Tapping In: Community-Based Water Monitoring Program in Atlantic Canadian First Nations Communities

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Abstract

Drinking water quality is an issue in First Nations communities across Canada. To address this, in 2003 Health Canada created the Community-Based Water Monitoring Program across Canada to employ First Nations community members to monitor their own community's drinking water. This study was part of a larger audit conducted by the Centre for Water Resources Studies to determine the effects this program had on water quality in Atlantic Canada, and to test its compliance with federal standards. Water quality data from WaterTrax (online database) for all First Nations in Atlantic Canada was evaluated for the following parameters: free chlorine residual, total coliforms, *Escherichia coli*, trihalomethanes, and haloacetic acids between 2007 and 2012. It was found that at least one third of all sites were not meeting the sampling frequency recommended in the Guidelines for Canadian Drinking Water Quality for chlorine and microbial samples. There was some improvement in total coliform concentration, and little to no improvement for the other parameters. No definitive conclusions could be drawn because there were not enough samples taken to provide an accurate representation of overall water quality. These findings indicate a need to re-evaluate the program's training and implementation effectiveness, and to also determine the cause(s) behind the poor water quality found in these communities.

Definition of Terms and Abbreviations

AANDC: Aboriginal Affairs and Northern Development Canada, formerly known as Indian and Northern Affairs Canada (INAC), or Department of Indian Affairs and Northern Development (DIAND). It is a Canadian federal government department responsible for First Nations, Inuit, Métis and Northern relations (AANDC, 2013).

CBWMP: Community-Based Water Monitoring Program, a program implemented in 2003 by Health Canada to establish a review of the First Nations drinking water quality, and monitor its safety for human consumption (Poulin & Lévesque, 2010).

Committee: The Standing Senate Committee on Aboriginal Peoples, involved in evaluating the status of First Nations drinking water quality in 2007 (AANDC, 2012b).

EHO: Environmental Health Officer, employee of Health Canada, certified to train CBWMs and perform water testing for all parameters outlined in the Guidelines for Canadian Drinking Water Quality (Poulin & Lévesque, 2010).

Expert Panel: Expert Panel on Safe Drinking Water for First Nations, created in 2006 to provide recommendations for a proposed drinking water regulatory framework in First Nations communities (AANDC, 2012b; Simeone, 2010).

FNWMS: First Nations Water Management Strategy introduced by AANDC and Health Canada in 2003 to improve First Nations drinking water quality and operations (AANDC, 2010).

FNWWAP: First Nations Water and Wastewater Action Plan launched in April 2008 to replace the recently expired FNWMS (AANDC, 2012B).

Guidelines: Guidelines for Canadian Drinking Water Quality; these guidelines produced by Health Canada provide up-to-date recommendations on the maximum levels of water contaminants allowable in drinking water, based on the health, aesthetic (e.g. taste) and operational (e.g. effect on treatment equipment) effects (Health Canada, 2012b).

Monitors: Community Based Water Monitors are in charge of taking water samples from their community's drinking water and test for microbial presence and free chlorine residual concentration. These results are then relayed to the community (Poulin & Lévesque, 2010). Each monitor is required to undergo 3-4 days of formal training, receiving a Certificate of Achievement upon completion, followed by on-job training by EHOs (McDonald et al., 2007).

Plan: Plan of Action for Drinking Water in First Nations Communities, introduced in 2006 to address issues of water quality in First Nations communities (AANDC, 2012b).

Procedure Manual: Procedure Manual for Safe Drinking Water in First Nations Communities South of 60° released in 2004, and acts as the main reference tool used by EHOs and monitors for water quality sampling and analysis (Poulin & Lévesque, 2010).

Protocol: Protocol for Safe Drinking Water in First Nations Communities, introduced in 2006 under the Plan of Action for Drinking Water in First Nations Communities (AANDC, 2006).

Sustainability: The integration of economics, society and the environment in such a way as to promote development that satisfies the needs of the present without compromising the ability of future generations to do the same (adapted from the United Nations definition of sustainable development; United Nations, 1987)

WaterTrax: Online database where water quality data is inputted by monitors and EHOs.

Preface

I was first introduced to the issue of First Nations water quality several years ago in a second year Sustainability class at Dalhousie University. We learned about a pulp mill operating in the small Nova Scotian community of Pictou Landing, and the effects of its effluent discharge on Boat Harbour. I had the opportunity to visit this community and hear some firsthand accounts from community members in the area. Since learning about that particular case, I have been highly motivated to investigate issues surrounding First Nations water quality more fully.

In 2012 I spent six months studying in New Zealand. Apart from being an amazing traveling experience, I had the opportunity to meet many incredible people. I was taken aback by the different government approach to aboriginal issues. The native Māori people commanded a significant amount of respect and power within their country. They had the power to resist negative legislative changes and instill their world values in both society and government. This was the result of decades of conflict, and there was still room for improvement, but that experience made me reflect on Canada's current efforts. It is my opinion that we are sorely lacking in this area, particularly when compared to countries such as New Zealand. I saw this need for change, and wanted to be a part of it.

I took these experiences and approached Dr. Graham Gagnon with my thoughts; he presented me with this project. I am very thankful to have been given this opportunity.

Thank you for reading.

1.0. Introduction – Statement of the Problem

The quality of drinking water in Canadian First Nations communities has been, and continues to be, an on-going problem. The government and legislative structure is such that regulation of water and wastewater in these communities is far more convoluted than that found off-reserve. First Nations on-reserve simply do not have the same level of regulatory protection governing their drinking water (Office of the Auditor General of Canada, 2005).

The federal government has made efforts in concert with First Nations stakeholders to try and change this trend. In 2003, Health Canada created the Community-Based Water Monitoring Program (CBWMP) across the country. This program trained a First Nations community member (the monitor) to conduct water sampling of their community's drinking water, testing for microbes (e.g. *Escherichia coli*) and chlorine levels. Health Canada Environment Health Officers (EHOs) were in charge of training these monitors and performing additional sampling and testing for other parameters (Poulin & Lévesque, 2010). An audit of the program was conducted, and the results released in 2007. Health Canada reviewed this assessment, and commissioned another be taken in 2012.

1.1. Purpose of the Study

The purpose of this study was to evaluate the sustainability of Health Canada's CBWMP. This study was a part of a larger CBWMP audit project conducted by Dr. Graham Gagnon and the Centre for Water Resources Studies. The project investigated the effects of program implementation on First Nations' water quality in the Atlantic region. It asked the following: What was the effect of implementing the CBWMP on water quality in Atlantic Canadian First Nations communities and how well does the program comply with federal guidelines? It was hypothesized, given the extensiveness of the program, that it would provide a complete and accurate picture of First Nations' drinking water quality, and that the monitoring program would have allowed targeted responses to community issues, improving overall quality.

This program was evaluated based on the improvements, or lack thereof, to the water quality in First Nations communities, as well as its compliance with the Guidelines for Canadian Drinking Water Quality (the Guidelines). A brief review of program technical documents provided context and insight into the program's compatibility with the Guidelines.

1.2. Delimitations/Limitations of Study

This section of the report refers solely to this study, as opposed to the larger study conducted by the Centre for Water Resources Studies. The scope of this project, and the time scale, did not allow for a thorough analysis of the CBWMP in-depth. As such, the program was evaluated based on water quality data inputted by monitors into the WaterTrax database. There were five parameters focused on for analysis, as it was unreasonable to evaluate all the contaminants reported. These five parameters were: free chlorine residual, *Escherichia coli* (*E. coli* bacteria), total coliforms (group of bacteria), trihalomethanes, and haloacetic acids. The bacterial parameters are the most significant in determining the safety of drinking water. The other three parameters tested relate to the use of chlorine in the disinfection process. The reference manual, annual water monitors' workshops and log book were reviewed for relevance to the Guidelines. The parameters tested are outlined in the Materials and Methods section of this report.

Far more extensive were the areas of research which lay beyond the scope of this study. These included a comparison to other drinking water quality programs elsewhere, analysis of communities outside the Atlantic region, site visits to First Nations communities for observation and independent testing, qualitative data collection of stakeholder perspectives of the program, and evaluation of the treatment facility, wastewater management and the source water site. While all of these variables would have provided significant insight to this project, they were unable to be incorporated due to temporal and financial constraints.

It is important to note that the majority of the data used in this report was collected by the monitors. This means the accuracy of the data set is entirely dependent on the accuracy of their testing procedures and the frequency of parameter sampling.

1.3. Professional Significance

The significance of this study in the field of sustainability cannot be over-emphasized. The issue of First Nations drinking water is clearly one of environmental and social justice concern, given that it impacts human health and the ecological integrity of the water bodies extracted from. In terms of economics, the problems regarding water systems treatment and facility accessibility in First Nations communities is, in many cases, an issue of funding. Though money has been allocated for these purposes, its use and application have been both questionable and inconsistent (Office of the Auditor General of Canada, 2005). First Nations drinking water in Atlantic Canada is a sustainability issue – both environmental and social. Clean drinking water is a necessity for life, as is the preservation of the ecosystems it is drawn from. An analysis of Health Canada's CBWMP and recommendations for future, has the potential to make a difference in the realm of sustainable and equitable development. It was hoped this study might be one small step forward for First Nations communities who are currently without clean drinking water.

2.0. Literature Review

2.1. Canadian First Nations People

Present scientific research suggests North American First Nations people first migrated across the Bering Strait to north-western Canada between 15,000 and 20,000 years ago (via a land mass called Beringia) (Dillehay, 2009; Larcombe et al., 2005). There are currently 614 First Nations communities across Canada, 33 of which are found in the Atlantic Provinces (New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island) (Aboriginal Affairs and Northern Development Canada, 2003). Each of these communities has its own particular history and culture, though often similarities exist between those of close geographic proximity (AANDC, 2011c).

In Atlantic Canada, the 33 First Nations communities are serviced by 35 water systems, and 2 individual wells. The community populations range from 35 to 3,700 people. See Figure 1 for an illustration of all First Nations in the Atlantic region.

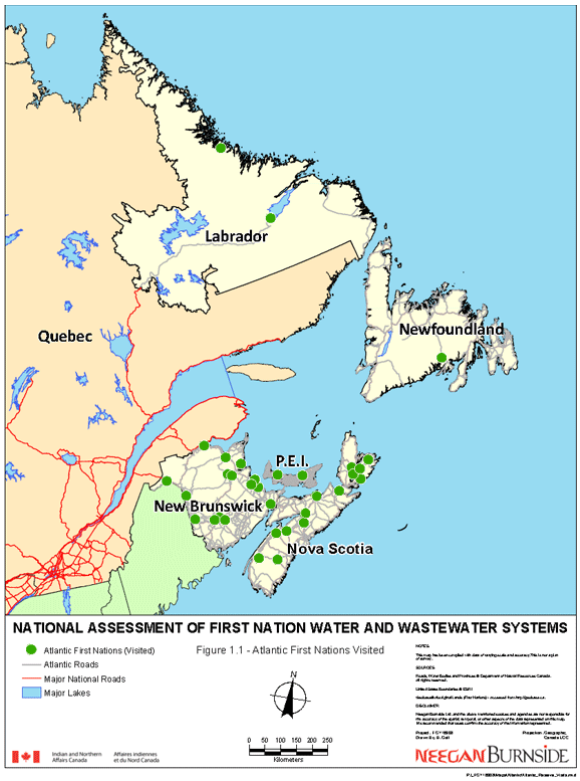

Figure 1 Distribution of the 33 First Nations in Atlantic Canada (Neegan Burnside Ltd., 2011).

