Development of Standard Operating Procedures for the Reduction of Boil Water Advisories in Newfoundland and Labrador

Prepared for:
Department of Environment & Conservation

Prepared by:
Big East Engineering Inc.

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DEVELOPMENT OF

STANDARD OPERATING PROCEDURES

FOR THE REDUCTION OF

BOIL WATER ADVISORIES IN

NEWFOUNDLAND AND LABRADOR

Submitted to:

Department of Environment and Conservation

Submitted by:

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BIG EAST
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EXECUTIVE SUMMARY

This report summarizes the findings and deliverables of the study entitled *Development of Standard Operating Procedures for the Reduction of Boil Water Advisories in Newfoundland and Labrador*. The study included the following tasks:

- Data collection and analysis on historical and active boil water advisories (BWAs).
- Review of common causes for BWAs and develop a BWA System Assessment form.
- Identify corrective measures for each of the 21 BWA reason codes currently being used in the Newfoundland and Labrador.
- Recommend preventative maintenance measures to communities to help reduce BWAs.
- Development of a set of standard operating procedures (SOPs) to be implemented by communities to remove BWAs.
- For two pilot communities demonstrate the application of the BWA System Assessment form and SOPs.
- Provide recommendations for the reduction of BWAs.

Data Collection and Analysis

Using historical and active BWA records provided by the Department of Environment and Conservation (ENVC) up to August 6, 2015, an analysis was completed on the data using geographic information, date of issuance, duration, reason code, community size and governance, operators, water sources, and treatment. The main findings of the data analysis included:

- Many of the 238 Active BWAs (as of August 6, 2015) are long term BWAs which have been in place for multiple years. Over 75% have been in place for more than one year and approximately 50% for more than five years. The number of BWAs at the end of each fiscal year has not changed significantly over the past 10 years; steadily ranging from 210-230.

- Inadequate disinfectant residual levels account for 36% of all active BWAs. BWAs in noncompliance with disinfection standards are generally of longer duration than those in noncompliance with bacteriological standards. This is believed to be due to the lack of understanding by communities and consumers on the role and importance of the disinfection process in providing safe potable drinking water. Also, funding and operational costs can be very costly for a small community to fund and operate a disinfection system.

- Communities with populations less than 500 people are much more likely to be on a BWA than larger communities. Approximately 86% of active BWAs are for communities with less than 500 people. Smaller communities appear to be performing less maintenance on water infrastructure than larger communities based on code D1 (water distribution system undergoing maintenance or repairs).

- Public water systems with certified operators are less likely to be on a BWA. Even though 33% of the communities have certified operators, only 12% of all active BWAs are for communities with certified operators.

Common Causes and BWA System Assessment Form

Using data collected from Service NL (SNL) and information found in the US EPA report *"Revised Total Coliform Rule Assessments and Corrective Action Guidance Manual (2014)"* a summary of common causes of active BWAs was prepared. Given that BWA reason codes A, B, C, and D were self-explanatory, the focus was on common causes for the 110 BWAs due to reason codes E and F. For the active BWAs of codes E and F; 38% were noted as being due to chlorine residuals, 15% due to insufficient funds or staffing resources to operate and maintain the disinfection system, 30% had no updates or missing information, and the remainder were due to maintenance, no disinfection system, and a BWA that had been lifted.

A BWA System Assessment form was prepared to allow owners of public water systems to undertake assessment of the water infrastructure to identify the root cause(s) for the current BWA (noted as critical issues) and identify areas of the system which would make it prone to re-occurring BWAs (noted as serious issues). The form assesses the water infrastructure from source to tap, asking questions which allow for 'Yes/No' responses and documenting whether the issue is 'Critical/Serious/OK'. The BWA System Assessment form is provided in Appendix A2 of this report. The form will be valuable to owners and regulators in documenting deficiencies that may exist, identifying root causes for BWAs, identifying which of the corrective measures in the SOP should be implemented, and documenting BWA causes and trends on a go-forward basis.

Corrective and Preventative Measures

For each BWA reason code a detailed summary of corrective measures which may be implemented to lift the BWA was provided. The corrective measures included "short-term" measures that may help lift the BWA and "long–term" measures that may reduce potential for the BWA reoccurring. With the exception of educating operators to bring them up to provincial standards of certification, most long term measures involve capital works funding, which may require funding under a number of programs delivered through the Department of Municipal and Intergovernmental Affairs (MIGA).

Order of magnitude cost estimates are given for each corrective measure. The costs for many of these measures will be site specific; depending on the extent of the problem, complexity of the system and construction, etc. Estimates should be used as a guide to the expected costs and the decision making process on which a corrective measure may be feasibly implemented. For each corrective measure, there is a list of stakeholders identified, who may be required to take some action or be consulted by the owner. See Section 4 of this report for BWA corrective measures.

Section 5 of the report prepared a detailed summary of preventative measures that may be implemented to further reduce BWAs. An overview was provided on the importance of proper operation and maintenance of the water infrastructure and recommended frequency and checklists for maintenance from daily through to five year intervals. Reference was made to the MIGA Maintenance Assurance Manual and forms previously prepared, as well as new forms developed for recording commonly collected data (See Appendix A3 for checklists and log forms).

Standard Operating Procedures

A set of Standard Operating Procedure (SOP) flowcharts were developed for each of the BWA reason codes currently being used in Newfoundland and Labrador (See Appendix A1). They are designed as a field level guide (fitted on 1 page) that outlines the various steps communities would take to have a BWA lifted. A flowchart was also developed (*Figure 6.1*) to show the overall process of removing a BWA, which include:

Step #1: Identify the root cause(s) of the BWA using the BWA System Assessment form.

Step #2: Implement short term corrective measures.

Step #3: Confirm system is meeting provincial disinfection standards.

Step #4: Contact SNL to have system tested for compliance with bacteriological and disinfection standards.

Step #5: Implement preventative maintenance program.

Step #6: Identify long term corrective measures to address deficiencies which may make the system prone to re-occurring BWAs.

Pilot Communities

Two communities were chosen to demonstrate the application of the BWA System Assessment form and SOPs. The communities chosen were Portugal Cove South (code E1) and Gander Bay South (code F4). The assessment forms were successfully applied to each community and proved to be very useful tools in documenting the deficiencies within the communities water infrastructure and root cause(s) for the current BWAs (See Appendices B1 and B2). Based on the results from the assessment tools and identified root causes, a list of corrective measures was identified that should be implemented to lift the BWA at each community. Based on the results of the site visits a list of recommended preventative maintenance measures was identified for each community. The next step would be for the communities to implement the recommendations identified in Section 7 of this report.

Recommendations for Reducing BWAs

Based on findings of this report and challenges that exist, the following recommendations were identified to help reduce BWAs in the province.

Recommendation 1: Use of SOPs to Remove BWA

Through the use of government resources and external consultants, the SOPs developed as part of this study should be implemented by any community which is on a BWA. On a go-forward basis, a completed BWA System Assessment form should be submitted by the community to regulatory agencies to aid in documentation of the root cause(s) for each BWA and any deficiencies within the water infrastructure system. The completed assessment forms should be maintained at communities' offices. The owner should take the necessary corrective measures to remedy the cause and have the BWA removed. Enforcement of applicable regulatory legislation should be implemented by the province to encourage owners to take the necessary actions in a timely manner and submit the completed BWA System Assessment forms.

Recommendation 2: Public Education on Disinfection Process

Public education and awareness on the importance of disinfection processes in providing safe potable water and the importance of boiling water when a BWA is in effect is a critical process in reducing the number of BWAs in NL and reducing potential health risks. Until the consumers believe that they should boil water that is not disinfected and want to have the service providers supply water that has been disinfected, the service will be at the discretion of the providers. When competing for money from small budgets, spending money on disinfection processes may not be high priority, especially if the consumers are not demanding this service and there is little enforcement of regulatory legislation. Once educated, consumers may be more willing to pay additional taxes to support the costs associated with operating and maintaining a potable public water system. Public education should be a province wide initiative, using many media types to reach a broader audience.

Recommendation 3: Operator Training

The province should continue to support and encourage operator education, training, and certification for those operating the water systems in the province. Results from this study and previous studies indicate that public water infrastructure is better operated and maintained when there are trained and certified operators running the systems. This results in fewer BWAs, and if a BWA is issued, it is usually rescinded much more quickly. Public water system operators should meet the minimum requirements as outlined under the ENVC's "Water and Wastewater System Classification".

Recommendation 4: Use of CT Value in Lieu of 0.3mg/L at First User

This recommendation may be more applicable to systems with small distribution systems. However, the use of the CT concept and the required CT value for viruses in lieu of 0.3mg/L at first user may also reduce the number of BWAs on smaller systems with short distribution systems. By taking into account the water temperature, as well as the time the water has been in the distribution system at the location of the first user (or sample location), the CT value can be determined in accordance with and in compliance with the *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems* (ENVC, 2005).

Recommendation 5: Pilot Study Implementation of SOPs

The assessment form and SOPs were found to be useful tools for assessing water infrastructure and identifying corrective measures at two pilot communities as part of this study. It is recommended that the province undertake a pilot study of 10 or more communities, to apply the BWA System Assessment form and use the SOPs to prepare corrective measures work plans, preventative maintenance plans, and to work with the communities to remove the BWAs. The SOPs and BWA System Assessment form should be further refined (as necessary) based on the results and findings from future pilot communities.

List of Acronyms

ACWWA – Atlantic Canada Water and Wastewater Association

AWWA – American Water Works Association

BWA – Boil water advisory

CCCBFP – Cross-connection control and backflow prevention

DBP – Disinfection by-product

EHO – Environmental Health Officer

ENVC – Department of Environment and Conservation

ERP – Emergency response plan

FES-NL – Fire and Emergency Services – Newfoundland and Labrador

GBS – Gander Bay South

HAA – Haloacetic acid

HCS – Department of Health and Community Services

LSD – Local Service District

MAC – Maximum acceptable concentration

MAM – Maintenance assurance manual

MCW – Municipal Capital Works

MIGA – Department of Municipal and Intergovernmental Affairs

MSDS – Material safety data sheet

NCO – Non-consumption order

NSF – National Sanitation Foundation

O&M – Operation and maintenance

OETC – Operator Education, Training, and Certification

PCS – Portugal Cove South

PWDU – Potable water dispensing unit

POM – Preventative operations and maintenance

SNL – Department of Services Newfoundland and Labrador

SOP – Standard operating procedure

THM – Trihalomethanes

TOR – Terms of reference

VFD – Variable frequency drive pump

WRA – Water Resources Act

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1.0 INTRODUCTION

This section will provide a brief background for this study, objectives, deliverables, and outline the structure of the report.

1.1 Project Background

Boil Water Advisories (BWAs) are issued on public drinking water systems where there is known microbiological contamination or a risk of such contamination, which may be due to lack of appropriate disinfection processes, issues within the water distribution system or lack of disinfectant residuals within the distribution system. A total of 21 BWA reason codes are currently being used in Newfoundland and Labrador to describe standard reasons for issuing BWAs.

Currently there are 521 public drinking water distribution systems in the province being operated and maintained by approximately 367 communities. From 2001 to 2006, the number of BWAs decreased by approximately 100 however since that time the number of active BWAs has remained in the 210 -230 range. As of August 6, 2015, there were 238 BWAs in place, affecting 173 communities servicing approximately 85,000 people. Many BWAs have been in place for long periods, some for longer than 10 years.

In May 2015 a request for proposals was issued for the development of standard operating procedures for the reduction of boil water advisories in Newfoundland and Labrador.

1.2 Project Objectives and Scope

The main objective of this project is to produce a set of Standard Operating Procedures (SOPs) for the prevention and removal of a BWA. The SOPs are written for use primarily by the owner and operators of public drinking water systems. The SOPs may also prove useful to government departments and agencies involved in the management of drinking water throughout the province.

Sub-objectives of this project are outlined below as per the terms of reference issued by the Government of Newfoundland and Labrador:

- Identify common causes for the issuance of BWAs on public drinking water systems.
- Identify operational data that should be regularly tracked and recorded by public drinking water system owners and the frequency of data collection.
- Develop standard templates for the assessment of all components of a public drinking water system (source water, treatment/disinfection, distribution system, service line and tap) and related water quality data.
- Provide guidance on how to undertake an assessment of a public drinking water system.
- Identify potential corrective measures for the common causes of BWAs in NL.
- Provide guidance on how to implement corrective measures.
- Identify measures for the prevention of further BWAs.
- Identify common barriers and challenges to the removal of BWAs in NL.
- Identify applicable lessons learned from other jurisdictions in dealing with reducing BWAs.
- Review of *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems* for the requirements relating to the design of public drinking water system infrastructure, treatment and disinfection facilities, and source waters.

1.3 Project Deliverables

As per the Terms of Reference (TOR) for this study, the project deliverables include:

- Task 1 – data collection and analysis of historical BWAs (Section 2),
- Task 2 – common causes of BWAs and development of a template for use by owners and operators to assess their drinking water systems (Section 3),
- Task 3 – identification of potential corrective measures that may be implemented to resolve a BWA (Section 4),
- Task 4 – summary of potential preventative measures that may be implemented to reduce the number of BWAs issued in the future, including sample data log forms that could be

used by owners and operators. As well a discussion of remaining barriers and challenges that may inhibit the resolution or reduction of BWAs (Sections 5 and 8),

- Task 5 – a set of SOPs that can be implemented by communities when a BWA has been issued (Section 6),
- Task 6 – provide sample application of SOPs on two pilot communities, one that has been on a BWA for more than 5 years (long-term) and one on a BWA for a reason code F relating to the detection of *Escherichia coli* (*E.coli*) (Section 7), and
- Task 7 – preparation of a study report pertaining to the 6 tasks outlined above and delivery of five hardcopies of the final report, along with associated digital copies/information (this report).

