing and drinking water management initiatives.

Education and Training

9. Offer more (and diverse) public outreach and education opportunities in various mediums concerning drinking water issues (e.g. source water protection, risks associated with untreated spring water collection, DBPs, home treatment options and conservation).
10. Provide greater education and capacity building opportunities concerning best practices on the management of drinking water systems for decision makers such as mayors, councillors and town staff.
11. Include mandatory certification for all water operators as part of the Water Resources Act legislation.
12. Offer more regional training opportunities for water operators.

Infrastructure and Operations

13. Enhance succession planning for water operators and designation of back up water operators.
14. Increase funding and support for asset management activities as well as management of relevant data concerning drinking water systems.
15. Implement Maintenance Assurance Manuals across the province with manuals that consider the particular challenges faced in small drinking water systems.
16. Include full cost accounting and appropriate pricing for water services in fiscal framework discussions.
17. Improve chlorine management and create guidelines for maximum chlorine levels in provincial drinking water treatment standards.
18. Continue to invest and plan for re-investment to address the infrastructure deficit in rural NL with particular attention to communities experiencing chronic problems (e.g. long term BWAs and high DBPs).

8.3 Future Research Needed

While comprehensive, this project was not intended or able to collect all of the information needed to delve into the wide range of identified issues and to explore potential solutions in detail. In fact, an important objective of the study was to identify future research needs. Below is a list of suggestions for future research, as identified by the research team. Many of the research topics below are interdisciplinary in nature and require various perspectives (e.g. social, cultural, economic, environmental as well as technological) to be adequately investigated. It would be useful for MUN to facilitate ongoing networking opportunities and strategically align water researchers across disciplines and campuses. This will grow the institution's own capacity to address drinking water-related issues and research needs, including those identified below.

Water Supply

1. Assessment of challenges and solutions related to private well supplies.
2. Baseline studies on all drinking water supplies in NL (e.g. mapping, characteristics, threats, etc.).
3. Contributing factors to water shortages in NL communities as well as potential solutions.

Technology and Operations

4. Review of small systems operational best practices and an ongoing review of technologies that are appropriate and feasible for the rural NL context.
5. Feasibility of remote technologies such as chlorine analyzer readers for small water systems.
6. A cost-benefit analysis of implementing filtration and/or other DBP reducing technologies within small-scale systems as well as at the household level. These analyses should be comprehensive and consider different conditions (e.g. raw water quality, combination of technology, and operational factors).
7. Effectiveness of PWDUs as a rural drinking water solution.

Human Health Implications

8. Resident perceptions (e.g. risks, preferences) and uses of drinking water (e.g. types of water sources and consumptions levels).
9. Population based research on gastrointestinal illnesses in communities with long-term BWAs, short-term BWAs and those not on a BWA, to compare probability, incidence rates, and length of illness.
10. Long term health impacts of DBPs as well as baseline data of the health of people in communities in NL that have high DBPs (i.e. over the Health Canada guidelines) and those who do not.

Policy and Governance

11. Feasibility of and options for water conservation programs and related outreach activities.
12. Feasibility of regional water operators and other regional approaches.
13. New governance options for source water protection and watershed planning.
14. Improved indicators for drinking water sustainability (e.g. how to improve the DWQI).
15. Accurate full cost accounting for drinking water service provision.
16. Feasibility of a specific drinking water act for NL.

9. List of Project Reports

Below is a list of all reports associated with the *Exploring Solutions for Sustainable Rural Drinking Water Systems* research project that contributed to the final report. All reports can be found on the project website: http://nlwater.ruralresilience.ca/?page_id=17

- Drivers-Pressures-State-Impacts-Responses (DPSIR) Scoping Document
- Regional Meeting Consultations Report
- Drinking Water Policy Workshop Proceedings
- Survey Results
    - Community Administrator Survey Results
    - Water Operator Survey Results