2.2. Overview of Drinking Water Quality in Canadian First Nations Communities

Drinking water quality in North American First Nations communities is a present and on-going issue. As of January 31st, 2013, there were 113 (of 614) First Nations communities under a drinking water advisory in Canada (AANDC, 2011d; Health Canada, 2013). This number has fluctuated slightly over the years, but has generally remained quite high. A national report commissioned in 2011 found more than one third of the First Nations water systems in Canada to be at high risk, and an additional third were categorized as medium risk (AANDC, 2011b). There appears to be limited comparable statistics for rural non-aboriginal communities in the rest of the country.

2.3. Regulation of Drinking Water

The regulation of drinking water in Canada is a complicated affair. Fundamentally, all levels of government are responsible for the provision of safe drinking water. However, the responsibility of regulation differs depending on the location and type of land. For the majority of Canadians, drinking water falls under the jurisdiction of the provincial or territorial government, and their municipality. Each province and territory has its own particular drinking water legislation and authorities; typically, the Ministries of Health and Environment (Health Canada, 2003). Thus, on land outside of federal jurisdiction, there are several levels of government involved in the drinking water regulation process.

For First Nations communities, however, this is not the case. Provincial drinking water legislation does not apply to on-reserve First Nations communities south of 60°N (north of this parallel, regulation is the responsibility of the territorial governments) (Simeone, 2010). All federally-owned lands, including military and government facilities, national parks and First Nations communities, fall under the jurisdiction of the federal government. This includes drinking water regulation (Health Canada, 2007).

There are three main federal bodies involved in First Nations drinking water, though none have the power of enforcing the current drinking water legislation in place. These ministries are: Aboriginal

Affairs and Northern Development Canada (AANDC), Health Canada, and Environment Canada. AANDC is primarily responsible for the provision of funding to First Nations communities for water operations and facilities maintenance and construction, providing the funds for up to 80% of the total costs. Health Canada is involved in the organization of drinking water monitoring programs in these communities (Simeone, 2010). They employee regional EHOs to assist community water monitors test water quality data parameters (McDonald, Gibbons & Gagnon, 2007). Overall, Health Canada adopts an advisory role in the drinking water quality scheme, providing funding for First Nations to sample and test their own water. Lastly, Environment Canada is involved in wastewater treatment and management. Their regulations apply indirectly to drinking water quality, as they are responsible for the control of effluent discharge into waterways (Simeone, 2010).

With AANDC taking up the role as financier and Health Canada as a general overseer, the majority of the responsibility for maintaining adequate water quality lies with the First Nations communities, chiefs and band councils. They must use the funding provided by the AANDC to construction, maintain and operate water systems, while simultaneously providing the remaining 20% of funds required. They are also required to ensure their water operators are adequately trained and that effective drinking water monitoring and sampling is in place (Simeone, 2010).

2.4. History of Federal Drinking Water Funding and Action

2.4.1. Up To 2003…

There is a long and complicated history to federal government funding and initiatives regarding water management in First Nations communities. The Guidelines were published in 1968 by Health Canada (updated throughout the years), and pose the recommended physical characteristics, chemical, microbiological, and radiological parameter levels for safe drinking water (Health Canada, 2012a). In 1991, the federal government dedicated $25 million over six years to allow Health Canada to implement the Drinking Water Safety Program in First Nations communities across the country. The program was

responsible for water quality monitoring and health advising for: water systems management and design, and water treatment operators (Poulin & Lévesque, 2010). This appears to be the first point of significant investment in this area.

In 1995, AANDC data research indicated that 25% of all First Nations drinking water posed a serious risk to human health. Thus, between 1995 and 2001, to counter these findings an estimated $560 million was spent on water system upgrades and $100-125 million spent annually on operations and maintenance (AANDC, 2007). Despite this funding, the situation continued to deteriorate, and in 2001-2002, this number had increased to almost 75% of First Nations communities in Canada (AANDC, 2007; Office of the Auditor General of Canada (OAGC), 2005). By 2003, the federal government had spent $1.9 billion on First Nations water and wastewater quality and safety (OAGC, 2005).

The following sections will present a chronological breakdown of the programs and initiatives implemented to-date, starting from 2003. It should be noted that several names are used in the literature to describe AANDC. Previous to 2011, this federal department was also known as Indian and Northern Affairs Canada (INAC) and the Department of Indian Affairs and Northern Development (DIAND). In 2011, the federal government changed the name to AANDC, and this is the name used throughout this report to maintain consistency (AANDC, 2011a).

2.4.2. 2003

An AANDC national assessment of many First Nations' water and wastewater systems across Canada was released based on data collected in 2001 and 2002. This assessment highlighted a need for significant investing (financially and energetically) in the area of water and wastewater quality management (AANDC, 2007).

In response to these results, Health Canada and AANDC launched the First Nations Water Management Strategy (FNWMS) in May 2003. The FNWMS was built around a five year timeline, with seven major areas of focus: upgrading and constructing water and wastewater facilities, a water quality

monitoring program, implement an operations and maintenance program for health and safety, expansion of training programs, implementation of water quality management protocols, First Nations public awareness regarding water safety, and a multi-barrier approach to safe drinking water (AANDC, 2010).

The multi-barrier approach to safe drinking water, a major focus in this strategy, considers water in every facet of its consumption life cycle. This is composed of: protection of source water, bringing drinking water treatment to standard, water system quality maintainance, and water quality testing (AANDC, 2006). These different areas of focus also happen to span different federal departments' responsibilities (Simeone, 2010), posing difficulties in implementation.

Health Canada launched its CBWM in this year. This program was designed to facilitate improved water quality monitoring in First Nations communities, thus allowing for easier policing, provisioning of recommendations and development of future improvements (Poulin & Lévesque, 2010).

To fund these initiatives (from 2003-2008), the Government of Canada allocated $600 million in Budget 2003, which was in addition to funding already in place by the AANDC and Health Canada. This $600 million sum was divided between AANDC and Health Canada as follows: $484.1 million to AANDC and the remaining $115.9 to Health Canada. Thus, over this 5 year time period, a total of $1.6 billion was dedicated to First Nations water and wastewater quality improvement (AANDC, 2010).

2.4.3. 2004

Health Canada released its Procedure Manual for Safe Drinking Water in First Nations Communities South of 60° (Procedure Manual), which is the main reference tool used by EHOs and monitors for water quality sampling and analysis (Poulin & Lévesque, 2010).

2.4.4. 2005

In 2005, the Report of the Commissioner of the Environment and Sustainable Development was released, with an entire chapter devoted to First Nations' drinking water. This report presented a very

critical evaluation of the federal government's efforts to-date. The report analysed government spending in relation to: the state of water quality in these communities (compared to non-aboriginal communities of similar size and location), value and magnitude of information provided on water quality data (by Health Canada) to First Nations and AANDC, and the relevance of the information gathered by Health Canada and AANDC regarding water quality and safety issues (OAGC, 2005).

In this report, five key recommendations were presented to Health Canada and AANDC. The first was to create and implement a targeted regulatory regime towards First Nations' water management which would include an aspect of enforcement. It was noted in the report that the only enforcement in place was through funding agreements, and was highly inconsistent. Second, the codes and standards of water facilities' design and construction should be made clear in consultation with these communities. Third, the magnitude of drinking water testing should be increased to comply with the Guidelines, and actions should be taken to ensure adequate communication between all stakeholders regarding the results and their implications. Fourth, these government bodies should help increase First Nations' capacity for water quality management. Lastly, progress reports should be submitted to Parliament to keep on task (OAGC, 2005).

The report also gave several notable insights into the general state of affairs in these communities regarding drinking water quality. First Nations do not benefit from the same degree of health safety as those communities located off-reserve. This was attributed to the absence of government regulation and enforcement regarding drinking water quality in these communities. There were (and presently are) only policy and guidelines managing First Nations water quality, as opposed to legally binding and enforceable regulation. In addition, despite the considerable federal funds dedicated to drinking water issues, many communities were still provided with water that poses a risk to consumers' health (OAGC, 2005).

One other issue, consistently mentioned in the literature, is one of inconsistency. The support, testing, and training were all identified as fragmented or inadequate. These issues make water quality monitoring and improvement a difficult obstacle to overcome. This is only exacerbated by the irregularity of communication between all relevant parties (specifically Health Canada, AANDC, and First Nations). The value First Nations' place on self-governance, and this communication gap, makes finding the "ideal" regulatory approach a contentious issue; something also noted by the Auditor General (OAGC, 2005).

2.4.5. 2006

In the spring, the federal government released the Plan of Action for Drinking Water in First Nations Communities ("the Plan") (AANDC, 2012b). This plan included a Protocol for Safe Drinking Water in First Nations Communities ("the Protocol") (AANDC, 2006), which details design and construction specifications for water systems, as well as their general up-keep, on a national scale (Simeone, 2010). The plan builds upon the FNWMS, requiring mandatory training for all water treatment plant operators, an expert advisory panel to assist with the development of a regulatory scheme, consistent progress reports, and address the top 21 most seriously at-risk communities with community-specific plans (AANDC, 2012b; Simeone, 2010).

In concert with (and to support) the Plan, the Government of Canada committed $60 million over a two year period (to terminate in 2008, alongside the FNWMS) in their federal budget. In addition to this, AANDC, the Assembly of First Nations, Health Canada and Environment Canada collaborated to create the Expert Panel on Safe Drinking Water for First Nations ("Expert Panel"). This panel's purpose was to provide recommendations for a proposed drinking water regulatory framework in First Nations communities (AANDC, 2012b; Simeone, 2010).

The Expert Panel released a report near the end of the year after conducting public hearings across the country which summarised their findings (AANDC, 2012b; Simeone, 2010). It advised against

placing too much faith in a regulatory regime, as it was their opinion that a regime alone would not be effective in guaranteeing First Nations safe drinking water. They recommended it be introduced simultaneously with human and physical infrastructure (e.g. treatment facilities and operators), so as to ensure the necessary resources exist to comply with regulations. The report also warned that the partitioning of investments to a regulatory scheme would only divert badly needed resources from the initiatives required to comply with the regime. Thus, it even had the potential to worsen the state of water quality (The Standing Senate Committee on Aboriginal Peoples (SSCAP), 2007).

The first annual progress report was tabled by the Government of Canada in December, detailing some progress made regarding the above Plan.

2.4.6. 2007

In keeping with their Plan, AANDC and Health Canada released a second progress report in the spring of 2007. Within the report it was noted the number of high risk water systems had been reduced by about half (from 193 to 97). This release coincided with the installment of a clean water education program for First Nations elementary school children, called "Water is a Treasure" (AANDC, 2012b). This was also implemented in the spring.

In May, the Standing Senate Committee on Aboriginal Peoples ("The Committee") held public hearings to consolidate and evaluate the progress in drinking water quality on-reserve to-date. The hearings focused on the report of the Expert Panel (released the previous year), the 2005 commissioner report, and AANDC's Plan (released in 2006). The Committee later requested a response from the federal government regarding their evaluation report (AANDC, 2012b).

The Committee's report outlined the perspectives of several stakeholders in the First Nations' drinking water quality realm, but most notably: AANDC, the Expert Panel, and the Assembly of First Nations. The report focused on the issue of regulation. Three options were discussed: federal legislation, the incorporation of provincial legislation into federal acts, or First Nations' self-governance. Discussion

with AANDC revealed their support for provincial legislation incorporation. This was met with great resistance from the Expert Panel and the Assembly of First Nations for several reasons. First Nations people would not easily accept provincial regulation or enforcement, as this would have implications for their rights and current agreements with the Government of Canada. In addition, because the provincial drinking water regulations differ across the country, incorporating all of these into one cohesive (and effective) piece of federal legislation would be very difficult. Conversely, the Assembly of First Nations and the Expert Panel propose that federal regulation be implemented, until such time as First Nations communities have the capacity to self-govern their water management. The Committee was in agreement with the latter parties (The Committee, 2007).