1.4 Report Organization

Sections 2 through 8 cover tasks 1-6 as identified in Section 1.3. Section 9 provides recommendations based on the works undertaken to prepare the SOPs. The appendices are prepared to be stand-alone documents for the SOPs, forms and assessment templates, as well as additional information related to the SOPs.

2.0 DATA COLLECTION AND ANALYSIS

Section 2 is prepared in accordance with Task #2 (Section 4.1) identified in the TOR. Long term trends related to BWAs analyzed in this section of the report were produced using data from the last ten full years (2005-2014) and are referred to as "10yr Record" throughout the report. Other analyses were completed using the data from each year for 2004, 2009, and 2014 providing a "snap shot" view at five year intervals. In addition, the analysis also includes the current 238 active BWAs as of August 6, 2015, which is referred to throughout the report as "Active BWAs". Much of the information used in the analysis was provided by the Department of Environment and Conservation (ENVC) in spreadsheet format to facilitate data collection.

In addition to the above, the following sources were also used in the analysis:

- *Operation and Maintenance of Drinking Water Infrastructure in Newfoundland and Labrador* – Conestoga-Rovers & Associates – September 2010,
- Drinking Water Safety in Newfoundland and Labrador Annual Reports – Water Resources Management Division , ENVC 2002-2014,
- Public Water Supply List – ENVC June 2015,
- Boil Water Advisories for the Province – ENVC Website – August 2015,
- Boil Water Advisories Fact Sheet – ENVC Website – October 2014, and
- Operator Certification Information Spreadsheet – ENVC – August 2015.

2.1 Reason Codes for BWAs in Newfoundland and Labrador

BWAs are issued for a drinking water system when coliform bacteria are found in the drinking water or the disinfection system is not meeting the provincial disinfection standards. In Newfoundland and Labrador (NL) there are currently 21 standard reasons for a BWA to be issued as described in *Table 2.1*. Reason codes A and B refer to the water supply lacking an effective chlorination/disinfection system. Reason codes C, D, E, and G refer to mechanical and operational issues within the drinking water system. Reason codes F and H are related to the detection of indicator parameters, total coliforms, and *E. coli*, in the drinking water system and an outbreak of a waterborne disease, respectively.

Table 2.1: **Standard Reason Codes for Issuing a Boil Water Advisory**

No.	**Standard Reasons**	**Code**
1	Water supply has no disinfection system	A
2	Chlorination system is turned off by the operator, due to taste or other aesthetic considerations	B1
3	Chlorination system is turned off by operator, due to perceived health risks	B2
4	Chlorination system is turned off by operator, due to lack of funds to operate	B3
5	Disinfection system is off due to maintenance or mechanical failure	C1
6	Disinfection system is off due to lack of chlorine or other disinfectant	C2
7	Water distribution system is undergoing maintenance or repairs	D1
8	A cross-connection is discovered in the distribution system	D2
9	Inadequately treated water was introduced into the system due to fire flows, flushing operations, interconnections, minor power outage or other pressure loss	D3
10	Water entering the distribution system or facility, after a minimum 20 minute contact time does not have a free chlorine residual of at least 0.3mg/L or equivalent CT value	E1
11	No free chlorine residual detected in the water distribution system	E2
12	Insufficient residual disinfectant in water system disinfected by means other than chlorination	E3
13	Total coliform detected AND repeat samples cannot be taken as required	F2T
14	*Escherichia coli* (*E. coli*) detected AND repeat samples cannot be taken as required	F2E
15	Total coliforms detected and confirmed in repeat sample	F3
16	*Escherichia coli* (*E. coli*) detected in an initial sample(s) is considered extensive and the water system has other known problems	F4
17	*Escherichia coli* (*E. coli*) detected and confirmed in repeat sample	F5
18	Viruses detected (e.g., Hepatitis A, Norwalk)	F6
19	Protozoa detected (e.g., Giardia, Cryptosporidium)	F7

20	Water supply system integrity compromised due to disaster (e.g., contamination of water source from flooding, gross contamination, major power failure, etc.)	G
21	Waterborne disease outbreak in the community	H

2.2 Data Analysis

Data analysis was completed on BWAs with consideration given to geographic region, date of issuance, duration, reason code, operator certification, water source, treatment systems, community size and governance. The analysis will be used to identify trends in the data which will provide an overall picture of issuance of BWAs in the province.

2.2.1 Geographic.

The geographic analysis was completed using 5 separate regions that were used by Service NL as listed in Table 2.2. The boundaries for each region are depicted in *Figure 2.1*.

***Table 2.2*: Service NL Region Codes**

Service NL Regions	Code
St. John's	SJ
Eastern (Clarenville)	E
Central (Gander)	C
Western	W
Labrador	L

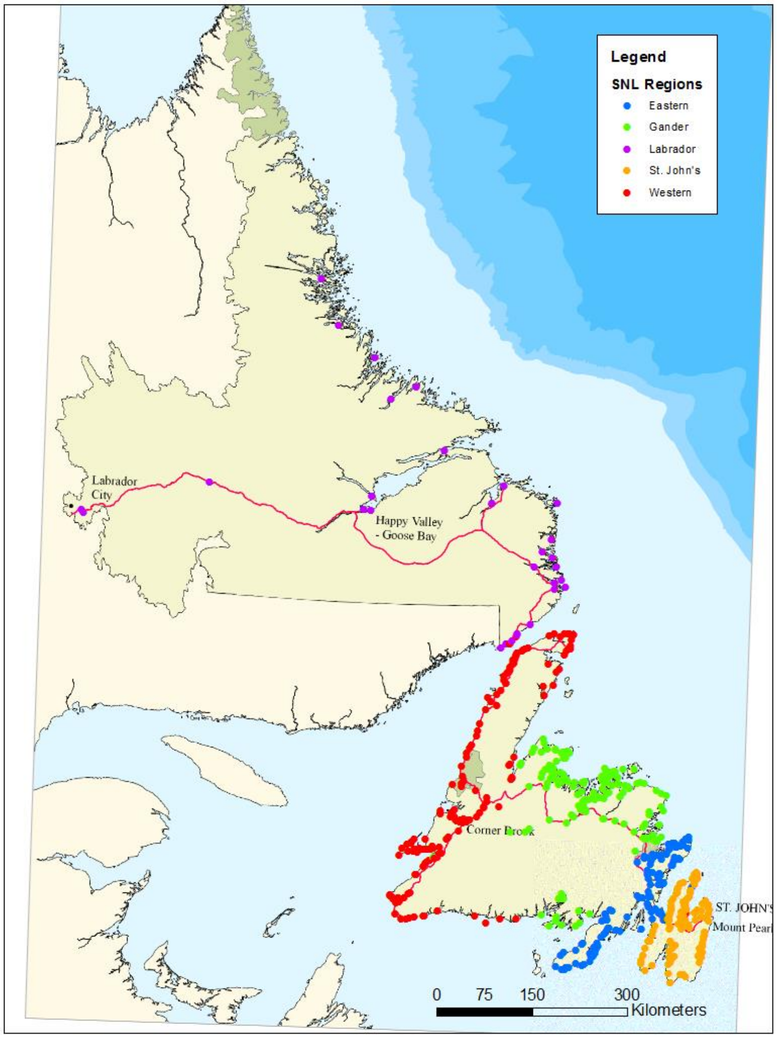

***Figure 2.1*: Service NL Regions**

Based on the 2011 Census the most populated region is St John's which has 50% of the total population (*Figure 2.2*). Western and Central regions each have just below 20% of the population, Eastern 9%, and Labrador 5%. These numbers are important when assessing the potential impact on BWAs in each of these regions.

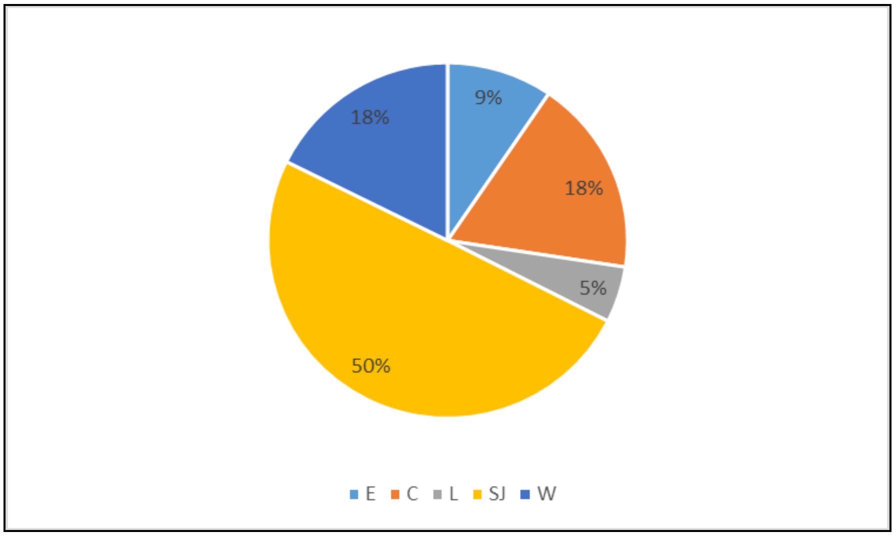

***Figure 2.2*: Percentage of Population per Region**

Figure 2.3 shows the total number of BWAs issued by region for the 10yr Record, while *Figure 2.4* shows the Active BWAs issued by region. The Western region had the largest number of BWAs at approximately 43% for 10yr Record and 31% for active BWAs. However, when considering the population and number of public water supplies in each region, the numbers of BWAs in the Eastern and Western regions were comparable. Both regions also have similar size communities and LSDs, which are higher than in the other three regions. The percent of Active BWAs in Central and St John's regions are slightly higher than the 10yr Record.

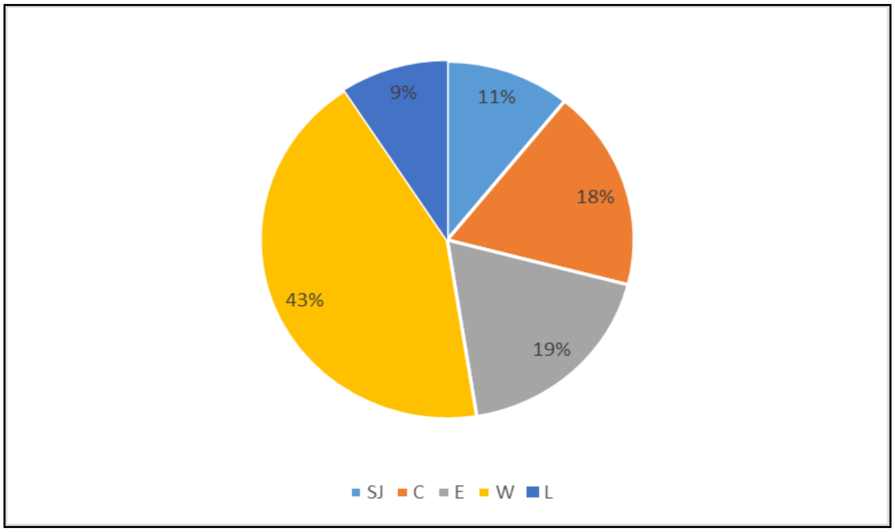

Figure 2.3: **Percentage of BWAs Issued By Region (2005-2014)**

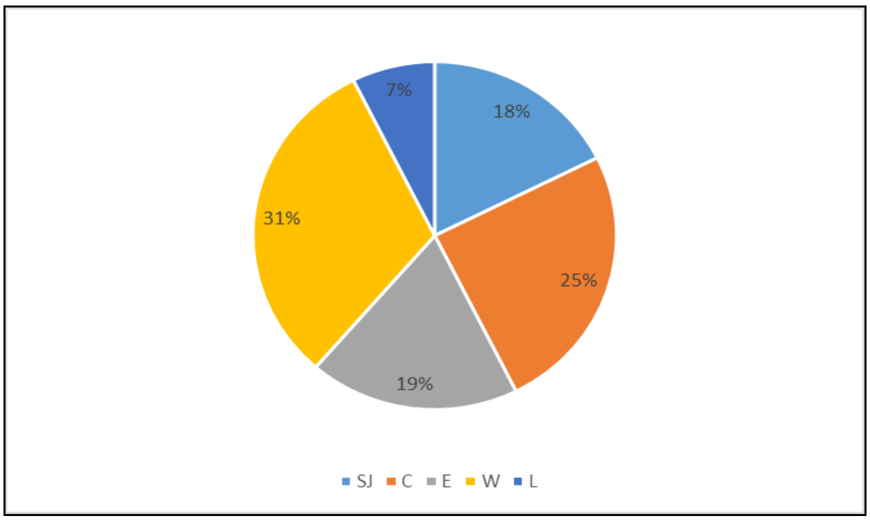

Figure 2.4: **Percentage of Active BWAs Issued By Region (August 6, 2015)**

2.2.2 Date of issuance.

Figure 2.5 below shows the total number of BWAs issued per fiscal year (Total Annual BWAs) and the number of BWAs still active at the end of each fiscal year (BWAs at Year End) for the 10yr Record. Even though the total annual BWAs has fluctuated from 350 to 550, the number of

BWAs at Year End has been generally around 210 to 230 and relatively constant over the 10 year period.