- Community Case Studies
    - "It's about quantity not quality": Drinking Water Successes and Struggles in Port au Port East, NL
        - Port au Port East Short Community Profile
    - Black Tickle-Domino, Labrador: *Case Study for the NL* Drinking Water Project
        - Black Tickle-Domino Short Community Profile
    - "Because our system is so long…": *Exploring the Drinking Water System in Sunnyside, NL*
        - Sunnyside Short Community Profile
    - Across the causeway: *Exploring the Drinking Water System in Greenspond, NL*
        - Greenspond Short Community Profile
    - "It looks like it's seen better days…": *Exploring the Drinking Water System in Woody Point, NL*
        - Woody Point Short Community Profile
    - Operating a public drinking water system with industrial high water user demand: Exploring the Drinking Water System in Old Perlican, NL
        - Old Perlican Short Community Profile
    - "We got it good here": Exploring the drinking water system in Makkovik, Nunatsiavut (FORTHCOMING, awaiting approval from Nunatsiavut Government)
        - Makkovik Short Community Profile (FORTHCOMING, awaiting approval from Nunatsiavut Government)
- Topics Based Case Studies/Learning Resources
    - TownSuite Mapping LITE (+Scanning) and Managing Municipal Water Systems: Spotlight on the Town of Centreville-Wareham-Trinity
    - NL Water Stewardship Lesson Plan
    - Interactive maps displaying communities with high THMs/HAAs and long term Boil Water Advisories
- Literature reviews
    - Potential Human Health Impacts of Water Contaminants in Newfoundland and Labrador
    - Disinfection By-Product Reducing Technologies
    - Drinking water challenges and solutions being employed in rural and remote areas in Canada (FORTHCOMING)
- A Regional Approach to Drinking Water Management: NL-BC Comparative Water Systems Study. (FORTHCOMING)

10. List of Appendices

- Advisory Committee Terms of Reference
- Communications Strategy

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Appendix

Appendix 1: Advisory Committee Terms of Reference

Exploring Solutions for Sustainable Rural Drinking Water Systems

Project Advisory Committee

Terms of Reference

Context

Grenfell Campus- Memorial University in association with Municipalities Newfoundland and Labrador (MNL), Memorial University of Newfoundland, and the Harris Centre, have launched a 16-month research project entitled, "Exploring Solutions for Sustainable Rural Drinking Water Systems**"** (officially "Seeking innovative policy and governance solutions for sustainable drinking water systems in rural and small town Newfoundland and Labrador" as per the Harris Centre funding agreement). Confirmation of funding for the project in February 2013 led to the establishment of the Project Advisory Committee.

Role/Mandate

The purpose of the Project Advisory Committee is to provide advice to the Research Team regarding the projects methodologies, design and findings. Specific duties include:

- providing feedback on proposed research approaches/methods and design;
- providing advice on communities and issues of interest;
- suggesting water governance mechanisms and policies of key importance within the province to be examined;
- providing expertise in regards to drinking water systems and their individual understandings of drinking water quality issues in rural Newfoundland and Labrador;
- highlighting important local or stakeholder-specific issues for consideration;
- "ground-truthing" research findings;
- giving feedback on research findings dissemination tools; and
- recommending future research directions.

Operation

Meetings:	At the call of the Chair/or in the Chair's absence the Project Coordinator
Frequency:	3 times throughout the life of the project
Quorum:	50% plus one
Alternates:	With prior approval of Chair
Guests:	With prior approval of Chair
Agenda:	Restricted to related topics and provided in advance of meeting

Action Minutes: Prepared and provided by the Project Coordinator or designate

Meeting Information

Where: to be determined by the Chair
When: to be determined by the Committee (under the direction of the Chair)

Membership

It is proposed that the Project Advisory Committee be composed of the following 15 individuals:

- Kelly Vodden, Grenfell Campus- Memorial University (Chair/Principal-Investigator)
- Sarah Minnes, Grenfell Campus- Memorial University (Project Coordinator)
- One representative from the Faculty of Engineering and Applied Science, Memorial University;
- One representative from the Faculty of Medicine, Memorial University;
- One representative from Municipalities Newfoundland and Labrador;
- One representatives from a regional health authority;
- One representative who serves as a municipal water operator;
- One representative from the Department of Environment and Conservation;
- One representative from the Department of Natural Resources;
- One representative from the Department of Municipal Affairs;
- One representative from the Department of Health and Community Services;
- One representative from Atlantic Canada Opportunities Agency;
- One representative from Health Canada;
- One representative from the Newfoundland and Labrador Environmental Industry Association; and
- One representative from the Atlantic Canada Water and Wastewater Association.

The Chair, on the recommendation of the Project Advisory Committee and/or Research Team, may add additional representatives.

Term of Office

Appointments for members of the Committee will be for the full length of the project (April, 2013– June, 2014).

Where a person ceases to be a member of the Committee for any reason, including resignation, inability to act or failure to attend three consecutive Committee meetings without just cause, the Chair may appoint another person representing that same affiliation to the Committee to hold office for the unexpired term of the member.