The Committee highlighted the necessity to bridge the resource gap preventing the development and maintenance of First Nations water management and treatment facilities, and the training required for operation. Doing so would allow AANDC to move forward with First Nations' drinking water federal regulation. This opinion was not shared by AANDC, who stressed the importance of a regulatory regime installment, and then its consequent implementation. Such implementation, roughly estimated by the Assembly of First Nations, could reach between $15 and $25 billion to bring all First Nations water quality up to the same level as their non-aboriginal countrymen (The Committee, 2007).

In light of the data and viewpoints gathered, the Committee presented AANDC with two recommendations. The first was for the conduction of a professional and independent audit and needs assessment of water and wastewater systems in First Nations communities across Canada. The proposed completion date of this project was March 2008 (the termination date of the FNWMS). Consequently, based on the results of this research, funds would be supplied to provide the necessary resources to improve these systems, and a plan outlined for implementation by June that year (to be presented to the Committee at that time). Their second recommendation was to emphasize increasing

communication between AANDC, the Expert Panel and the Assembly of First Nations. The importance of consultation with the latter two stakeholders regarding legislation development was stressed (The Committee, 2007).

2.4.7. 2008

A third annual progress report was released in January. This was closely followed by the released of Budget 2008 (in February) dedicating $330 million over two years to improve First Nations drinking water quality. This investment was part of a First Nations Water and Wastewater Action Plan (FNWWAP), launched in April (AANDC, 2012B). This plan replaced the recently expired FNWMS, and made several additions relating to drinking water: a national engineering assessment of First Nations water treatment facilities to be completed in 2009, consultation regarding federal drinking water regulation, increased funding to the Circuit Rider Training Program (established in the 1990's where qualified instructors travel to First Nations communities and train operators), promote increased investment in small water system initiatives, and development of procedures relating to waterborne maladies (AANDC, 2007; Simeone, 2010).

The Government of Canada responded to the Committee's report and evaluation. Their FNWWAP addressed the recommended independent audit, as well as increased funding. This revised plan also emphasized improved communication between all stakeholders, another issue raised by the Committee in their report.

2.4.8. 2009

To help improve communications between the federal government and First Nations regarding drinking water regulation, AANDC and Health Canada conducted 13 public engagement sessions across Canada in February and March. These sessions were specifically geared towards developing a First Nations drinking and wastewater regulatory scheme. At the time, the federal government proposed the

integration of provincial regulations into a federal legislative framework, with a First Nations' focus. 544 First Nations members were in attendance (Simeone & Troniak, 2012).

In addition to the consultation sessions, Budget 2009 included $165 million for First Nations water and wastewater infrastructure (AANDC, 2012b). A national assessment of First Nations water and wastewater systems was launched in this year by AANDC, conducted by the independent engineering firm, Neegan Burnside, Ltd (AANDC, 2012a).

2.4.9. 2010

The FNWWAP was renewed for an additional 2 years, with the additional funding provided in Budget 2010, in the amount of $330 million over this time period. In addition, Bill S-11, the *Safe Drinking Water for First Nations Act*, was proposed. It was given to the Committee for review at the end of the year (Simeone & Troniak, 2012).

2.4.10. 2011

As a result of the committee review, and resultant concern regarding the bill, Bill S-11 did not receive a third reading, dying on the Order Paper in March, with the dissolution of Parliament (AANDC, 2012a).

The Neegan Burnside national assessment of First Nations water and wastewater systems report was released. 571 First Nations, of the approached 587, participated in the study. Across Canada, 72% of First Nations homes receive piped drinking water, but a surprising 13.5% (15,451 homes) relied solely on truck delivery. The rest rely on individual wells, though a small percent (1.5%) had no water service in place.

Each of these systems was analyzed on a three tiered grading scale (low risk, medium risk, and high risk). The overall risk of each system was based on AANDC's Risk Level Evaluation Guidelines, dictating the following weighted evaluation of water systems' components: 10% source, 30% design, 30% operations, 10% reporting, and 20% operators. Systems deemed to be low risk were those which usually

complied with the Guidelines. Medium risk systems contained deficiencies, posing a medium risk to human health and safety, but were not deemed to require immediate action. A high risk system was classified as such if it contained significant deficiencies, leading to a serious risk to human health and safety; often including a drinking water advisory, repeated non-compliance with the Guidelines, and an insufficient water supply. Immediate action was recommended for these communities (Neegan Burnside Ltd., 2011b).

Of the water systems assessed, 39% fell into the high risk category, and 34% in the medium (Neegan Burnside Ltd., 2011b). On this national level, Neegan Burnside estimated an amount of $846 million to bring all First Nations communities up to the current standard (in terms of construction and non-construction costs (training, studies, documentation), but excluding operation, maintenance and servicing into the future (2011b). These are the estimates required to bring each community up to the AANDC Protocol. It is worth noting, however, that a three-tiered system allows for a considerable margin of error, and does not demonstrate data variability to its full extent. In addition, the sample size of 571 excludes the remaining 43 First Nations communities across the country, for reasons unknown. Some did not wish to participate, and others did not have active infrastructure in place on the reserve at the time of the study (Neegan Burnside Ltd., 2011b), but the reduced sample size also creates a certain degree of error in the study.

As for Atlantic Canada, all 33 First Nations communities participated in the study, with a total of 35 water systems. 94% of homes received piped water, and the remaining 6% receive water from an individual well. Of the 35 water systems assessed, 6 were classified as high risk, 19 as medium, and 10 as low. The total construction and non-construction costs estimated for this region to comply with Protocol standards was $31.1 million (Neegan Burnside Ltd., 2011a).

The report gave several recommendations for the AANDC to consider. First, it was noted that action must be taken to reduce the gap between the quality of infrastructure and systems in place, and

the requirements that must be in met. It was also suggested that action should be taken to consider the projected growth in First Nations' populations on reserve in the coming years while planning and implementing drinking water systems. Lastly, the design of a refined assessment tool for these systems was recommended, as they require clarification for successful application. This included the proposal for a regulatory framework (Neegan Burnside Ltd., 2011b).

A status report written by the Auditor General of Canada in 2011 remarked on the progress of AANDC and Health Canada on the issue of First Nations drinking water quality. It found, on the whole, that though progress had been made in the areas of regulation and evaluation, significant improvement had not been made since the 2005 audit. An action plan along with specific targets, and the recommendations made in the 2005 report were emphasized (OAGC, 2011).

2.4.11. 2012

The Government of Canada committed $330.8 million over a two year period towards First Nations water infrastructure and the development of future planning (Government of Canada, 2012). The FNWWAP (renewed in 2010) terminated in March and was not renewed (Simeone & Troniak, 2012).

Bill S-8, stemming from the former Bill S-11, was introduced in February under the same name: Safe Drinking Water for First Nations Act. This federal act, like its predecessor, addressed drinking and wastewater treatment, quality and disposal in First Nations communities. It also allows the integration of provincial regulations into the legislation governing First Nations' water, by reference (Simeone & Troniak, 2012). The term 'by reference' ensures that while provincial legislation may be used as a guideline to develop this act, it does not give provincial governments jurisdiction over these communities (AANDC, 2012c). However, the new bill can apply for First Nations self-government agreements, at their request (AANDC, 2012a).

2.4.12. From 1995 to 2014…

Thus, from 1995 to 2014, the Government of Canada has allocated $3.1 billion towards improving water infrastructure in First Nations communities.

2.5. Water Quality Parameters- An Overview

This next section provides a brief overview of the health effects of the five water contaminants evaluated in this report. The presence of *E. coli* bacteria indicates fecal waste contamination in the drinking water. This can cause serious gastrointestinal issues in humans, and if untreated may be fatal. It poses the most immediate threat to human health of the five parameters in this study. Total coliforms are also an indication of fecal contamination, but are found naturally in soil matter. They are used more so as an operational determinant to see if the treatment system is functioning properly. They are an indication and a warning sign of escalating microbial content in drinking water. Free chlorine residual has low toxicity at the levels found in drinking water. Haloacetic acids are a potential carcinogen, particularly related to liver cancer. Trihalomethanes are chloroforms, another potential carcinogen (particularly of the kidney and colorectal area). Both haloacetic acids and trihalomethanes, are by-products of a reaction between organic matter and the chlorine disinfection treatment. As a result, they are most commonly found in surface water (e.g. lakes), as opposed to ground water (e.g. wells) sources, given the prevalence of organic matter in the former setting (Health Canada, 2006; Health Canada, 2008). All of the above health effects are potential consequences if the water samples taken exceed the maximum allowable concentrations indicated, though the exact probability is unknown and dependent on magnitude and length of exposure (Health Canada, 2007).

2.6. The Community Based Water Monitoring Program (CBWMP)

The CBWMP began in 2003 as Health Canada's part in the FNWMS. It employs EHOs and water monitors (First Nations community residents) to take community water samples and perform regular tests to determine water quality. The water samples are tested for bacterial, chemical, physical, and

radiological data, in reference to the Guidelines. The EHOs are responsible for testing all parameters, evaluating the results, and presenting these results to the specific First Nation community. The monitors are specifically responsible for monitoring bacteriological and free chlorine residual parameters, and disseminate their own results back to their community. They are trained by the certified EHOs. Unlike 2002, all First Nations communities currently have access to an EHO or CBWM (Poulin & Lévesque, 2010).

As per the requirements of the program, an evaluation of the program's progress was commissioned by the Confederation of Mainland Mi'kmaq several years after its launch. This assessment was conducted by a Dalhousie University research team at the Centre for Water Resources Studies for the time period of April 1st 2005 to March 31st 2006. The report was released in 2007 (McDonald, Gibbons, & Gagnon, 2007).

2.6.1. The Assessment

The Dalhousie University audit had four main goals: the evaluation of technical documents provided to, and followed by, the monitors and EHOs and a literature review of other water monitoring systems nationally and internationally; evaluation of water quality data from WaterTrax and identification of data trends; focus groups and surveys conducted with monitors and community representatives to gain their perspective on the program and experience; and a final report to be presented to First Nations and Inuit Health and the Confederation of Mainland Mi'kmaq (McDonald et al., 2007).

The scope of the project was such that the water treatment and operations were not evaluated, data was analysed for a one year period, and the report evaluation process was drafted with the contribution of water monitors and community representatives. Of the 30 eligible First Nations communities, 29 participated in the program at the time of this assessment (McDonald et al., 2007).

2.6.2. The Results and Recommendations

Overall, it was found that the CBWMP was achieving its goal of enhancing First Nations' capacity to monitor their drinking water for the purposes of public health safety (Health Canada, 2007; McDonald et al., 2007). The program requirements were consistent with the international best practices found, and complied with the guiding principles outlined by the World Health Organization regarding the operation of small water management systems. As a community based program, among its other qualities, it was called a "pioneering program" on the international stage. The weekly sampling program implemented was sufficient enough to allow efficient water problem identification and resolution if required (McDonald et al., 2007).

Quantitatively, 12 of the 29 communities met or exceeded the target of 20 samples per month for microbial sampling (therefore 17 failed to meet this requirement). Only two communities exceeded a value greater than 5% for total coliform detection. The chemical data findings were not presented in the report (McDonald et al., 2007).