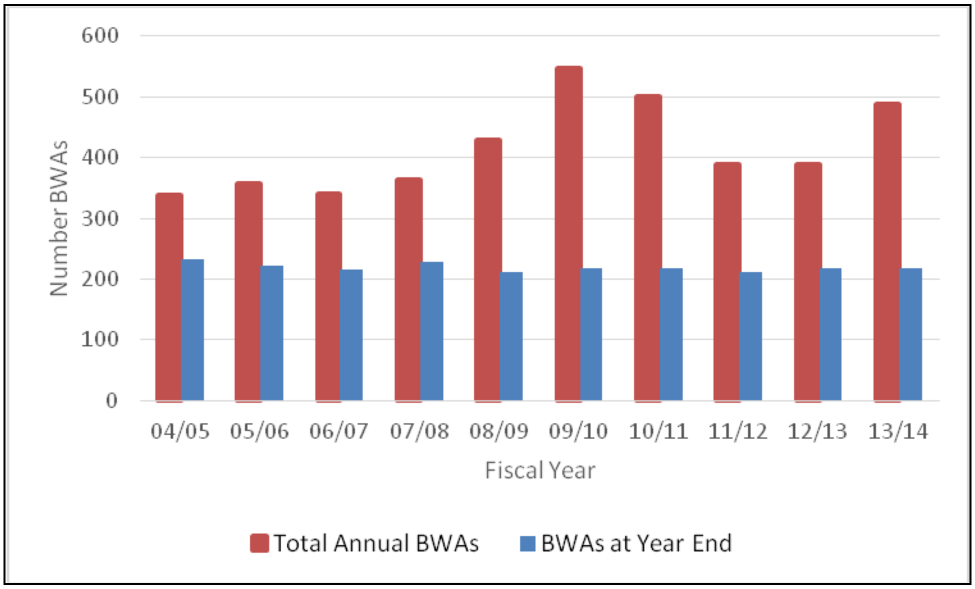

***Figure 2.5*: Annual Statistic for BWAs**

Average number of BWAs issued per month for the 10 Year Record are plotted in *Figure 2.6* and show a trend of increased issuance of BWAs from May through September and then a gradual reduction in the fall. The increase is between 20-30 BWAs per month. This may be due to a combination of increased construction and maintenance activity on the drinking water systems, changes in flows, water chemistry, and environmental conditions such as snowmelt and warmer temperatures. The possibility of volunteer or part-time operators participating in seasonal work elsewhere could also contribute to this trend.

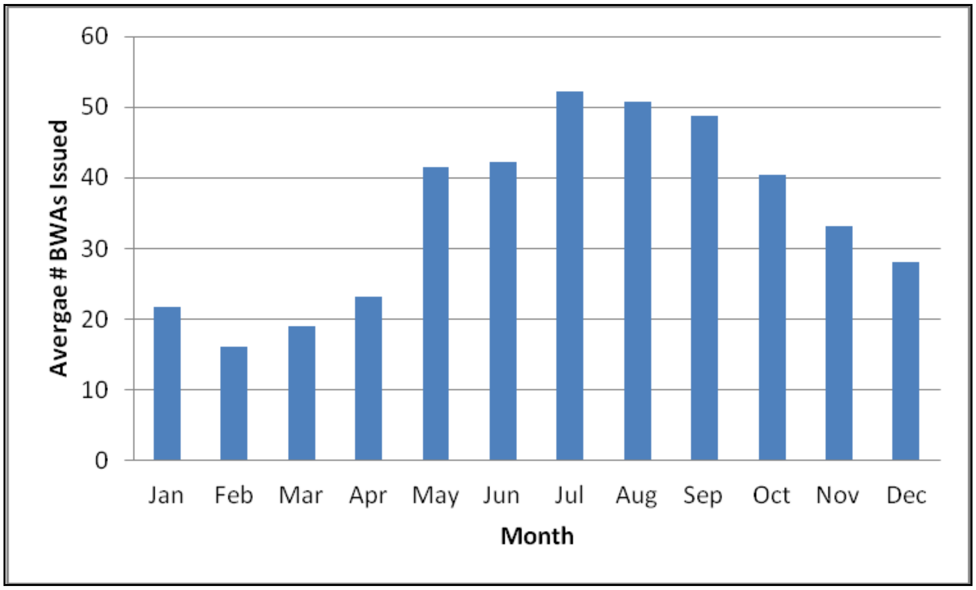

***Figure 2.6*: Average Number of BWAs Issued by Month – 10 Year Record**

This increase trend in summer time BWAs is even more evident in *Figure 2.7* and *Figure 2.8* which plots only codes E and F BWAs. Of the 20-30 BWAs increase during the summer months, approximately 5 are due to code E and 10-15 are due to code F.

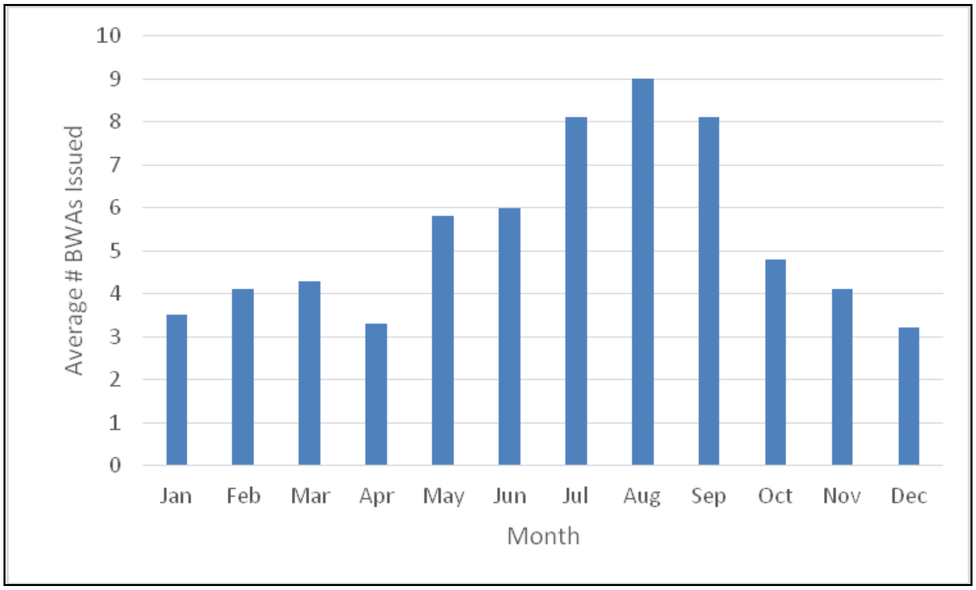

***Figure 2.7*: Average Number of Code E BWAs Issued by Month – 10 Year Record**

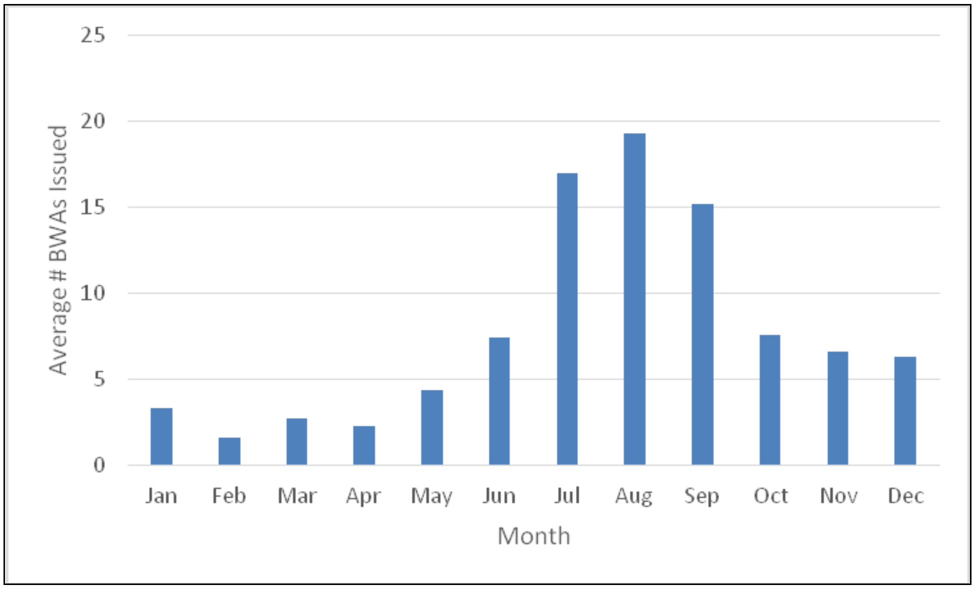

Figure 2.8**: Average Number of Code F BWAs Issued per Month – 10 Year Record**

2.2.3 Duration of BWA.

The duration of a BWA is of particular significance to system users and may negatively affect the public's confidence in their water supply. An analysis was completed on the average duration a BWA was in place prior to being lifted. This was completed by using the fiscal year the BWA was issued and duration of the BWA before it was lifted to calculate the average duration for the fiscal year of issuance. For example, for fiscal year 2004/05, all BWAs issued in that year and lifted prior to August 6, 2015 would have been included in the analysis to determine the duration for that fiscal year. The results presented in *Figure 2.9* shows that the average duration of BWAs for 9 of the 10 years ranged between 100 and 200 days. For the last two years the average duration has dropped down to just over 100 days.

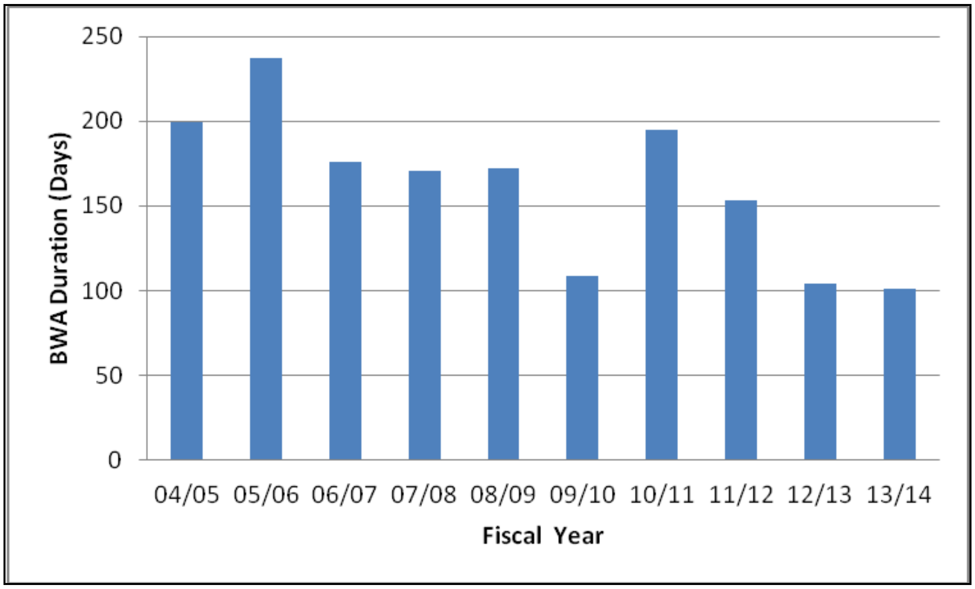

***Figure 2.9*: Average Length of Lifted BWAs for Year of Issuance**

In *Figure 2.10* the duration of Active BWAs was grouped into 4 categories; more than 5 years, 1-5 years, 1-12 months and less than 1 month. The most common duration of Active BWAs is more than 5 years (~50% of all BWAs) and over 75% of the Active BWAs have been in place for over a year.

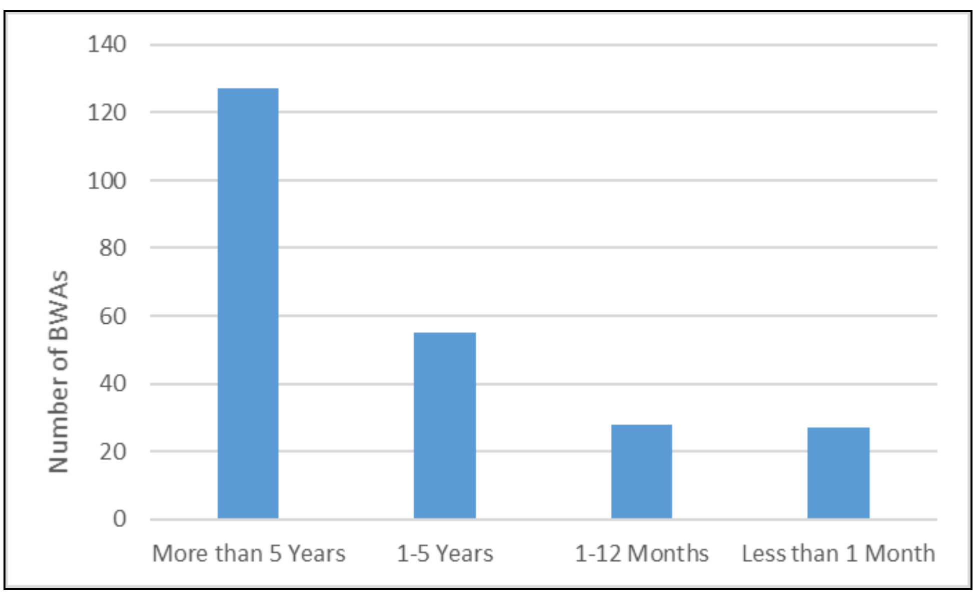

***Figure 2.10*: Duration of Active BWAs**

Figure 2.11 shows the average duration for each of the reason codes from 2005-2014. The reason code B3 had the highest average duration of 1685 days followed by code A (1265 days) and code E3 (1074 days), which is for one public water supply.