Travel Costs

Travel costs associated with Project Advisory Committee meetings will be reimbursed according to the Grenfell Campus- Memorial University travel policy (http://www.mun.ca/finance/policies_procedures/Schedule_of_Reimbursable_Expenses.pdf) for Project Advisory Committee members located within Newfoundland and Labrador who are not employed by the Newfoundland and Labrador Provincial government or the Canadian Federal government. Committee members outside Newfoundland and Labrador will be provided with teleconference information for meetings.

Changes to Terms of Reference

The authority to change the terms of reference rests with the Research Team.

Appendix 2: Communications Plan

Communications Plan
Exploring Solutions for Sustainable Rural Drinking Water Systems
Date Drafted: April 5, 2013
Revised: April 11, 2013
Prepared By: Sarah Minnes, Project Coordinator

Background:

This research project aims to explore the types of risks and challenges influencing drinking water quality and availability in rural areas. There is a particular emphasis in this research on communities of 1,000 residents or less in Newfoundland and Labrador (NL). There are four major components of this research study that will be assessed: source water quality and quantity; water distribution infrastructure and municipal water supply; policy and governance; and public perception, awareness, and demand. A priority of this project is to engage stakeholders at every level of drinking water systems. This will require a comprehensive and multi-faceted communications strategy for the collection of data, the validation of findings and for the possible translation of findings of the project into remedial efforts, policy changes or further research.

Approach:

It is the intention of the research team to have proactive communication with stakeholders, funders and partners. This includes the general public, federal, provincial, and municipal government, water system operators, Municipalities Newfoundland and Labrador and the Harris Centre.

Communications Objectives:

- To engage the necessary stakeholders through focus groups, surveys and interviews in order to fully understand the current state and potentials for drinking water systems in rural Newfoundland and Labrador.
- To validate ongoing findings of the project with stakeholders.
- To communicate the intentions of the project, the project's activities as well as the project's findings to stakeholders in an ongoing and timely manner.
- To utilize a variety of strategies and approaches for knowledge translation and effective communication with stakeholders and other interested parties.
- To develop networks with other drinking water research groups and interested individuals, thus creating the opportunity to exchange knowledge and perspectives concerning rural drinking water systems.

Target Audiences:

- Newfoundland and Labrador provincial government (with an emphasis on the Department of Environment and Conservation, NL Services, and the Ministry of Municipal Affairs.
- Government of Canada (with an emphasis on the Atlantic Canada Opportunities Agency).
- Municipal governments as well as Indigenous communities in Newfoundland and Labrador (with an emphasis on communities of 1,000 residents or less).

- The Leslie Harris Centre of Regional Policy and Development.
- Municipal and regional water operators in Newfoundland and Labrador.
- Newfoundland and Labrador rural residents (those residing in communities of 1,000 or less).
- Other researchers and organizations in Canada exploring rural drinking water quality.

Strategic Considerations:

- All communication efforts should be done following the project's Ethics application and approval.
- Research team members should conduct themselves in a friendly, transparent and approachable manner when interacting with stakeholders to encourage interest and cooperation in the research project.
- Communication efforts concerning this project with media (print, on-line, radio, television, etc) should be approved by the Principal Investigator (Kelly Vodden) or Project Coordinator (Sarah Minnes).

Tactics

Audience	Tactic	Person Responsible
All Stakeholders*	Website	Ryan Gibson, Sarah Minnes
All Stakeholders*	Social Media (Twitter and Facebook)	Ryan Gibson (CRRF), Gail Woodfine (MNL), Rebecca Cohoe (Harris Centre)
Municipal Government	Focus groups; Case study interviews	Sarah Minnes; Mitacs interns
Municipal Government and Water Operators	Municipal Online Surveys	Sarah Minnes, Kelly Vodden, Gail Woodfine
All Stakeholders*	Final Report	Sarah Minnes, Kelly Vodden
Municipal Government and Indigenous Communities	Regional Presentations	Sarah Minnes, Kelly Vodden
All Stakeholders	Conferences	Sarah Minnes
Water Researchers	Academic Journals	Sarah Minnes, Kelly Vodden
Policy Makers	Policy Briefs	Sarah Minnes, Kelly Vodden

*All Stakeholders refers to federal, provincial and municipal government, Indigenous communities, other drinking water researchers, public health and other non-governmental water related organizations as well as the general public.