The focus group sessions and surveys conducted with monitors and band representatives found the program wanting in the following areas: sampling procedures and lab facilities, communication, and technical and educational support. It was found that some monitors were unsure of where they should be taking samples. Almost half of the respondents were not given a calibration kit for their laboratory equipment, and half of those who did receive a kit were not given instructions on how to use it. Calibration of instruments is crucial to ensure accurate results are reported. It was found that the majority of communities have a secondary monitor in place, should the primary monitor become unavailable. There was confusion amongst monitors regarding the measurement of water turbidity (no longer required), the collection of samples from private wells (outside the CBWMP jurisdiction), and the protocol for the detection of low or no chlorine in a sample. No emergency response plan was in place (McDonald et al., 2007).

As a result of the findings above, the auditors made some recommendations. In general, it was suggested that Health Canada improve communication between themselves and the monitors, especially regarding specific sampling procedures and emergency contact information and preparedness. Site safety (e.g. test chemical handling and disposal procedures) and computer training were identified as another area of focus. This could be addressed through annual training refresher courses for the monitors. It was also recommended that the analytical procedures be clarified for the monitors, as some procedures were unclear. Repetition of external audits of the program was suggested, so as to continue making improvements. Sample collection needed to be increased to the recommended 20 samples per month, and data used more actively to interpret the results. Additionally, it was suggested that the monitors be reminded to consistently enter their data into the WaterTrax database on a monthly basis. Overall, however, the CBWMP was identified as a successful example of a community based water monitoring system of international significance (McDonald et al., 2007).

As per the recommendations in the 2007 report, another audit of the CBWMP was commissioned in 2012 (to be released in 2013). This study was a smaller subset of this larger program audit to determine the effect the CBWMP had on water quality in Atlantic Canadian First Nations communities and how well the program reflected federal drinking water guidelines. The research approach is presented in the following chapter.

3.0. Materials and Methods

The majority of the research conducted in this project was based on the water quality data collected and submitted to an online database called WaterTrax. It is to the WaterTrax database where the results from the monitors' and environmental health officers' tests from all First Nations communities in Atlantic Canada are recorded. There are 34 First Nations communities listed in the Atlantic Canada region on this database. There were several instances where each of these communities included more than one subset (or community site). The results collected in this study were evaluated based on the number of community sites listed in WaterTrax (52). Because each of these sites and/or communities were listed in the database, they were assumed to be of importance to the CBWMP, and thus to this assessment.

The five main parameters evaluated (free chlorine residual, total coliforms, *Escherichia coli*, trihaloacetic acids, and haloacetic acids) were collected by province (New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island), and then by community site, for every year between 2007 and 2012. These values were then compared to the Guidelines to determine areas of non-compliance. Data was then compiled to look for trends in the water quality for each region, and by year. The percent compliance and non-compliance relating to the Guidelines was calculated for each parameter, in each province. These trends were used to determine if any changes had occurred over the set time period. Basic statistical analyses helped elucidate possible data trends.

More specifically, the quantitative data measures were evaluated based on the following criteria: a minimum of 20 free chlorine residual samples, and 20 microbial water samples (*E. coli* and total coliforms) must be taken per month in accordance with the 2007 report (McDonald et al., 2007), and at least four samples taken per year for trihalomethanes and haloacetic acids (Health Canada, 2007). Upon examination of the water monitors' reference manual, it was found that: "For communities of up to

5,000, [the monitors] should sample once per week. It is recommended to take a minimum of two samples from different locations in the distribution system" (Health Canada, n.d., p6.3.1). Thus two analyses were done based on the limits presented in the previous report (minimum 20 samples per month), and that listed in the reference manual (minimum 4 samples per month). It was assumed that these sampling guidelines must be met for each community site, as opposed to each First Nations community (which may or may not have several sites).

There is no minimum amount of free chlorine residual suggested in the Guidelines, though the Procedure Manual recommends a concentration greater than 0.2mg/l (Health Canada, 2007). In addition, there must be no detectable *E. coli* or total coliforms per 100ml of sample taken (in a drinking water system), or no more than 10% of samples should contain total coliforms (in a distribution system). The distinction between system types was not made in this evaluation. Instead, the community sites in violation of either guideline (or both) were highlighted. The maximum allowable concentration (MAC) of haloacetic acids is 0.08mg/l, and 0.1mg/l for trihalomethanes (Health Canada, 2012b).

Once the quantitative data analyses were completed, the reference manual and log book provided to the water monitors during their certification course was reviewed, as were the slide decks from the annual community based water monitoring and operator workshops in 2010-2012. These documents were reviewed for consistency with the Guidelines and Procedure Manual based on the five parameters discussed above.

4.0. Results

The results of this study are organized by each parameter tested, with all provincial data compiled together. All WaterTrax data extends from January 1st 2007 to December 31st 2012 for the 52 community sites in Atlantic Canada.

4.1. Free Chlorine Residual

It is stated in the 2007 report that a minimum of 20 free chlorine residual samples be taken per month. This is the same for *E. coli* and total coliforms (McDonald et al., 2007). In 2007, 87% of all community sites were not taking the required number of samples per month. This number improved slightly by 2012, when 73% of the community sites were not in compliance with this guideline. This pattern is described in Figure 2.

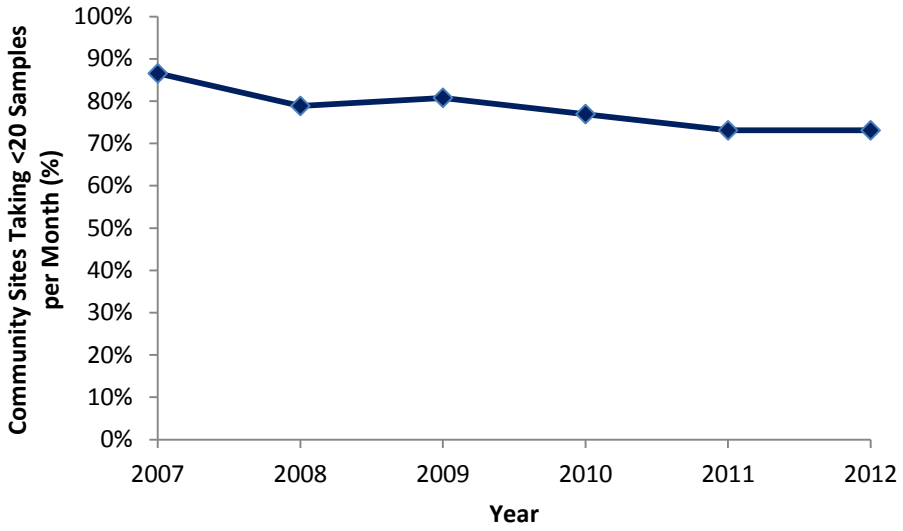

Figure 2 Atlantic Canadian First Nations community sites' violation of the free chlorine residual's sampling guidelines in the Guidelines for Canadian Drinking Water Quality. A minimum sampling frequency of 20 samples per month is required (McDonald et al., 2007). Data was provided from the WaterTrax online database.

To maintain consistency with the 2007 report, sampling frequency was evaluated based on the 20 samples per month limit. However, review of the water monitor reference manual indicated a mandatory 4 samples per month by the monitors (for free residual chlorine, *E. coli* and total coliforms).

In 2007 almost half of all community sites were taking less than 4 samples per month. This number improved over the years, to approximately one third in 2012. This was representative of a 13% improvement over this time period. These results are illustrated in Figure 3.

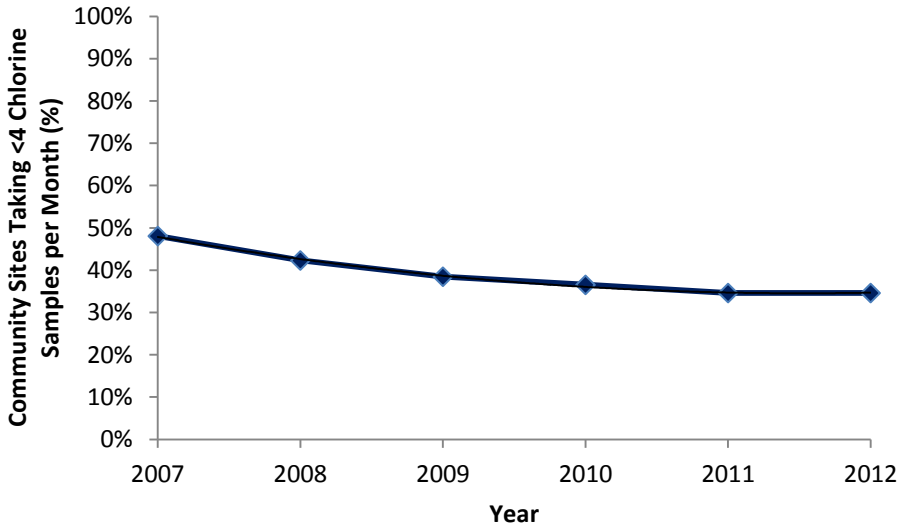

Figure 3 Atlantic Canadian First Nations community sites' violation of the free chlorine residual's sampling guidelines in the Guidelines for Canadian Drinking Water Quality. A minimum sampling frequency of 4 samples per month is required according to the water monitors' reference manual (Health Canada, n.d.). Data was provided from the WaterTrax online database.

To achieve a better understanding of the range of sampling frequencies, a sample histogram was constructed based on the minimum sampling frequency quoted in the 2007 report (20 samples per month). This histogram shows the average free chlorine residual sampling frequency per month, for all community sites between 2007 and 2012. The histogram bins grouped the number of samples taken per month (if less than 20) into smaller ranges. In 2007, just under 50% of all community sites were taking less than five samples per month. By 2012, 35% of all community sites were still taking less than five samples per month. In 2007, about 14% of all sites were in compliance with the minimum sampling requirement. This number increased to 27% by 2012. Thus, over the time period of this study, the percentage of community sites taking less than five samples per month continually exceeded the percentage of sites taking 20 or more samples per month. The histogram is illustrated in Figure 4.

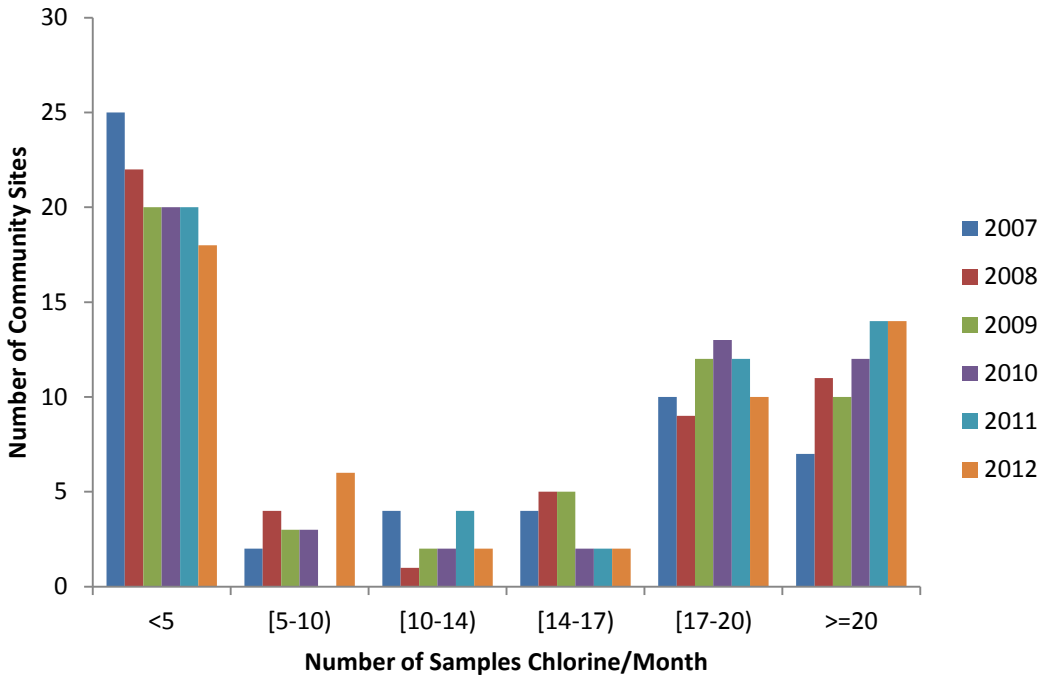

Figure 4 Histogram of free chlorine residual sampling frequency in the Atlantic Canadian First Nations community-based water monitoring program from 2007 to 2012. The square brackets indicate inclusion of the number within the range. The circle brackets indicate any value up to, but not including, that value in the range. Data was provided from the WaterTrax online database.