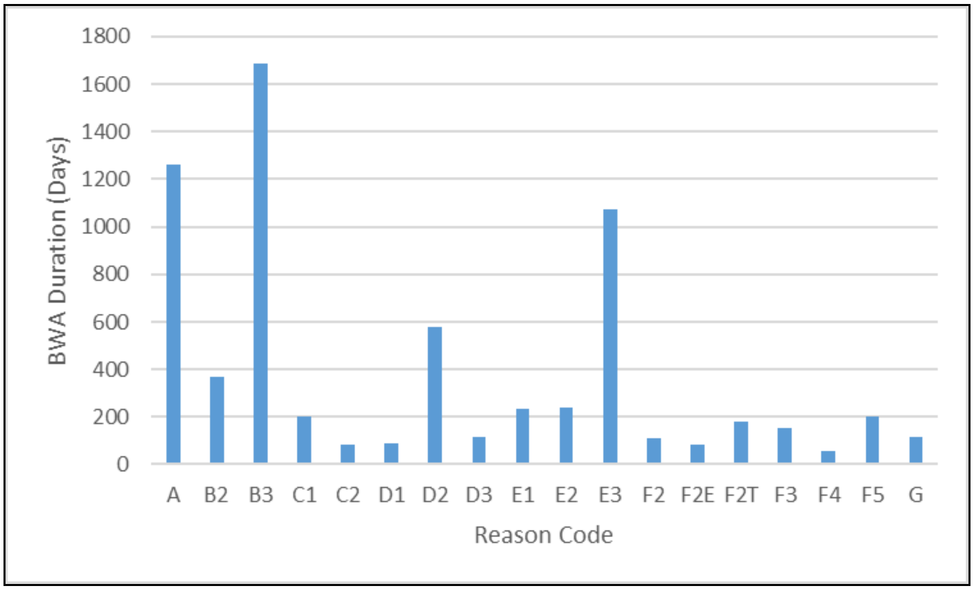

***Figure 2.11*: Average Duration of Each BWA Reason Code (2005-2014)**

Figure 2.12 provides an average duration for each reason code class and shows that the duration for codes A and B are much higher than all other codes. Code D is the most commonly issued BWA but is on average lifted within 95 days, as would be expected for a system undergoing maintenance. For the next three most frequently issued BWAs (codes C, E, and F), code F has the shortest average duration (130 days). This may be due to the perception that a code F is much more serious of an issue than a BWA issued due to lack of disinfectant residuals or the disinfection system not working.

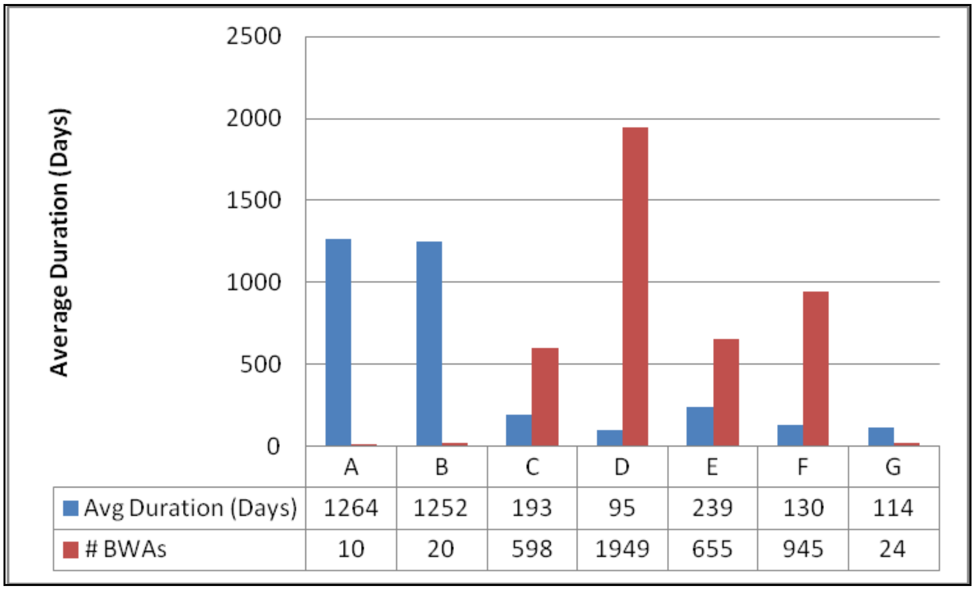

***Figure 2.12*: Average Duration of Each BWA Reason Code Class (2005-2014)**

Figure 2.13 below provides an overview of the active BWAs as of August 6, 2015 that has been issued pre-2014 and those issued in 2014/15 by reason code class. Approximately 50% of code D was issued pre-2014, and 100% and 95% of code A and B, respectively have been issued pre-2014. Approximately 96% of the codes F BWAs were issued since 2014. This suggests that of all the Active BWAs there are very few long term code F BWAs as compared to other code classes.

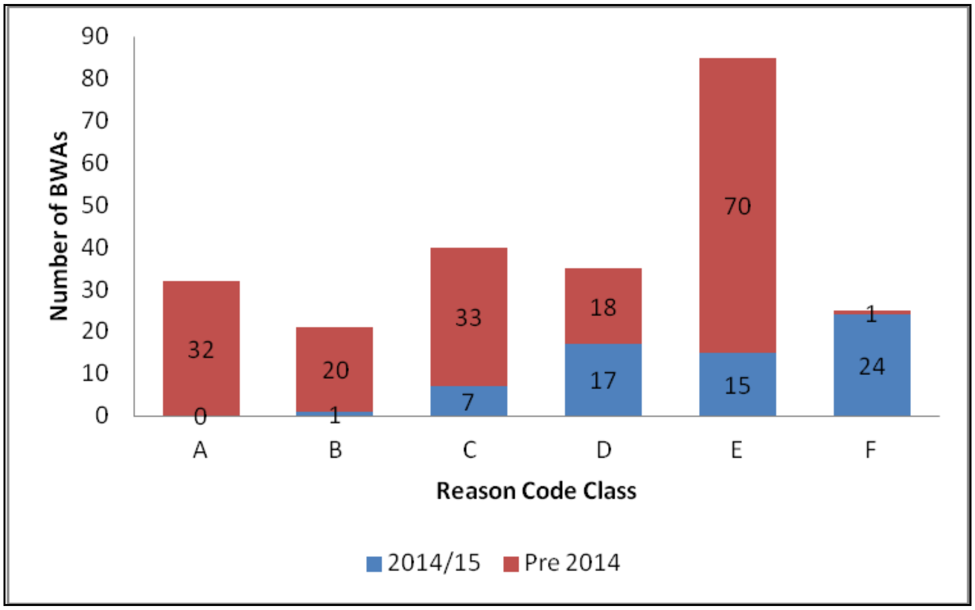

***Figure 2.13*: Active BWAs Issued pre 2014 by Reason Code Class**

2.2.4 Reason code for issuance.

Figure 2.14 shows the total BWAs issued for each reason code over the 10yr Record. Codes C, D, and E are related to operation and maintenance issues and represent the most frequent BWAs. Replacing broken or old components of a drinking water system is an important part of maintaining a system. It would be expected that most BWAs should be due to codes C1 and D1, which are related to maintenance/repairs in progress for disinfection and distribution systems, respectively. Planned maintenance for distribution systems would generally occur during the construction season from May to November. While planned maintenance on the disinfection system may be completed year round or during low demand periods (e.g., after fish plant is closed).

After codes C1 and D1 the next four most frequent reasons codes are:

- F3 – Total Coliforms detected and confirmed in repeat sample,
- D3 – Inadequately treated water entered system,
- E1 – Inadequate chlorine residual after 20 minute contact time, and

- E2 – No free chlorine residual detected

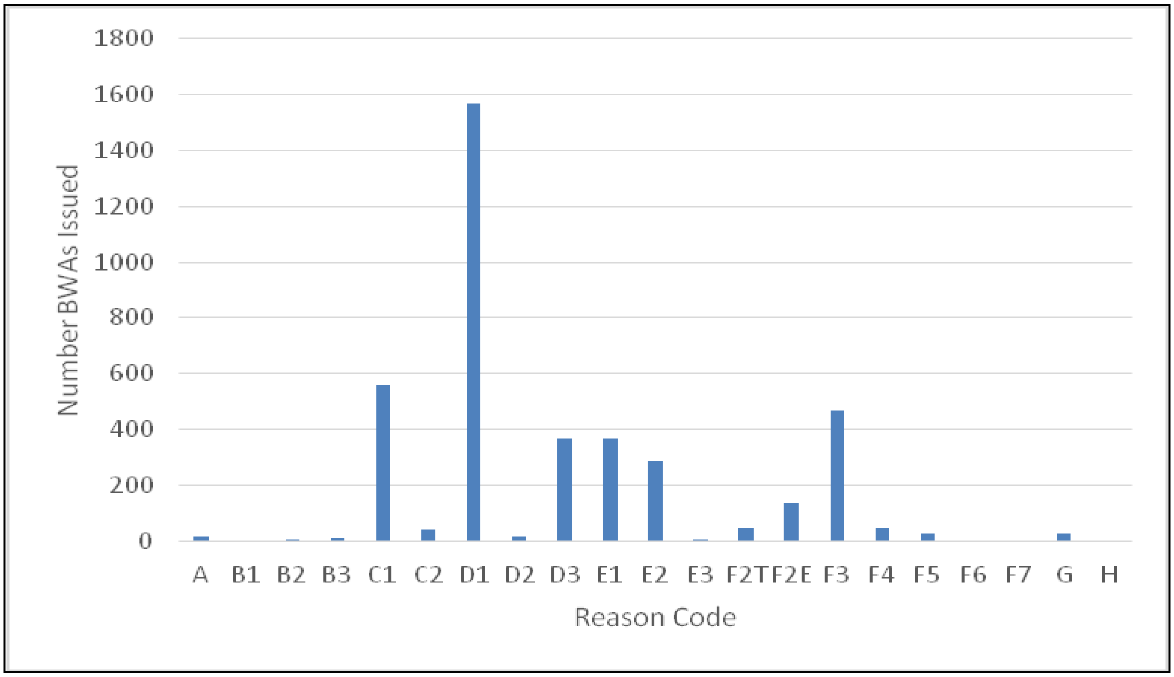

***Figure 2.14*: Number of BWAs Issued per Reason Code (2005-2014)**

Figure 2.15 shows the percentage of Active BWAs that have been issued for each reason code. The most common reason code is code E (36 %) which indicates a chlorine residual problem. Approximately 9% of the BWAs are due to the chlorination system being turned off by operator (code B), and codes A, C, D, and F range from 10 to 17%, while G and H are 0%.

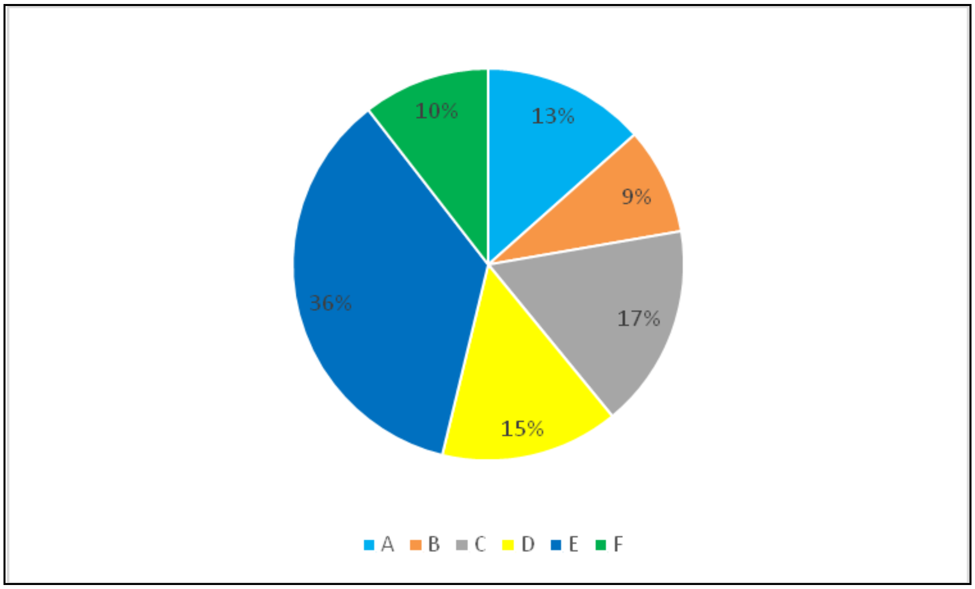

***Figure 2.15*: Percentage of Active BWAs per Reason Code**

Figure 2.16 shows the number of BWAs issued for reason code classes A, B, C, D, and E issued in the years 2004, 2009, and 2014. In all years reason code D1 was the most common and jumped significantly in 2009 and 2014. This may be attributed to a number of factors such as increased maintenance (both planned and emergency) on drinking water systems, improved education on when to issue a BWA, aging infrastructure or increased maintenance funding. *Figure 2.17* shows the number of BWAs issued for reason codes F in 2004, 2009, and 2014 (note: no codes F6, F7, G or H in these years). The most common reason code in all years was F3, with the number issued in 2009 almost twice that issued in 2004 and 2014. In 2014, 33 F2E codes (*E.coli*) were recorded, while none were recorded in 2009 or 2004 because this code did not come into effect until 2010.