The minimum required free chlorine residual concentration in drinking water is 0.20mg/l. Any sample containing less than 0.20mg/l free chlorine residual is considered to violate this requirement. When the WaterTrax program provides information on the number of samples violating this guideline, it presents samples with no detectable traces of chlorine and those with concentrations less than the minimum requirement as separate values. To maintain consistency, this is how these values are presented in this study as well. Between 2007 and 2012, about one third of all chlorine samples taken were either found to contain less than 0.20mg/l or absolutely no chlorine was detectable. There was minor improvement over the 6 year time period, by approximately 5%. These results are illustrated in Figure 5.

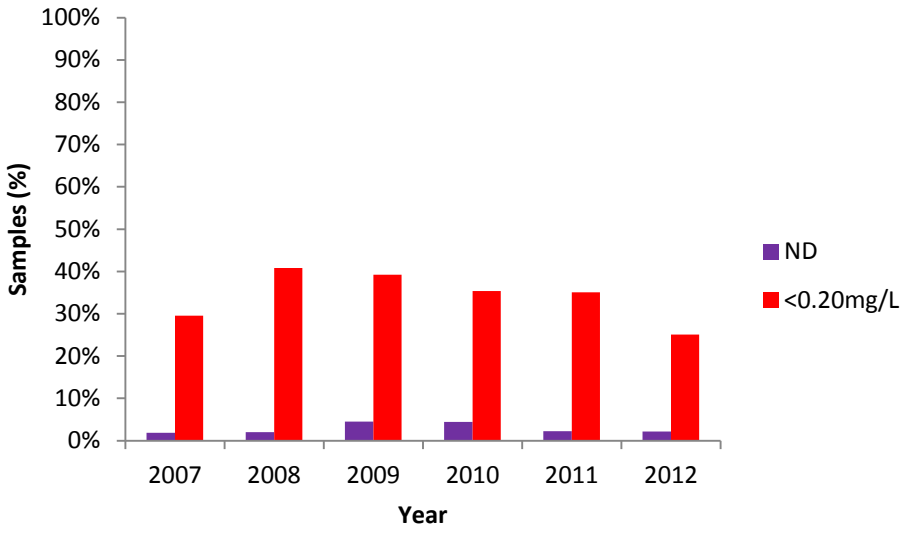

Figure 5 Atlantic Canadian First Nations community sites' violation of the free chlorine residuals' minimum concentration guidelines in the Guidelines for Canadian Drinking Water Quality. Any sample containing less than 0.20mg/l of residual chlorine is in violation (Health Canada, 2007). "ND" represents samples with no detectable free chlorine residual. Data was provided from the WaterTrax online database.

To establish if any relationship existed between non-compliance with the chlorine sampling requirements (listed in the 2007 report), and the minimum allowable concentration, these variables were compared to one another. The percentage of community sites taking free chlorine residual samples less than 0.20mg/L, within those taking less than 20 samples per month, was determined. This same value was then determined for community sites taking 20 samples per month or greater. In most years, compliance with the sampling requirement did not appear to affect compliance with the minimum free chlorine residual concentration. In 2012 however, there was a 13% difference between community sites taking less than 20 samples per month, than those taking 20 or greater. In other words, community sites taking less than 20 samples per month were 13% more likely to also violate the minimum free chlorine residual concentration than sites taking the required number of samples. This relationship is illustrated in Table 1.

Table 1 Relationship between the percentage of community sites taking less than 20 free chlorine residual samples per month, or taking 20 samples or greater, and exhibiting less than 0.20mg/L chlorine. Data was taken from the Atlantic Canadian Community-Based Water Monitoring Program from 2007 to 2012, from the WaterTrax database. A minimum of 20 samples per month and a concentration of 0.20mg/l of residual chlorine are required by the Guidelines for Canadian Drinking Water Quality (Health Canada, 2007; McDonald et al., 2007). "Cl" represents chlorine.

Year	Cl samples <0.20mg/l in Community Sites Taking <20 Samples/Month (%)	Cl samples <0.20mg/l in Community Sites Taking >=20 Samples/Month (%)
2007	29.3%	35.7%
2008	26.6%	23.2%
2009	29.8%	17.9%
2010	24.5%	19.6%
2011	21.0%	17.3%
2012	21.6%	8.7%

4.2. *E. coli* and Total Coliforms

There is a minimum requirement of 20 samples per month for both *E. coli* and total coliforms in the 2007 report. The colilert test used by water monitors tests for the presence of both *E. coli* and total coliforms, thus the number of samples taken per month for *E. coli* should be the same for total coliforms. This was not the case. Though slight in many cases, the number of *E. coli* results provided did not equate to that of total coliforms. Thus these results are presented independently.

Among all the Atlantic provinces, the majority of community sites took less than the required 20 samples per month over the time period. In 2007, 83% of the sites were taking less than 20 *E. coli* samples per month, and 79% were taking less than 20 total coliform samples per month. By 2012, these numbers had fallen to 77% and 69%, respectively. These results are illustrated in Figure 6.

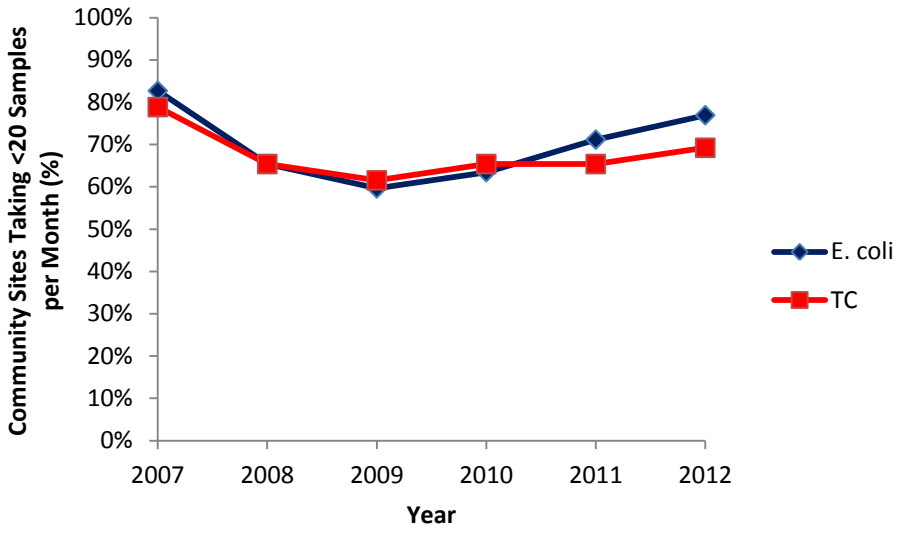

Figure 6 Atlantic Canadian First Nations community sites' violation of the microbial sampling guidelines in the Guidelines for Canadian Drinking Water Quality. A minimum sampling frequency of 20 samples per month is required (McDonald et al., 2007). Data was provided from the WaterTrax online database. "TC" represents total coliforms, and "*E. coli*" refers to *Escherichia coli*.

The water monitors' reference manual requires a minimum of four microbial samples per month from the monitors (Health Canada, n.d.). For both *E.coli* and total coliforms, the number of community sites taking less than four samples per month stayed relatively consistent at one third of all sites. This is less than if the sample minimum was 20 samples per month, but still quite high. These results are illustrated in Figure 7.

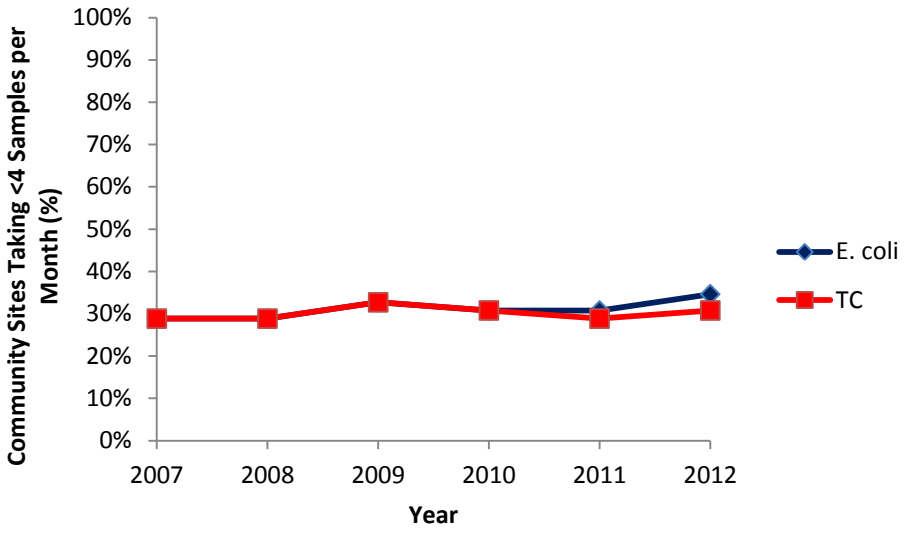

Figure 7 Atlantic Canadian First Nations community sites' violation of the microbial sampling guidelines in the Guidelines for Canadian Drinking Water Quality. A minimum sampling frequency of four samples per month is required in the water monitors' reference manual (Health Canada, n.d.). Data was provided from the WaterTrax online database. "TC" represents total coliforms, and "*E. coli*" refers to *Escherichia coli*.

To determine the distribution of sampling frequency per month, for sites taking less than 20 samples, a histogram was developed separately for *E. coli* and total coliforms. In 2007, 29% of the community sites were taking less than five *E. coli* and total coliform samples per month. By 2012, these numbers had worsened to 35% *E. coli* and 31% total coliforms. Community sites taking 20 or more samples per month improved from 17% to 23% for *E. coli*, and from 21% to 31% for total coliforms. Thus, in 2012, there were more community sites taking less than five *E. coli* samples per month than there were community sites taking 20 or more samples per month. For total coliforms, there were an equivalent number of community sites taking less than five samples per month and 20 or more samples per month. The histograms for total coliforms and *E. coli* sampling frequency are presented in Figures 8 and 9.