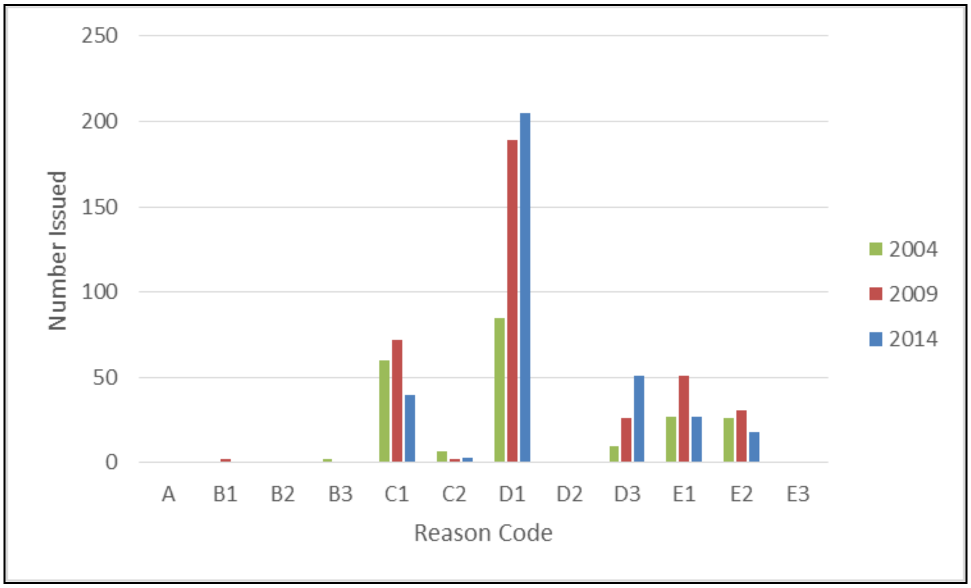

***Figure 2.16*: Number of BWAs for Reason Codes A to E (2004, 2009, and 2014)**

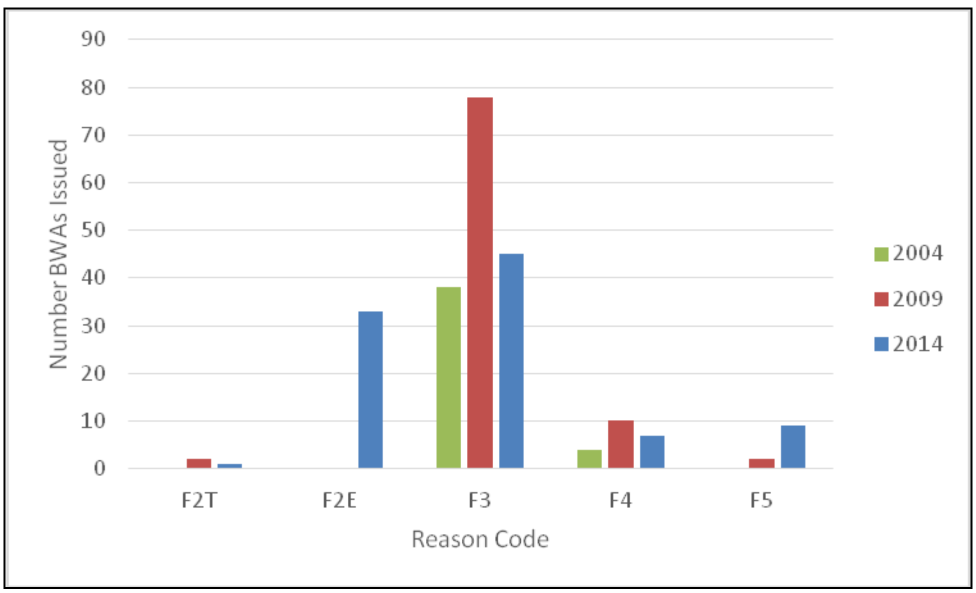

***Figure 2.17*: Number of BWAs for Reason Codes F to H (2004, 2009, and 2014)**

2.2.5 Community size.

Table 2.3 below shows the distribution of public drinking water systems based on community population using 2011 Census data. Of the 521 public drinking water systems, 358 are for communities with populations less than 500 (very small). Some communities may have more than one public drinking water system serving the community.

***Table 2.3*: Water Distribution Systems in NL Based on Population Groupings**

Water Distribution System	Population	Number in NL
Very Large	>50,000	1
Large	15,001-50,000	2
Medium	1,501—15,000	41
Small	501-1,500	82
Very Small	≤500	358
Unknown	Variable	37

Not all communities will have the same resources to operate and maintain a drinking water system. Communities with higher populations may have higher tax revenue base to provide resources and to attract and retain certified operators. *Figure 2.18* shows that 53% of the 10Year Record BWAs have been issued for very small systems, while *Figure 2.19* shows that 86% of the Active BWAs are for the same population group. For small, medium and large communities the total cumulative BWAs issued represent 47% of the 10 Year Record and 14% of the Active BWAs. Only 5% of the 10Yr Record BWAs were for communities with serviced populations greater than 15,000 people and there are no Active BWAs. Based on these figures, the smaller communities are more likely to issue a BWA.

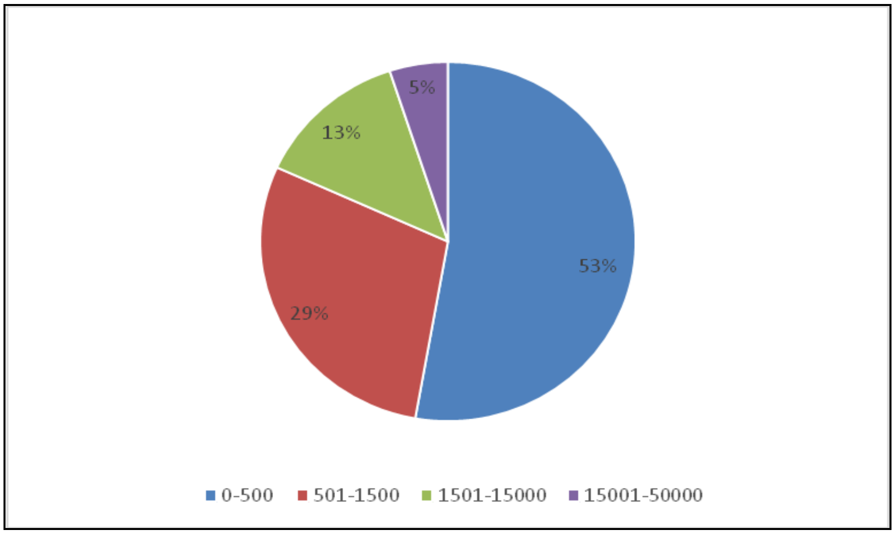

Figure 2.18**: Percentage of Communities that Issued BWAs According to Size – 10 Year Record**

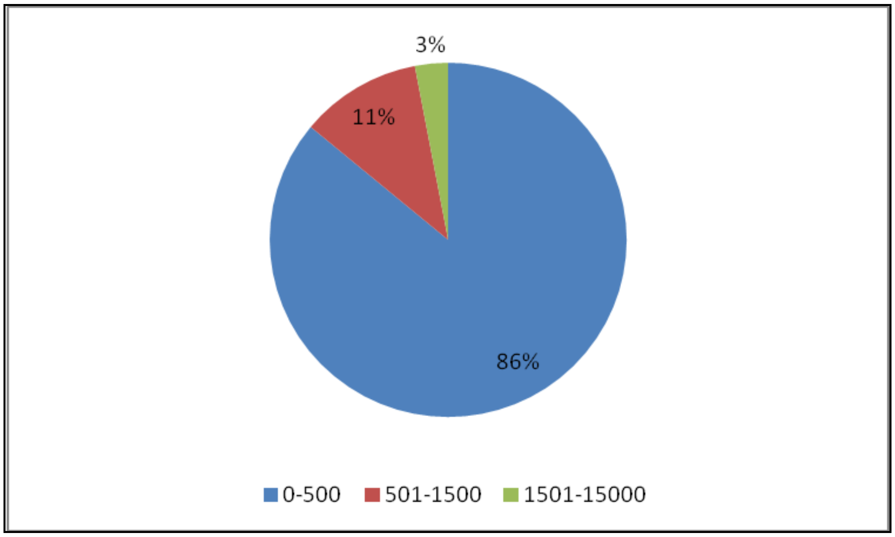

Figure 2.19**: Percentage of Communities with Active BWAs According to Size**

Table 2.4 shows the top five common BWA reason codes for the 10Yr Record for the four smallest community sizes which represent 95% of the 10Yr Record and 100% of the Active BWAs. Observations from the table include:

- Code D1 (distribution system undergoing maintenance) is the top reason code for all population groups,
- Code D1 is much lower in very small communities which may indicate lack of maintenance being undertaken on the system,
- Code C1 and D1 (disinfection and distribution system undergoing maintenance) represent 93% of BWAs for large communities, and
- Very small communities issued more BWAs with reason codes pertaining to microbial contamination (code F) than communities with larger populations.

***Table 2.4*: Top 5 Most Common Reason Codes for BWAs (2005-2014)**

Population Served	**0-500**	**501-1500**	**1501-15,000**	**15,000+**
Most Common Code	D1 (22%)	D1 (42%)	D1 (47%)	D1 (84%)
	F3 (16%)	C1 (14%)	E1 (11%)	C1 (9%)
	C1 (15%)	D3 (10%)	D3 (11%)	D3 (3%)
	F2 (13%)	F3 (10%)	C1 (9%)	F3 (2%)
Least Common Code	E1 (11%)	F2 (9%)	E2 (7%)	E2 (1%)
Total Number of BWAs	1801	1347	765	294

2.2.6 Community governance.

For the purpose of this section communities are classified as either a Municipality (MUN) or Local Service District (LSD). Of the 367 communities listed with public drinking water systems, 115 (31%) are LSD while the remaining 252 (69%) are MUN. *Figure 2.20* shows that 85% of all BWAs for the 10Yr Record occurred in MUNs. The fluctuations in BWAs per year for MUN and LSD are shown in *Figure 2.21*. *Figure 2.22* shows that 51% of Active BWAs exist for MUN. These figures indicate that even though MUN are issuing more BWAs annually they are generally removing many of the BWAs. This may be indicating that the MUN are completing more maintenance on their drinking water systems.