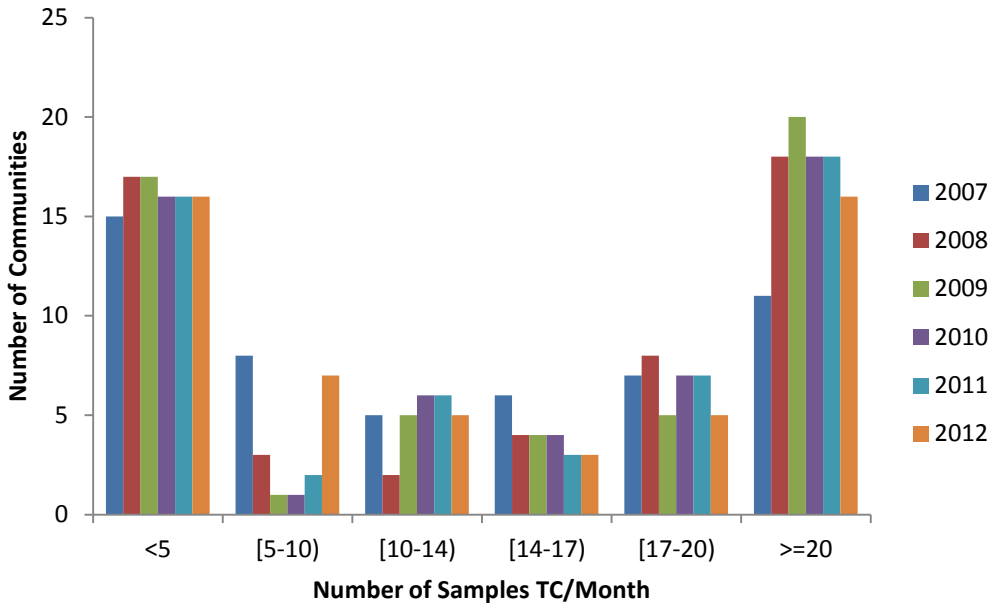

Figure 8 Histogram of total coliforms' sampling frequency in the Atlantic Canadian First Nations community-based water monitoring program from 2007 to 2012. The square brackets indicate inclusion of the number within the range. The circle brackets indicate any value up to, but not including, that value in the range. Data was provided from the WaterTrax online database. "TC" represents total coliforms.

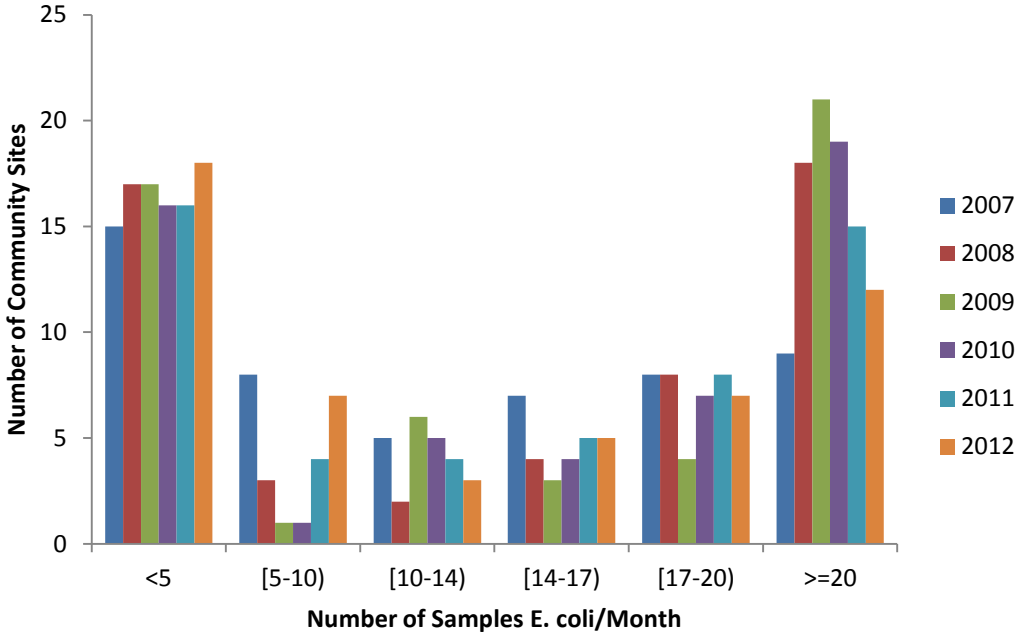

Figure 9 Histogram of *Escherichia coli* sampling frequency in the Atlantic Canadian First Nations community-based water monitoring program from 2007 to 2012. The square brackets indicate inclusion of the number within the range. The circle brackets indicate any value up to, but not including, that value in the range. Data was provided from the WaterTrax online database.

The MAC for *E. coli* is none detectable per 100ml of drinking water. Of the thousands of *E. Coli* samples taken each year, nine samples tested positive for *E. coli* in 2007 (0.13% of total samples), and three tested positive in 2012 (0.04% of total samples). Also, no more than 10% of the samples should contain total coliforms if the samples are taken in the distribution system. Some community sites violated this condition; 13.5% in 2007, and none in 2012. This was not a linear pattern of improvement, as a spike occurred in 2010, where 7.7% of community sites violated this condition. If the samples are taken from the drinking water system, the MAC is the same as that for *E. coli*. The percent of samples where total coliforms were present ranged from 2% in 2007 (114 positive samples) to 1% in 2012 (50 positive samples). These data are represented in Figure 10.

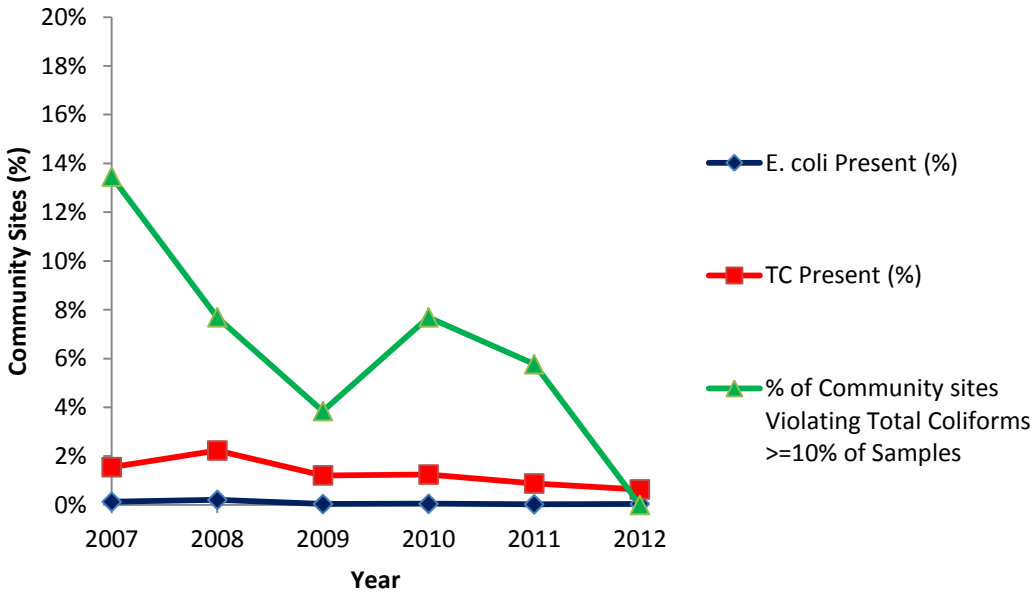

Figure 10 Atlantic Canadian First Nations community sites' violation of the microbial MAC guidelines in the Guidelines for Canadian Drinking Water Quality. An MAC of no *Escherichia coli* detectable per 100mL drinking water sample and less than 10% of the samples are positive for total coliforms is required in the Guidelines (Health Canada, 2012b). Data was provided from the WaterTrax online database. "TC" represents total coliforms, and "*E. coli*" refers to *Escherichia coli*.

To establish if any relationship existed between sampling non-compliance (according to the 2007 report sampling frequency) and MAC non-compliance, these variables were compared for both *E. coli* and total coliforms. The percentage of positive microbial samples found in communities taking less

than 20 samples per month was compared to the percentage of positive microbial samples in community sites taking greater than or equal to 20 samples per month. Overall, compliance with monthly sampling frequency was not related to absence of *E. coli* or total coliforms. In the case of *E. coli*, the community sites taking 20 samples or greater per month often had greater instances of *E.coli* presence. These results are illustrated in Table 2.

Table 2 Relationship between the percentage of community sites taking less than 20 microbial samples per month, or greater than or equal to 20 samples per month, and obtaining positive results. Data was taken from the Atlantic Canadian water monitoring program from 2007 to 2012, from the WaterTrax database. A minimum of 20 samples per month, with no detectable *Escherichia coli* per 100ml, are required by the Guidelines for Canadian Drinking Water Quality (Health Canada, 2007). The MAC for total coliforms is less than 10% of the samples have total coliforms present (Health Canada, 2012b). "TC" represents total coliforms, and "*E. coli*" refers to *Escherichia coli*.

Year	***E. coli* Present in Community Sites Taking <20 Samples/Month (%)**	***E. coli* Present in Community Sites Taking >=20 Samples/Month (%)**	**TC Present in Community Sites Taking <20 Samples/Month (%)**	**TC Present in Community Sites Taking >=20 Samples/Month (%)**
2007	0.11%	0.16%	1.66%	1.4%
2008	0.19%	0.22%	4.00%	1.2%
2009	0.00%	0.05%	1.42%	1.1%
2010	0.03%	0.05%	1.58%	1.0%
2011	0.03%	0.02%	1.12%	0.7%
2012	0.00%	0.08%	1.01%	0.4%

4.3. Trihalomethanes and Haloacetic Acids

Trihalomethanes and haloacetic acids are chemical by-products of chlorine disinfection, and indicate the presence of dissolved organic matter (Health Canada, 2012). As such, they should be found in greater concentrations in surface water than ground water sources (Health Canada, 2006). The results of this study, for these parameters, are presented to allow a comparison between surface and ground sources. It should be noted that of the 52 community sites evaluated, only 2 were surface water sources (S and FF).

4.3.1.Trihalomethanes

Trihalomethanes' data was collected between 2007 and 2012. The number of community sites taking the required four samples per year did not improve over this period, remaining at 70% of the ground source sites, and 100% of the surface source sites. The sampling data for this parameter are illustrated in Figure 11.

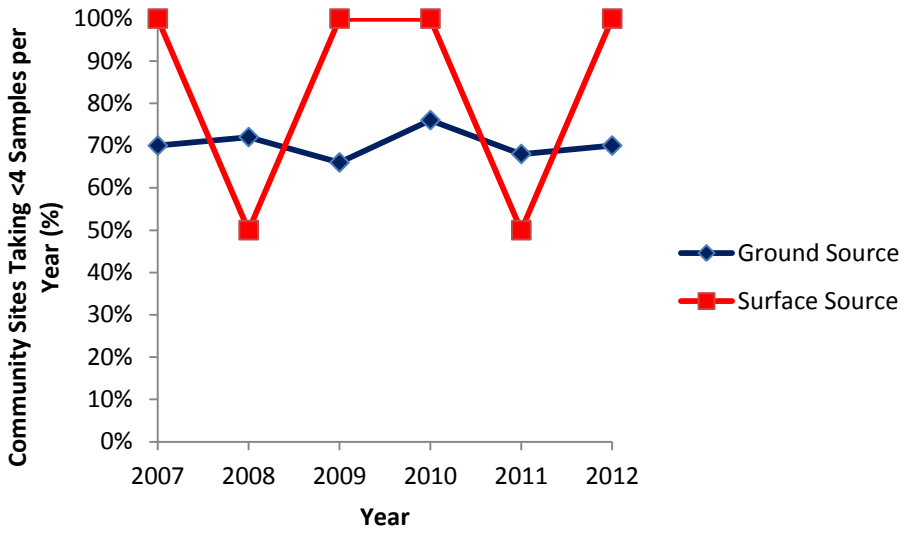

Figure 11 Atlantic Canadian First Nations community sites' violation of the trihalomethanes' sampling guidelines in the Guidelines for Canadian Drinking Water Quality. A minimum sampling frequency of four times per year is required (Health Canada, 2007). Data was provided from the WaterTrax online database.

The number of ground water community sites violating the MAC for this parameter (0.10mg/l) in 2012 did not improve from 2007, staying at 2 community sites. The number of surface water community sites in violation of the MAC was reduced from one site in 2007, to none in 2012. The MAC data for this parameter are illustrated in Figure 12.

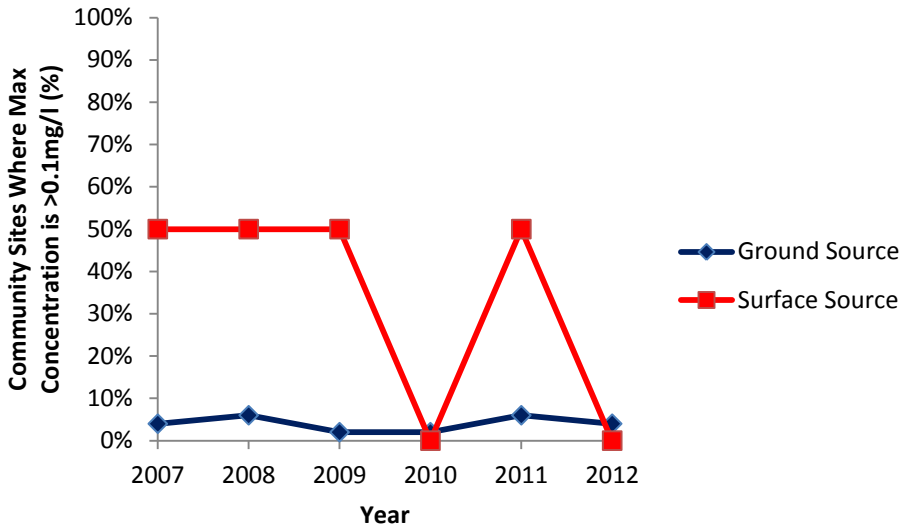

Figure 12 Atlantic Canadian First Nations community sites' violation of the trihalomethanes' maximum allowable concentration guidelines in the Guidelines for Canadian Drinking Water Quality. The maximum allowable concentration for this parameter is 0.10mg/l (Health Canada, 2008). Data was provided from the WaterTrax online database.

4.3.2. Haloacetic Acids

No haloacetic acid data was collected in any community in 2007 and 2008. This improved over the given time period, so that in 2012, 22 of the 52 community sites had taken haloacetic acid samples that year, though 65% of all community sites in 2012 had not reached the mandated four samples per year. For the ground source sites, 66% had not managed to take four haloacetic acid samples in 2012; and for the surface source sites, one of the two had not reached the quota. These results are illustrated in Figure 13.

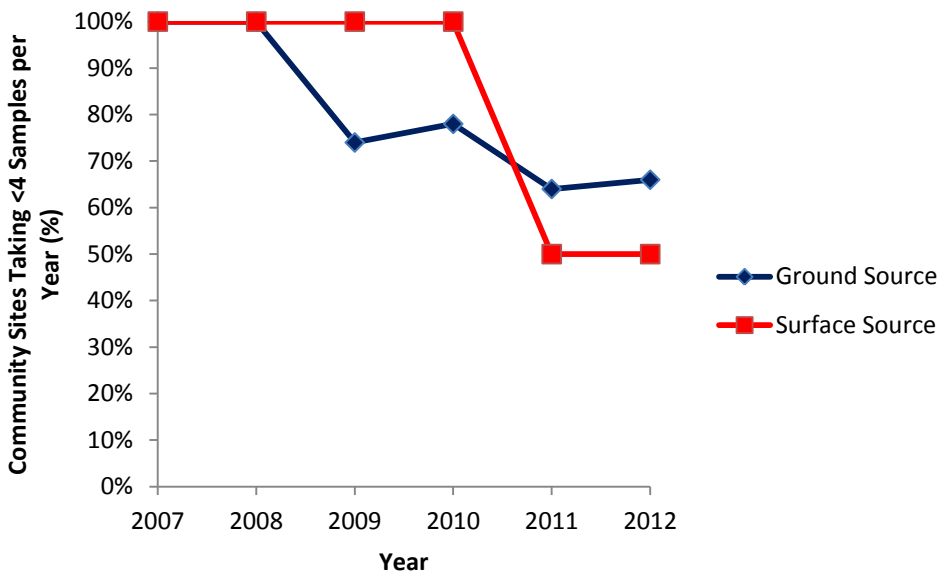

Figure 13 Atlantic Canadian First Nations community sites' violation of the haloacetic acid sampling guidelines in the Guidelines for Canadian Drinking Water Quality. A minimum sampling frequency of four times per year is required (Health Canada, 2007). Data was provided from the WaterTrax online database.

Only in community sites FF (surface water), HH, and MM was the MAC (0.08mg/l) exceeded between 2009 and 2012. In 2012, this resulted in 3.8% of the community sites in Atlantic Canada exceeding the 0.08mg/l MAC for haloacetic acids. All of these communities were located in Nova Scotia; one was a ground source site, the other a surface source. These results are illustrated in Figure 14.

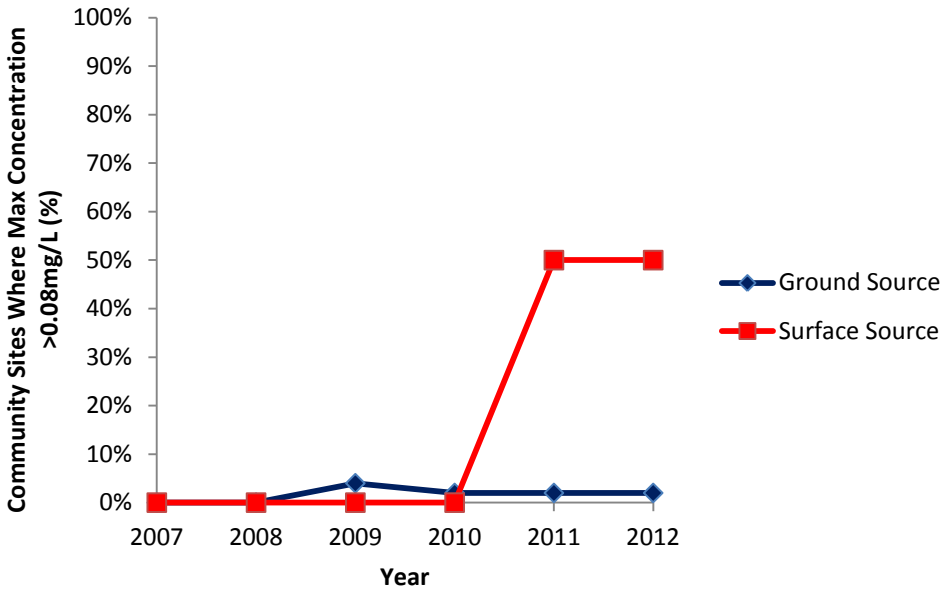

Figure 14 Atlantic Canadian First Nations community sites' violation of the haloacetic acid maximum allowable concentration guidelines in the Guidelines for Canadian Drinking Water Quality. The maximum allowable concentration for this parameter is 0.08mg/L (Health Canada, 2008). Data was provided from the WaterTrax online database.

4.4. Results Summary

Listed here are the conclusions drawn from the above data analyses. These conclusions were used to evaluate the effectiveness of the water monitor reference manual and annual workshop slide decks.

- Community sites taking less than five samples per month continually exceeded the percentage of sites taking 20 or more samples per month for free chlorine residual. These sampling frequencies were equivalent for total coliforms by 2012.
    - About one third of all community sites between 2007 and 2012 were taking less than four samples per month for free chlorine residual, *E. coli* and total coliforms.
- Just under one third of all residual chlorine samples consistently violated the Guidelines' minimum concentration value over this time period.

- Nine samples for *E. coli* tested positive in 2007 and three in 2012. For total coliforms, 13.5% violated the greater than 10% guideline in 2007, and none in 2012. In 2007, 114 samples tested positive for total coliforms; in 2012 there were 50 positive samples recorded.
- The percentage of community sites taking at least 4 quarterly trihalomethane samples per year did not improve between 2007 and 2012.
- There was some improvement in the percentage of community sites taking quarterly haloacetic acid samples, but by 2012, 65% of all sites were still not meeting this quota.
- Though a low percentage of community sites violated the MAC for trihalomethanes and haloacetic acids, there was little improvement over this time period.

All of the above findings helped inform the technical document review and discussion sections below.

4.5. Technical Document Review

Mention of the specific guidelines for free chlorine residual, total coliforms, *E. coli*, trihalomethanes and haloacetic acids was sought out in the water monitors' reference manual, log book, and annual workshop slide decks from 2010 to 2012. All limits and sampling frequencies were included in the reference manual, though the trihalomethane and haloacetic acid data was not highlighted as the other parameter guidelines were. Monitors are not required to test those two parameters, perhaps explaining the lack of emphasis. Also, review questions in the back of the manual addressed: free chlorine residual minimum concentration, total coliforms' MAC, *E. coli* MAC, and the sampling frequency for all three parameters. The log book did not list any of the guidelines for any parameter. The 2010 slide decks included the following: free residual chlorine sampling frequency, minimum free chlorine residual concentration, and the MAC for all remaining parameters. The 2011 slide decks included the minimum free chlorine residual concentration and the MAC for total coliforms and *E. coli*. The 2012 slide decks did not mention any of the specific guidelines for any of the parameters evaluated in this study.

See Table 3 in Appendix A for a summary of these results. Several conclusions may be drawn from this review:

- All specific guidelines for free chlorine residual, total coliforms and *E. coli* are included and highlighted in the water monitors' reference manual.
- No specific guidelines are listed in the monitors' log book.
- There appears to be little consistency in the reiteration of parameter guidelines at the annual water monitors' workshop events.

It is recommended to consider these conclusions in relation to those found in the technical water quality data review. Changes to the technical documents, or instruction, provided to the monitors may improve the program's compliance with the Guidelines. The implications of this study's results are discussed in the following chapter. The discussion relates these results to the wider water monitoring program and water quality issues as a whole. Potential for future research and development is also discussed.

5.0. Discussion

In this chapter, the significance of the results is discussed in relation to the overall purpose of the study. Supplementary scholarly articles are incorporated into these conclusions, as are suggestions for potential future areas of research. Though this study sought to answer several questions regarding the CBWMP, it fundamentally raised more questions than it answered.

5.1. Data Trends

Though there were significant sampling frequency gaps in the data, the trends observed may still provide insight. This section discusses the results with this consideration in mind.

On the whole, there was little to no improvement in the parameter concentrationswater quality of the 5 studied parameters between 2007 and 2012. Though there were less total coliforms detected by 2012, and there was a definite decline in the number of sites taking samples with 10% or greater total coliforms present, these trends are still not a concrete demonstration of improvement in water quality since the number of samples taken varies from site to site. Only if the requisite sampling frequency was met in all community sites would the parameter concentrations be an accurate reflection of the water quality. At present, it can only be stated that more samples are required to make any conclusive statements regarding water quality improvement. The data currently show, overall, that the water quality in these communities oftenis not meeting the Canadian Drinking Water Quality Guidelineslacking.