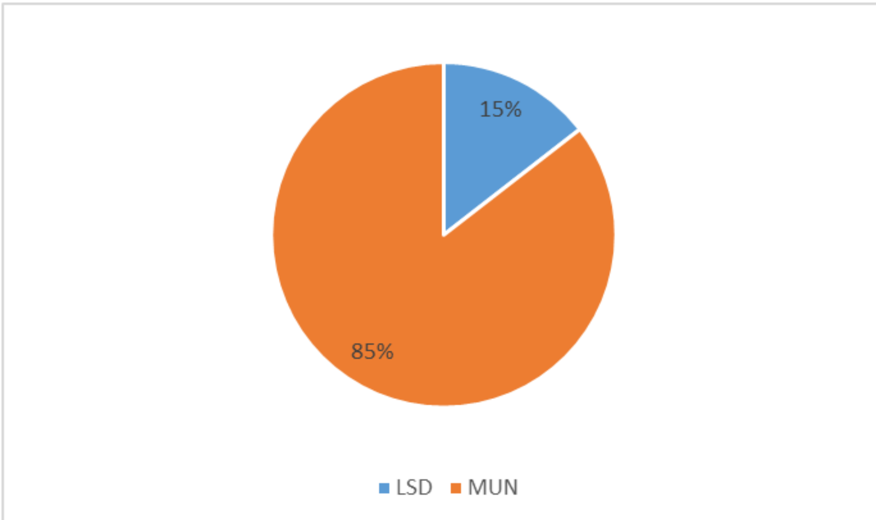

***Figure 2.20*: Governance of Communities that Issued BWAs (2005-2014)**

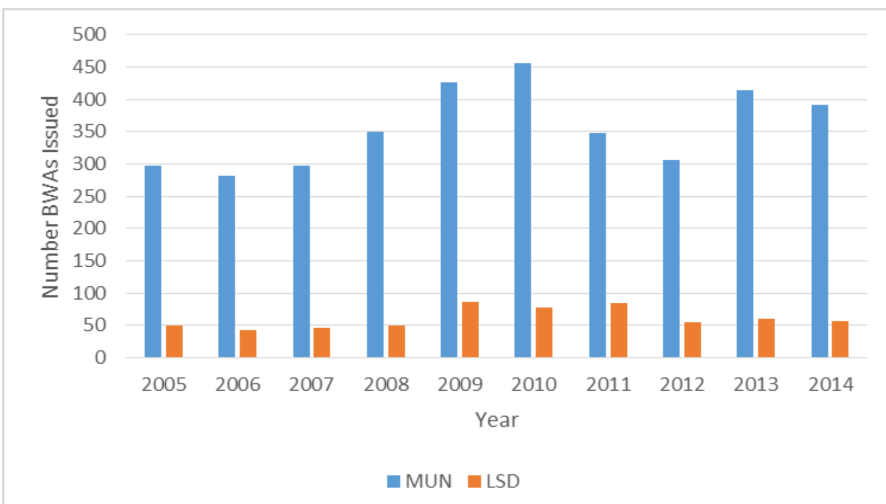

***Figure 2.21:* BWAs Issued per Year for MUN and LSD**

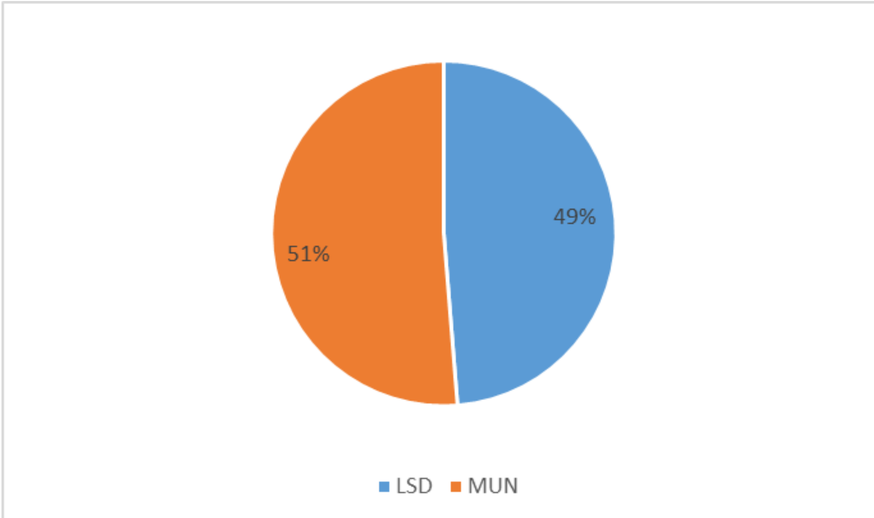

***Figure 2.22*: Governance of Communities with Active BWAs**

2.2.7 Operator certification.

In 2002 the Operator Education, Training, and Certification (OETC) program was developed by ENVC to provide operators with education and training to improve operation and maintenance of a drinking water system. The most recent operator certification data provided by ENVC was used to create *Table 2.5*. Information provided in *Table 2.5* shows that only 17% of the communities with populations of 0-500 had certified operators for water treatment or distribution (per 2011 Census Population). In communities of over 1500, the percentage of communities with certified operators increased to 93%. Since the majority of BWAs take place in communities that service 500 or less, there is a connection between a lack of certified operators and the issuance of BWAs. In total, 33% of the communities with public water supplies have certified operators with water treatment and/or distribution. *Figure 2.23* shows that only 12% of Active BWAs are for public drinking water systems with certified operators.

***Table 2.5*: Certified Operators (as of August 2015)**

Population Serviced	Number of Communities with Certified Operators	Number of Communities in Population Grouping	Percent with Certified Operators
0-500	35	208	17%
501-1500	37	83	45%
1501+	39	42	93%

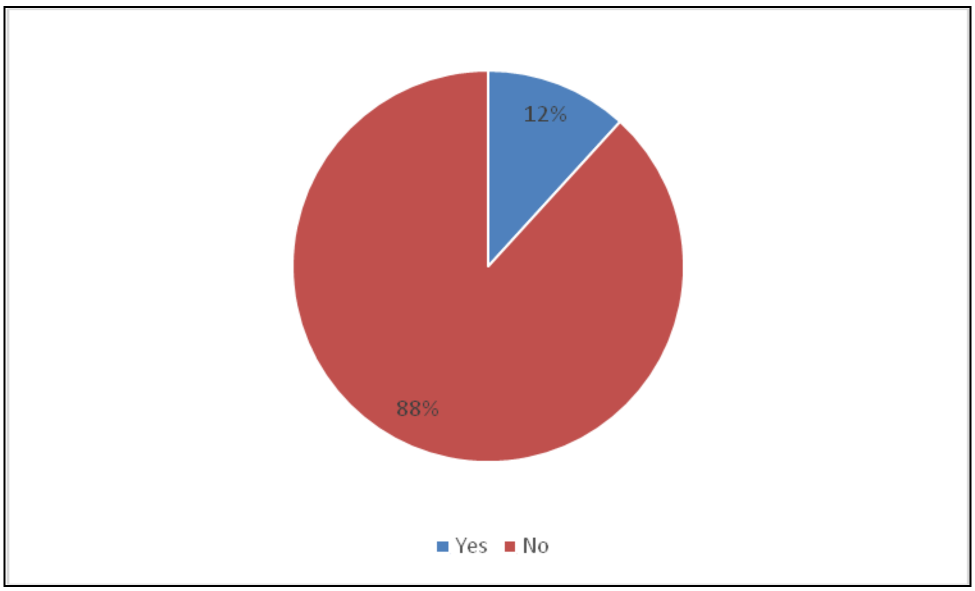

***Figure 2.23:* Percentage of Active BWAs for Communities with Certified Operators**

Of the 510 certified operators with either water distribution or water treatment certifications identified in the list provided by ENVC, 179 (35%) no longer work as operators. Of the 111 communities with certified operators only 5 were LSDs. In addition, on-site training information provided by ENVC indicated that the 16% of the training was for LSD while the remaining 84% were for MUN. Generally, operator certification and training is occurring more frequently in

MUN than in LSDs because many LSDs do not have operators. In addition, operator certification is more prominent in larger communities than in very small communities and public water systems that have a certified operator are generally on fewer BWAs.

2.2.8 Water source.

Drinking water sources can be broadly categorized as surface water, groundwater, or GUDI (groundwater under direct influence). Surface water sources are extracted from a surface water body such as lakes, ponds, rivers, brooks, canals, or reservoirs. In this analysis groundwater refers to water that is obtained from wells drilled into subsurface aquifers. GUDI is groundwater under direct influence from surface water such as in the case of a dug well. *Table 2.6* summarizes the drinking water source numbers taken from the public water supply listing provided by ENVC and the number of BWAs for the 10Yr Record associated with that type of source. Approximately 62% of all source types are surface water while the remaining is mostly groundwater. *Figure 2.24* show that the most common water source of BWAs for 10Yr Record was on systems using surface water (87%). Similarly, in *Figure 2.25*, the most common water source for Active BWAs is also surface water (75%). Given that surface water sources account for approximately 62% of all public water sources, it would be expected that more BWAs would be issued for systems using surface water. In addition, the water quality for surface water is also subject to higher seasonal variability from natural environmental factors (high precipitation, snowmelt, and wind), more microbial contamination and/or prone to impacts from human activities than would groundwater sources.

Table 2.6: **Drinking Water Sources in NL**

Water Source	Number in NL	Number of BWAs (2005-2014)
SW	294 (62%)	3672
GW	177(37%)	555
GUDI	3(1%)	11

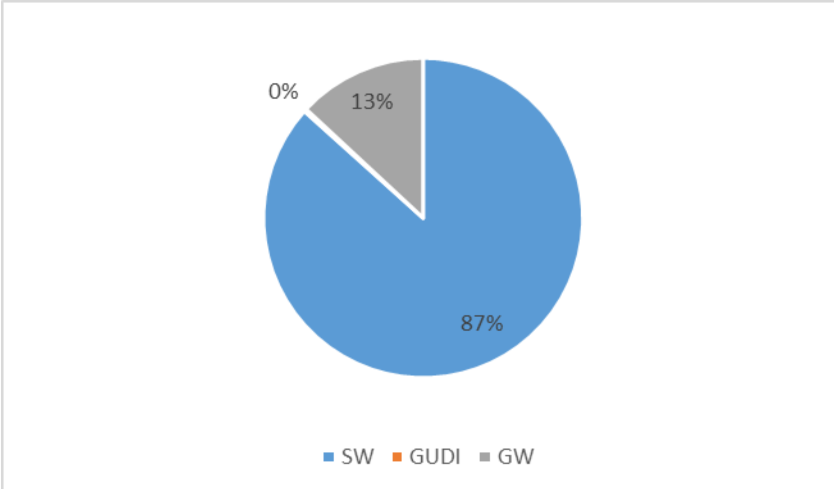

Figure 2.24: **Source Water Types for BWAs (2005-2014)**

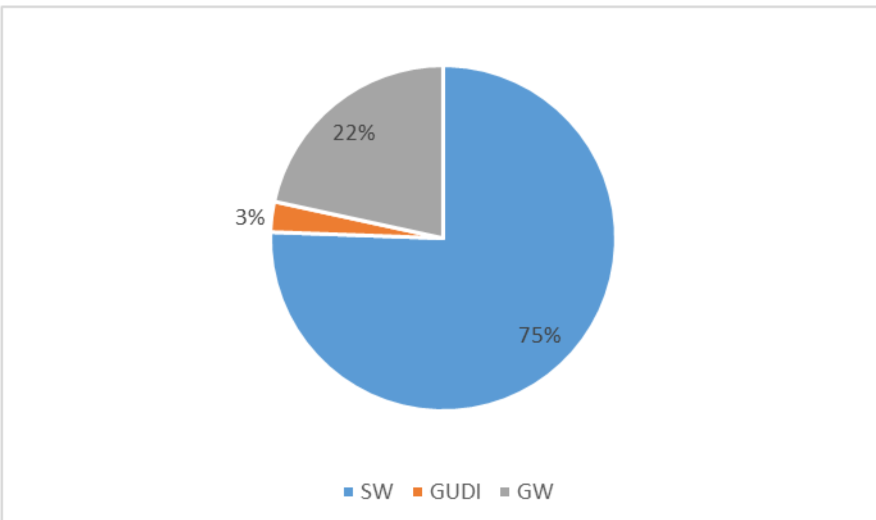

Figure 2.25: **Source Water Types for Current BWAs (as of Aug. 6, 2015)**

Source water protection helps protect public health and reduces the cost involved in treating public drinking water by reducing the potential sources for contamination. According to ENVC's Drinking Water Safety in NL Annual Report 2014, approximately 85% of all surface water and 34% of all groundwater sources are protected under Section 39 of the *Water Resources Act*. Combined, approximately 65% of all public water supplies are protected under the *Water Resources Act*. *Figure 2.26* shows that 60% of BWAs from the 10Yr Record were on systems with protected water supplies, while *Figure 2.27* shows that 85% of active BWAs are on systems with protected water supplies. This seems to contradict the benefits of protecting the water supply, however, as was discussed previously most BWAs are issued due to communities not meeting the disinfection standards, not necessarily poor quality source water.

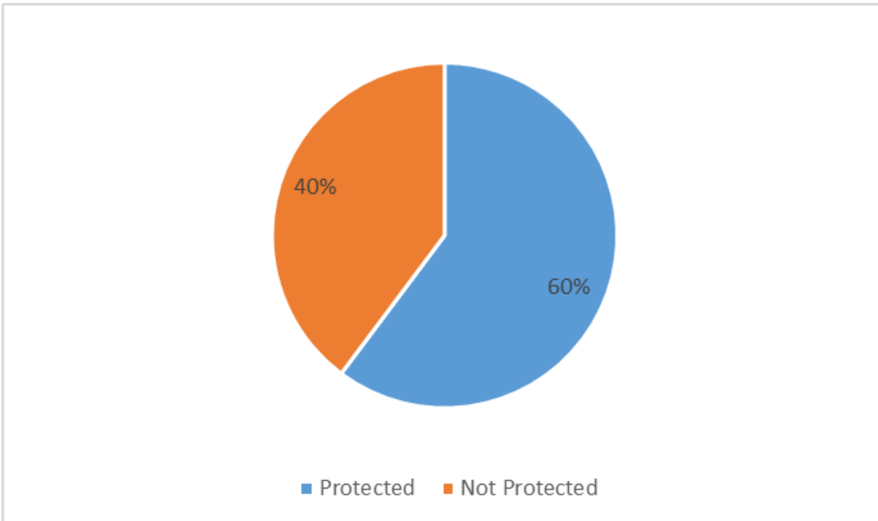

***Figure 2.26*: Protected and Non-protected Water Supplies for 10 Year Record BWAs**

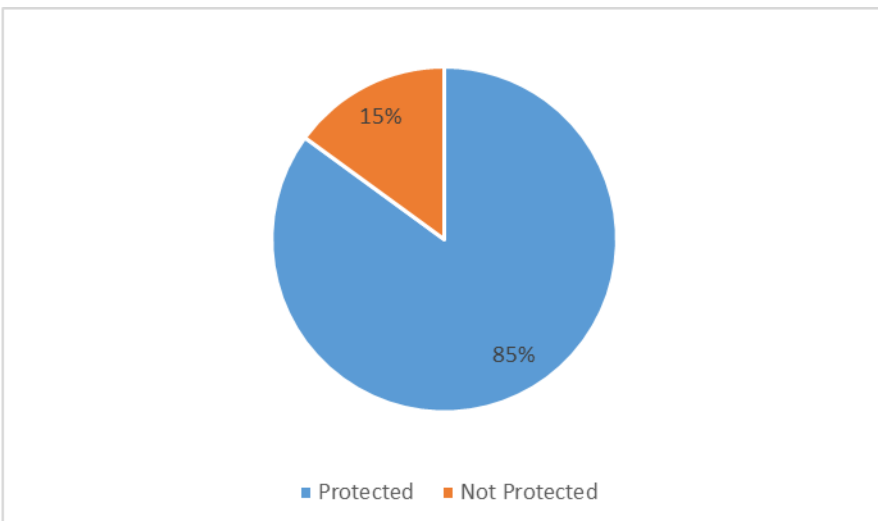

***Figure 2.27*: Protected and Non-protected Water Supplies for Active BWAs**

2.2.9 Type of treatment.

Many small communities use disinfection as the only form of water treatment, while some others may use additional treatment methods. The most widely used method of disinfection in the province is chlorine (via sodium hypochlorite, calcium hypochlorite or chlorine gas), mixed oxidants, chloramine, ozone, and ultraviolet (UV) disinfection. *Table 2.7* was reproduced from ENVC's Drinking Water Safety in NL: Annual Report 2014 and indicates that 90% of the communities with disinfection systems are using chlorination. The majority of the systems (67%) are using sodium hypochlorite, while 31% are using chlorine gas.

***Table 2.7*: Number of Disinfection Systems in NL (2013-14)**

Disinfection Systems	**Number in NL**
Chlorination	441
Ultraviolet Light (UV)	33
Mixed Oxidants (e.g., MIOX)	8
Ozone	4
Chloramines	2

A number of water systems in NL are known to have parameters outside the recommended *Guidelines for Canadian Drinking Water Quality*. For some of these water systems, communities have installed parameter specific water treatment systems. *Table 2.8* provides a summary of the more common parameter specific treatment systems used in the province, with pH adjustment being the most common.

***Table 2.8*: Number of Parameter Specific Water Treatment Systems in NL (2013-14)**

Drinking Water Treatment Systems	Number in NL
pH Adjustment	54
Micron/pressure Filters	34
Infiltration Galleries	24
Arsenic Removal	9
Iron/Manganese Removal	6
Lead Removal	1
Strontium Removal	1

Figure 2.28 shows that for Active BWAs, 59% and 3% are using sodium hypochlorite and calcium hypochlorite systems.

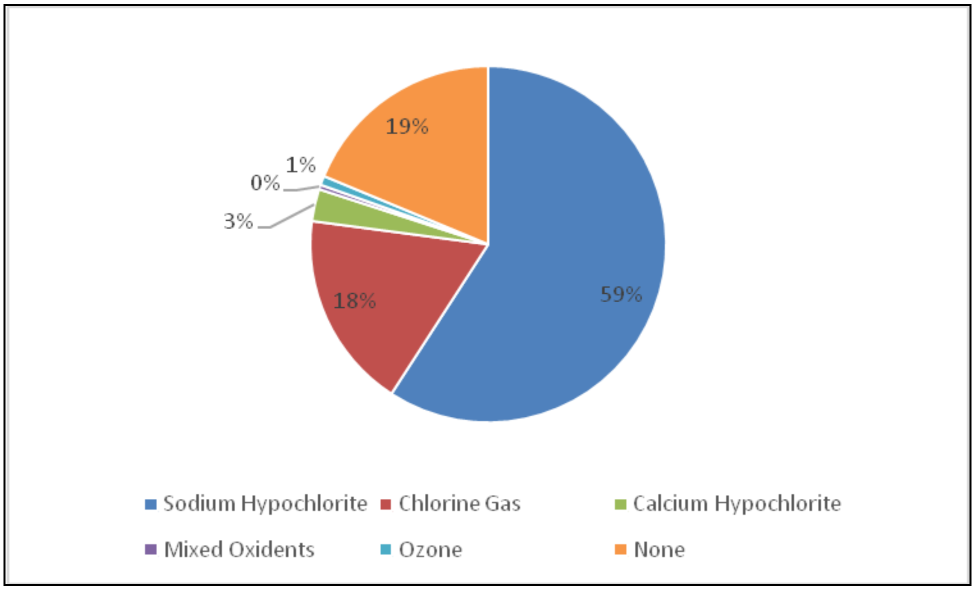

***Figure 2.28*: Disinfection Methods for Active BWAs**

2.3 Summary

The following observations on the data analysis have been made:

- Over 75% of 238 active BWAs have been in place for over a year and approximately 50% for more than 5 years.
- The average duration of code F BWAs (130 days) is generally shorter than many other codes such as codes A, B, C, E. This may be due to perception that once pathogens are shown to be in the water system the issue is taken more seriously than some of the other codes. Only codes G (gross contamination) and code D (maintenance) were of a shorter average duration than Code F BWAs.
- The most commonly issued reason code for a BWA for all sizes of communities is D1 (water distribution system undergoing maintenance or repairs), however the smaller communities have much lower percentage of D1 codes which may indicate lower levels of maintenance being undertaken in these communities.
- Smaller communities are more likely to have a BWA issued for reason code F (microbiological), communities with populations 500 or less and 501-1500 had 29% and 19% respectively, while only 2% of BWAs for populations >15,000 were due to code F;
- Communities with populations 500 or less account for 86% of the Active BWAs.
- The number of BWAs issued changes significantly from year to year, however the year end number of BWAs has not changed significantly over the past 10 years; steadily ranging from 210-230.
- Chlorination is the most widely used means for disinfection of drinking water in the province and the most common disinfection method in Active BWA. Inadequate disinfectant residual levels account for 36% of all Active BWAs.
- The number of BWAs issued per month increases in the spring and summer, mostly due to codes E and code F.
- Operator certification and training is occurring more frequently in MUN than in LSDs, operator certification is more prominent in larger communities than in very small communities and when a certified operator is operating a public water system they are more likely to be not on a BWA (only 12% of the Active BWAs have certified

operators).

3.0 COMMON CAUSES FOR BOIL WATER ADVISORIES

A public drinking water system is owned and operated by an incorporated city/town, or an unincorporated entity such as LSD. The system is generally composed of a water source, treatment system (e.g., filtration), disinfection system and distribution system in order to bring water from source to tap. It should be noted that in NL many communities have only disinfection using chlorination as treatment of their raw water.

A public drinking water system is designed to meet a community's demand for drinking water. In addition to this, it is also used to supply industrial and commercial users, and possibly fire flows, in accordance with the Guidelines for the Design, Construction and Operation of Water and Sewerage Systems (ENVC 2005) (NL Design Guidelines). In NL, communities are required to apply for approval under Section 37 of the *Water Resources Act* (WRA) in order to construct or install municipal drinking water infrastructure. A Permit to Construct must first be issued before the infrastructure may be installed. Once construction and required testing is completed, the drinking water system is ready to deliver water to the consumers. However, the infrastructure alone cannot provide safe drinking water. The owner of public drinking water system(s) must operate and maintain the system. To cover these requirements, a Permit to Operate may be issued under Section 38 of the WRA for operation and maintenance of the system.

Section 3 is prepared in accordance with Task #2 (Section 4.2) of the TOR. This section provides an overview of potential issues associated with the various components of a drinking water system, common causes for BWAs in NL (as identified from comments provided by Service NL), common causes for reason code F and H BWAs as per a US EPA report titled "Revised Total Coliform Rule Assessments and Corrective Action Guidance Manual (2014)", and introduces a BWA assessment form for use by owners and operators.

3.1 Potential Causes of BWAs in Public Drinking Water Systems

The causes of BWAs in NL can typically be assigned to one or more of the following areas: problem with disinfection, distribution, operation/maintenance, source water, negative environmental factors and/or monitoring/testing. For some of the BWA reason codes, such as code A, B, C, and D, the cause for the BWA is generally self-explanatory. However, for reason codes E, F, G, and H, the actual cause of the BWA may not be obvious. For example, the cause of a code E1 (free chlorine residual of 0.3mg/L after a minimum 20 minute contact time or equivalent CT value) may be due to a number of factors, such as:

- Inadequate chlorine dosage
- Changes in water quality, and therefore chlorine demand
- Change in flows, which may affect the contact time at sampling locations

Operationally, as the flow and water chemistry changes, the operator of a drinking water system must be monitoring and adjusting the disinfectant dosages as necessary. In addition, the required CT value may change with water temperature. Therefore a code E1 may be caused by factors involving the water source, disinfection, or operation/maintenance.

It is important that any cause(s) of a BWA be identified as this will help identify the corrective measures which may be implemented to have the BWA lifted. Below is a summary of the causes which may affect the performance of a drinking water system, eventually leading to a BWA.

3.1.1 Source.

Both surface water and groundwater are commonly used as source water for drinking water systems in NL, and each have their own challenges related to treatment and disinfection. Many surface water supplies provide water via gravity feed through to the water treatment and disinfection facilities. By using gravity feed, water pressure and flow to the treatment plant may vary with water levels in the surface supply, which may change after significant rainfall or snowmelt events. Surface water supplies are also susceptible to receiving contamination from overland surface runoff, which may result in increased sediment and organic loadings, as well as contamination from human activity in the watershed. Surface water is also used by animals, such as moose, beavers and many types of birds for resting places, which may lead to the introduction of pathogenic microorganisms to the water source. The water chemistry of surface water bodies will also vary seasonally, with changes in turbidity, pH, organics, and water temperature, which all impact the treatment and disinfection processes. These changes in raw water quality require close monitoring and adjustments to treatment and disinfection systems to ensure the water entering the drinking water distribution system meets the chlorine residual requirements and is free of pathogens.

Groundwater differs from surface water in that its quality, temperature, and other parameters are less variable from season to season. As groundwater flows through an aquifer, it is naturally filtered. This filtering, combined with the long residence time underground, means that groundwater is usually less prone to contamination from disease-causing microorganisms and contains less suspended solids. However, groundwater is more likely to have high levels of iron, manganese, arsenic, strontium, and other metals due to its residency time and geology. These may also result in challenges for water treatment and distribution systems. Groundwater is not immune to contamination; with poor well construction methods and certain types of activity (industrial, agriculture, etc.) in close proximity to the well, risk of contamination increases.

Source water protection for both surface and groundwater wells is an important component of the NL multi-barrier strategic action plan. At the end of 2014, 314 of the 479 public water supplies in the province were protected under Section 39 of the WRA. Once protected under the WRA, any development within the protected area is subjected to regulatory review to ensure developments do not negatively impact the water source and adhere to ENVC policies.

3.1.2 Disinfection/treatment.

ENVC reported 34 operating water treatment plants in NL in the 2014 fiscal year, 17 of which were potable water dispensing units (PWDU). In addition, some communities may have parameter specific water treatment processes to address specific water quality challenges, such as pH adjustment, filtration, and removal of arsenic, iron, manganese, lead, and strontium.

Water disinfection is one of the most critical components of a drinking water system and refers to the destruction or inactivation of pathogenic microorganisms from a water supply. The most commonly used disinfection systems in NL is chlorination, either by adding chlorine gas or sodium hypochlorite to water. Chlorine is used because it is a strong oxidant that rapidly kills harmful bacteria and is used as a residual disinfectant in the water as it is distributed throughout the drinking water system. Free chlorine residuals of 0.3mg/L are required by NL standards after a 20 minute contact time (or equivalent CT value) and detectable chlorine residual (or other suitable disinfectant) must remain in all areas of the distribution systems. One of the disadvantages of using chlorine as a disinfectant is that it has the potential to form disinfection by-products (DBPs), such as trihalomethanes (THMs) and haloacetic acids (HAAs), which are potentially carcinogenic in large quantities. The fear of DBPs may result in a decision by some communities to go on BWAs so they don't have to chlorinate and expose residents to high levels of DBPs. This may be occurring even though the health risks from pathogenic contamination are much greater than possible effects from a lifetime of exposure to DBPs.

The removal of suspended solids and micro-organisms by filtration prior to disinfection may reduce the chlorine dosage requirements, while removal of dissolved organics will reduce the formation of DBPs such as THMs and HAAs, and also the chlorine demand. In some surface water supplies, infiltration galleries have been incorporated into the design to help reduce suspended sediment levels and turbidity in shallow water sources exposed to high winds and waves.

At the end of the 2014 fiscal year, two drinking water systems in NL were using chloramines for secondary disinfection. Chloramines may be used as a secondary disinfectant because it has a longer lasting residual than chlorine and does not readily form THMs or HAAs. Other methods used for disinfection of drinking water in NL include ultraviolet light and ozone. These methods are generally combined with chlorination to provide the required residual disinfectant. In addition, the province is currently piloting a hydrogen peroxide disinfection system.

3.1.3 Distribution systems and associated appurtenances.

Distribution systems transport the water from the source to the consumer. These systems are typically made up of underground piping, valves, pressure reducing stations, storage tanks, and pumping stations. They are specifically designed for the community they serve, and are typically modified as the community grows. As such, the age of the distribution equipment can vary greatly within a system. Appropriate care must be taken when undertaking repairs or new construction as there is a potential risk of system contamination.

Some distribution systems may also be designed to handle large industrial users, such as fish plants. The addition, removal, or seasonal demands of a large industrial user may change the operating regime of the drinking water system. Lower flows may result in longer retention times for water in the distribution system, while higher flows may reduce the chlorine contact time to the first users. Changes in system demand may be significant when a large user, such as a fish plant, is shut down for the winter. Major changes in flow should be considered when treating and disinfecting the water, and may also affect suitable locations for testing for disinfectant residuals to meet the required 20 minute contact time. Generally, communities use the first user on their system as the testing location to ensure adequate free chlorine residuals.

During prolonged cold temperatures surface water supplies can freeze, causing problems with water intakes. The frost may also cause contraction related failures or freezing of the water mains. Low pH (acidic) water sources may lead to corrosion of distribution system pipes and fittings, further increasing the probability of a break within the distribution system.

Communities in NL are generally spread out along the coastlines, which require long linear distribution systems to provide drinking water. This feature may result in long retention times for water within the system and may result in problems with maintaining disinfectant residuals at the end of the lines.

3.1.4 Operations and maintenance.

The operation and maintenance of a public drinking water system is a very important component to providing safe drinking water to consumers. The level of operation and maintenance of these systems in NL varies significantly from community to community. The owner (LSD/municipality) is ultimately responsible for operation and maintenance of the water systems. The owner entrusts a high level of responsibility to the system operator for providing safe drinking water on behalf of the owner. Some drinking water systems are operated and maintained by certified full time operators, while others may be operated by part-time operators or volunteers with varying levels of training, or possibly no training at all.