There was an interesting relationship noted when the sampling frequency and water quality suggested concentrationsresults were compared. It was found, for free chlorine residual, there appeared to be a correlation between meeting the sampling frequency, and yielding samples also meeting the minimum suggested concentration guideline. It must be emphasized that this is only an observed correlation, not a causal relationship; taking more samples is not an indication of improved free chlorine residual concentration. Thus, increasing sampling frequency may be a means to ensure adequate monitoring of water quality in these communities, and thus allow for quicker emergency

response. Conversely, it was more frequent that sites taking the requisite number of samples had higher rates of microbial presence in their water samples. Even though these sites were meeting the sampling frequency guidelines, they had higher presences of microbes. This, again, is an issue of data gaps. The sites taking fewer samples may very well have had total coliforms or *E. coli* present in their water systems, but the smaller sample size did not accurately reflect the overall water quality of the system. Until the sampling frequency is met by all sites, it will be difficult to draw accurate conclusions from these data.

There were at least two community sites in 2012 (regardless of source) which were not in compliance with the MAC for trihalomethanes and haloacetic acids. One of these was a ground water source, the other a surface water source for haloacetic acids; both were ground sources for trihalomethanes. Trihalomethanes and haloacetic acids are generated when the chlorine disinfectant product reacts with organic matter in water. These substances are typically found in surface waters, as opposed to ground water sources, given the high concentration of organic matter in surface sources (Health Canada, 2008). The presence of these by-products in a ground water source indicates an above average concentration of organic matter. There may be reason to investigate the possibility of organic matter pollution which could mean the groundwater source is under the direct influence of surface water. Though trihalomethanes and haloacetic acids both have potential health risks associated with human exposure, it is emphasized in the Guidelines that these risks are far less acute than those with microbial contamination. Thus, emphasis should be on chlorine disinfection, with the possibility of by-product formation, as opposed to risking the persistence of microbial life forms in drinking water (Health Canada, 2008).

The review of the technical training documents provided some contextual information. It was found that the requisite sampling frequencies and allowable concentrations, for all parameters, are included in the water monitor reference manual. These guidelines are not listed in the log book, and are

mentioned somewhat inconsistently in the annual water monitor workshops. These findings raise the question of identifying the division between what is instructed in the training process, and what is implemented afterwards. How to bridge the divide is an entirely separate research topic. As well, there are emergency response strategies in place to address water quality issues that arise. There is also an emergency contact list included in the water monitors' log books which identifies key people to contact in case of a poor sample (Centre for Water Resources Studies, 2013). Given the water quality results, and the apparent lack of action, the effectiveness of this process may also be brought to question. These technical documents were not the focus of the study, but did help generate areas for potential future research.

5.2. Sources of Error

As noted in Chapter 4 and above, not enough samples were taken for any of the five parameters over the six year time period. Even if the prerequisite monthly sampling frequency for free chlorine residual, total coliforms, and *E. coli* was reduced to four per month, about one third of all community sites were not meeting this quota. There is still confusion as to the actual required number of samples per month for these three parameters. The reference manual is not clear as to the exact sampling frequency requirements for the monitors, stating: "For communities of up to 5,000, [the monitors] should sample once per week. It is recommended to take a minimum of two samples from different locations in the distribution system" (Health Canada, n.d., p6.3.1). It is uncertain as to whether or not one sample should be taken per week overall, or if one sample should be taken per week from different locations in the distribution system. Furthermore, the 2007 report quoted a requisite 20 samples per month for these parameters (16 from the monitors and four from the EHOs) (McDonald et al., 2007). The current report was written to maintain consistency between the evaluations, though the question still exists as to the actual minimum sampling frequency.

In addition, the data was evaluated based on each community site (e.g. some First Nations had more than one community listed on WaterTrax), as opposed to each First Nations community. Logically, samples should be taken for each First Nations site, as opposed to each First Nations community as a whole. However, the sampling frequency compliance for the program may have been evaluated based on the 34 First Nations communities listed on WaterTrax, as opposed to the 52 community sites individually. It is unclear whether this was the case, so the program was evaluated by community site.

In the water monitor reference manual it is specifically stated that chlorine and microbial testing be conducted concurrently (Health Canada, n.d.). The number of chlorine samples taken did not match the number of microbial samples taken. Likewise, even though the total coliforms and *E. coli* tests are one and the same, the number of samples taken for each differed. This raises the question of missing data. This study relied entirely on data entered into the WaterTrax database. It is possible that some data was never entered onto this online program. There is also the possibility that it was not made clear to the monitors that all tests must be done with equal frequency, and all data entered into the online database. Therefore, the required number of samples may have been taken, but may not have been recorded on WaterTrax. It would, thus, appear that the program was not meeting its sampling frequency targets.

The trihalomethane and haloacetic acid samples are the responsibility of the EHO. The sampling frequency for these parameters is four times per year (Health Canada, 2007). The vast majority of community sites, regardless of water source type, did not meet this criterion, thus there seem to be issues with sampling frequency for both the operators and EHOs, unless some data was not entered into WaterTrax.

In the technical document review, it was only the slide decks which were evaluated to determine inclusion of the Guidelines in the annual monitor workshops. It is not known whether the various presenters said the specific guidelines for each parameter aloud, without having these facts

written on their slides. Thus, the inclusion or exclusion of the Guidelines in the annual workshops, based solely on the slide decks presented, may have created some error within the data presented.

The majority of this study, apart from the technical document review, was based on data collected and reported by the water monitors and EHOs. Thus, the quality of research and data acquisition was entirely dependent on those individuals. The researchers in this study could not control for any bias or potential error on their parts. The reliance on secondary data may have very well caused some skewing and/or error in the results presented, however; this should not have been significant enough to affect the overall data trends observed.

5.3. Looking Ahead

As of January 31st 2013, there were 113 First Nations communities under a drinking water advisory across Canada (this includes boil water advisories and do-not-drink advisories) (Health Canada, 2013). This trend had been constant and worsening since 2002 (Poulin, 2010). While the CBWMP has collected a considerable amount of water quality data since its inception, there have only been two assessments conducted over this time period in the Atlantic region, and arguably, very little progress has been made in water quality improvements. More frequent audits of the program may allow quicker responses to problems that arise, and may also allow community-specific recommendations to be made.

This study looked at water quality data over six years, but there is still a considerable number of avenues this research could be taken. Ideally, the sampling frequency for all parameters would increase to meet the Guidelines. Once this occurred, the data could be accurately interpreted for the current status of water quality in First Nations communities in the Atlantic Canada region. Also, research could be expanded to include other water quality parameters and perhaps a qualitative investigation into the training and experiences of the monitors, EHOs and band councils. Qualitative surveys, interview or focus groups with these stakeholders were beyond the scope of this study. These research tools,

however, could help identify areas where the CBWMP might be improved to address non-compliance with the Guidelines.

While this study indicates issues with water quality still exist, there is the question of why this is the case. It may be an issue with treatment or distribution infrastructure, or water source quality. Evaluation of each community site's drinking water facilities would allow the suggestion of site- tailored recommendations. If it is not an issue of the infrastructure or facility operations, there may be problems with the monitor training in the program; it may not be extensive enough to adequately prepare the monitors for their work. Given the lack of research in this area (and the difficultly of doing so) it is challenging to identify the culprit causing the perpetuation of poor water quality in these communities. Most likely it is an amalgamation of a number of issues, including: infrastructure, funding, training programs, resource accessibility, and enforcement mechanisms.

These findings were comparable to another study conducted on a smaller scale in Alberta, Canada. This study was not an evaluation of a CBWMP, but of the drinking water quality system in First Nations communities as a whole. Smith, Guest, Svrcek & Farahbakhsh (2006) conducted a study which evaluated the water quality, treatment technology, monitoring and reporting system, operation, maintenance, and operator training of 56 First Nations water systems. Their study was a far more extensive evaluation of these communities, but reached very similar conclusions to this project; mainly, there were inadequate monitoring and testing programs in place.

They recommended the implementation of a training program that not only taught the Guidelines to public works employees, but did so in the context of First Nations values. They found that many communities had sufficient treatment technology, but because it was not properly maintained, monitoring or operated, water quality issues arose. They recommended proactive action to address poor water quality to prevent health risks from developing (Smith et al., 2006). While it is important to address the issues currently abound in First Nations communities, it is arguably just as important to

ensure these problems are prevented in other communities. Their findings may be very applicable in the Atlantic Canadian context. Repeating their study in this region would elucidate more specific recommendations and ways forward.

5.4. Addressing the Research Question

Fundamentally, the effect of the CBWMP on drinking water quality in Atlantic Canadian First Nations communities is unclear. The microbial data trends showed some improvement. There was little to no improvement in terms of free chlorine residual, trihalomethanes and haloacetic acids. Furthermore, these observations cannot be considered fully representative of the effects of the program; there were significant data gaps present in the WaterTrax database. Not enough samples were taken per month in the program, neither by the water monitor reference manual standards, nor by the standards set by the previous 2007 report.

The monitors' reference manual complies with the federal drinking water Guidelines and the Protocol. The program itself, however, is not in compliance with these Guidelines (based on the data provided). Until the recommended sampling frequency is met by all sites, an accurate picture of the Atlantic Canadian First Nations drinking water quality cannot be drawn. Though the instruction and training appear to follow the Guidelines, they do not seem to have been applied successfully in these communities. More data is required to conclusively state the effects this program has had, and if it complies with the current federal standard.

How can the issue of water quality in First Nations communities be addressed? This has been a question across Canada for decades. It is an ever-present concern that is not going away anytime soon. It is only by working together with all stakeholders and developing infrastructure enabling adequate enforcement, treatment, operation (including training), and monitoring and enforcement of drinking water that this problem may become part of the past, and clean drinking water the way of the future.

Appendix A

Table 3 Evaluation of the Community Based Water Monitoring Program technical documents for mention of specific water quality parameter guidelines, as listed in the Guidelines for Canadian Drinking Water Quality. Parameters of focus were: free residual chlorine, total coliforms, *Escherichica coli*, trihalomethanes, and haloacetic acids. Guidelines of focus were: recommended concentration and sampling frequency (Health Canada 2007).

	Reference Manual	Log Book	2010 Workshop Slide Decks	2011 Workshop Slide Decks	2012 Workshop Slide Decks
Chlorine Sampling Frequency	Dependent on size of community (min 1/week) 6.3.1	No	*note made to "sample on a weekly basis" (tab 14)	*note made that regular sampling is important (tab 15)	
Chlorine >0.2mg/L	**Yes- 4.1.4, 6.1.1**	No	Yes (tab 10)	Yes (tab 1)	
Total Coliforms Sampling Frequency	Dependent on size of community (min 1/week) 6.3.1	No	Min 2/year for wells (tab 9)		
Total Coliforms Present in <10% of Samples/ MAC	**Yes- 3.1.4, 3.1.5, 6.1.1 (highlighted)**	No	Yes (tab 5)	Yes (tab 1)	
E. coli Sampling Frequency	Dependent on size of community (min 1/week) 6.3.1	No			
No *E. coli* Present per 100mL	**Yes- 3.1.4, 3.1.5, 6.1.1 (highlighted)**	No	Yes (tab 5)	Yes (tab 1)	
Trihalomethanes' Sampling Frequency	**Yes- 4.1.3 (not highlighted)**	No			
Trihalomethanes' <0.1mg/L	**Yes- 4.1.3 (not highlighted)**	No	Yes (tab 13)		
Haloacetic Acids' Sampling Frequency	**Yes- 4.1.3 (not highlighted)**	No			
Haloacetic Acids <0.08mg/L	**Yes- 4.1.3 (not highlighted)**	No	Yes (tab 13)		

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