In 2002, ENVC developed the OETC program to provide training and certification opportunities to operators of public drinking water systems. As was shown in Section 2, many larger communities have availed of this training and certification program, while smaller communities generally continue to struggle in this area. Table 2.5 shows that as of August 2015, 17% of communities serving a population of less than 500 people had a certified operator. This is concerning as under-trained operators may not have the necessary knowledge required to adjust the treatment and disinfection processes for changes in water flow and chemistry. In addition, untrained operators may not:

- understand the importance of their role,
- know the best management practices for system operation and maintenance,
- be able to identify risks to the system, and/or
- know the corrective measures needed to remove a BWA.

BWA reason codes such as C1, D1, and D3 are related to maintenance on the drinking water system, and when these codes are issued for short durations, it indicates that these systems are being maintained. However, when these codes remain in effect for long durations, this may indicate more serious problems with the system's infrastructure or operation. Preventative maintenance on any system is critical to increasing the life span and efficiency of a system. Section 5 of this report provides more information on recommended preventative maintenance procedures for a drinking water system.

3.1.5 Monitoring and testing.

It is very important that water is sampled both frequently and consistently to accurately reflect the quality of the water supplied to consumers. Testing should be completed within the distribution system for bacteriological contamination and for total and free chlorine residuals.

Water quality can vary greatly within the distribution system, so it is vital that samples are taken from many different locations that are representative of the entire distribution system. Locations that should be sampled include main lines, dead end pipes, branch lines, loops, water sources, and storage tanks. Table 3.1, summarized from the 2012 Drinking Water Manual (NL Department of Health and Community Services, 2012), provides the required number of bacteriological samples that should be taken on a monthly basis.

Table 3.1: Minimum Monthly Sampling Requirements

Distribution Systems Serving (Population)	**Number of Samples Per Month**
No distribution system or system serving less 100 people	1
<5000	4
5000-90,000	1 sample per 1000 people served
>90,000	90 plus 1 sample per additional 10,000 served

The Environmental Health Officers (EHOs) are responsible for the collection of water samples from public drinking water systems for bacteriological analysis at public health laboratories and checking for chlorine residual levels within the distribution system. This is the case for most all communities, except for the City of St. John's and many of the coastal communities in Labrador. Samples are shipped to one of the seven Public Health laboratories, located at the following centres:

- Clarenville
- Corner Brook
- Gander
- Grand Falls-Windsor
- Happy Valley-Goose Bay
- St. Anthony

- St. John's

The EHO's are also responsible for interpretation of the results and advising the owners when to issue and lift a BWA. The Maximum Acceptable Concentration (MAC) for bacteriological quality is no coliforms detectable per 100mL of water (Bacteriological Water Quality, HCS, 2012). However, due to variations in water quality throughout the distribution system, the following are used in practice to conform to the MAC:

- no sample contain *E. coli*, and
- no consecutive samples from the same site, or no more than 10% of the samples from the distribution system in a given sample set should show the presence of Total Coliforms.

A BWA may be issued for a number of reasons as outlined below:

- continuous disinfection is not being provided,
- bacteriological sampling not meeting MACs for Total Coliform or *E.coli*, and/or
- no disinfectant residual is detected at sampling locations, or after a 20 minute contact time the free chlorine residual is less than 0.3mg/L or equivalent CT value.

Table 3.2 was reproduced from data in Table 4.2 of the Guidelines for the Design, Construction and Operation of Water and Sewerage Systems (ENVC 2005) to provide a summary of the required CT values to inactivate viruses by free chlorine. The province is considering adopting a 2.0 log inactivation criteria for viruses and bacteria. For pH ranges of 6-9, the CT value is highly dependent on the water temperature; the warmer the water, the more effective the disinfectant and lower CT value required. The 0.3mg/L free chlorine residual after a 20 minute contact time is equivalent to a CT value of 6, which is for a water temperature of 0.5^{o}C. During summer months, the water temperature rises and the required CT value drops. For example, if the temperature is 10^{o}C, a CT value of 3 is required, which is equivalent to a chlorine residual of 0.15mg/L for 20 min contact time. Requiring 0.3mg/L free chlorine residual at water temperatures of 10^{o}C is equivalent to a 4 log inactivation for water at pH 6-9; thus increasing the level of disinfection and protection of the drinking water. Monitoring chlorine residuals without considering the water temperatures may result in triggering more BWAs even though the 2 log inactivation may be achieved.

Table 3.2 CT Values for Inactivation of Viruses by Free Chlorine (2 Log Inactivation)

Temperature (ºC)	pH 6-9	pH 10
0.5	6	45
5	4	30
10	3	22
15	2	15
20	1	11
25	1	7

3.2 Common Causes of Active BWAs

This section will first discuss the common causes of BWAs for NL, and then review common causes identified by the US EPA for reason codes F.

3.2.1 Common Causes for BWAs in Newfoundland and Labrador

Information provided on common causes for 238 active BWAs (as of August 6, 2015), especially for codes E and F (note: others are self-explanatory and there were no codes G and H issued) are analyzed for each region as summarized in Table 3.3.

Table 3.3: Total and Code E/F Active BWAs (as of August 6, 2015)

Region	Total Number Active BWA	Reason Codes E & F
SJ	55	17
E	45	17
W	76	45
C	45	24
L	17	7
Total	**238**	**110**

Based on the responses from Service NL, the common causes were separated into seven categories:

- chlorine residual levels,
- insufficient resources, such as financial and/or staffing,
- maintenance & mechanical (which includes cross-connections),
- no disinfection system,
- other (e.g., non-consumption order in place), and
- missing information (no update available),

3.2.1.1 Active BWAs in St. John's region.

A summary of the 55 active BWA reason codes for the St. John's (SJ) region is provided in *Figure 3.1*. 18 of the 55 were coded C1, indicating the system is off for maintenance or mechanical failure. A closer look at the C1 codes showed that all BWAs have been in place longer than one year, 14 of which were in place for over 10 years. Six of these were for groundwater wells for a small group of communities with total population less than 500 people. The seven D2 codes are for groundwater wells servicing one municipality and have been in place for a duration of greater than two years. Two drinking water systems serving populations of greater than 500 people have been on BWAs for more than two years (one of which has been in place for 15 years).

There were a total of 17 reason codes E and F with active BWAs in the SJ region, 13 of which have been in place for a duration of greater than one year. *Figure 3.2* shows that BWAs fall into four categories; four due to chlorine residuals, five due to insufficient funding and staffing to operate and maintain the system, one is undergoing maintenance and the one classified as "Other". Based on the information provided by Service NL, many of the E1 codes could now be coded to something other than E1 (e.g., insufficient funding, disinfection system turned off). Note: the F2T code was noted as being a funding issue and the system was manually being chlorinated, which results in problems when there is heavy rainfall.

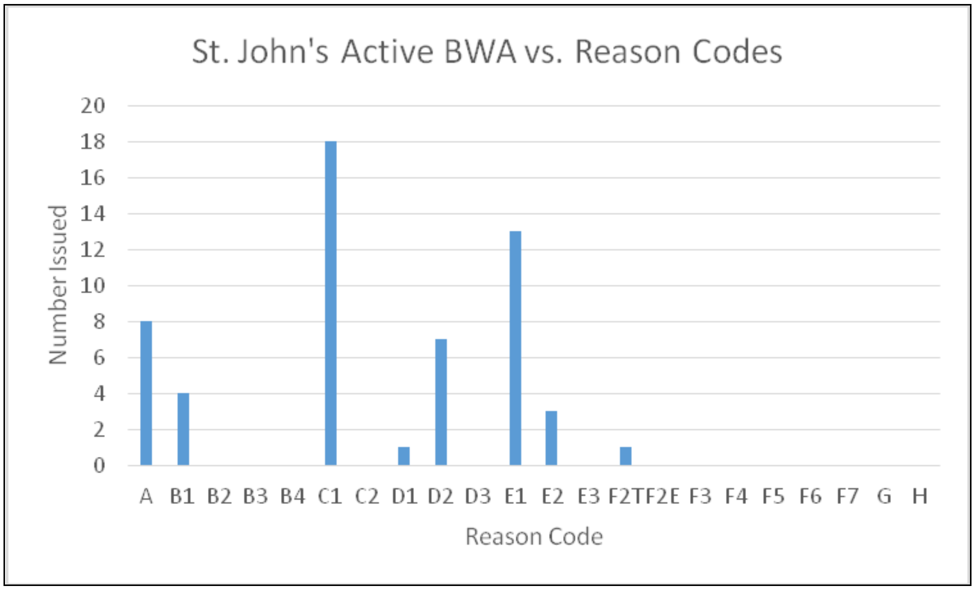

Figure 3.1: St John's Active BWAs vs. Reason Codes

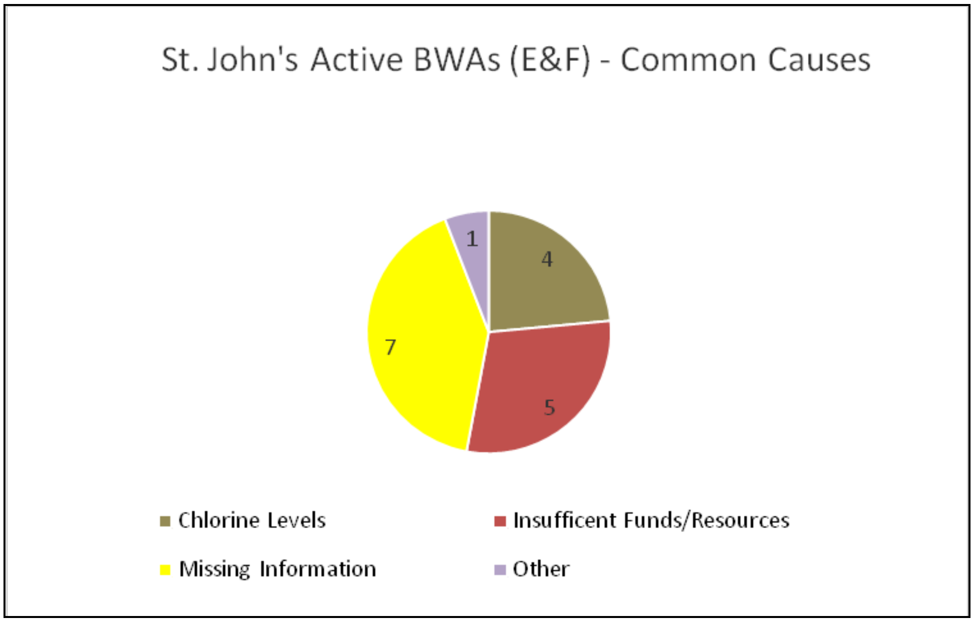

Figure 3.2: St. John's Active BWAs (Codes E and F) – Common Causes

3.2.1.2 Active BWAs in eastern region.

The Eastern region has 45 active BWAs which are summarized in *Figure 3.3*. Three BWAs, two code D3s and one code D1, were also on Non-Consumption Orders (NCO). It is believed that two of the NCOs were updated within the past year and the other has been in place since 2006 (note: one NCO was due to arsenic levels, while the others were due to "unapproved water supplies"). Approximately 25% of the BWAs were due to code A – no disinfection system.

17 of the BWAs were due to reason codes E and F, of which 16 were code E and one code F. *Figure 3.4* shows that 10 of the BWAs were due to chlorine levels; eight of which have been in place for a duration of two years or more. Three systems were noted as having insufficient funds/resources; two have no disinfection system and one noted as undergoing maintenance. As of the end of August 2015, one BWA was already lifted. One of the drinking water systems serving a population of over 500 people has been on a BWA for over nine years.

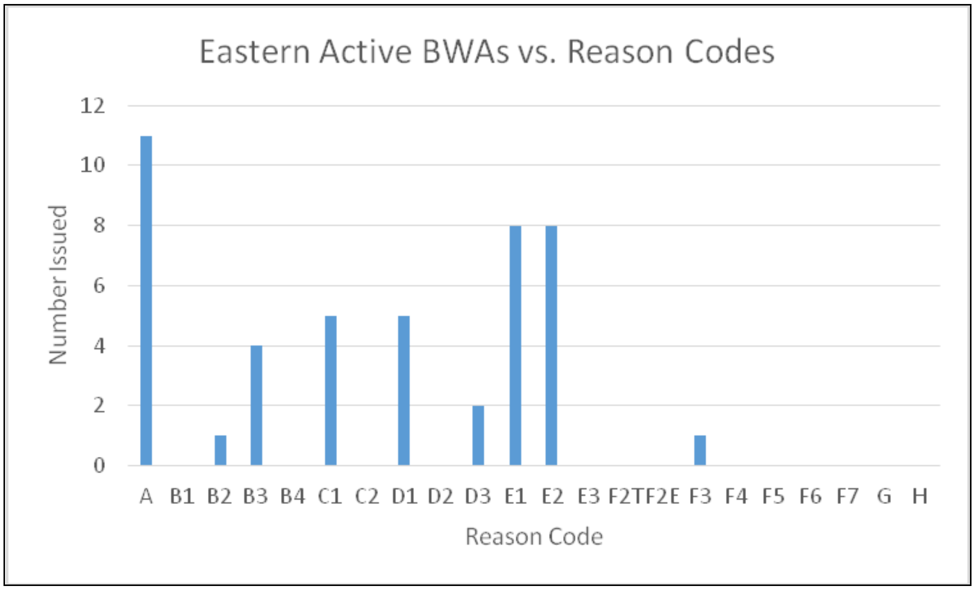

Figure 3.3: Eastern Active BWAs vs. Reason Codes

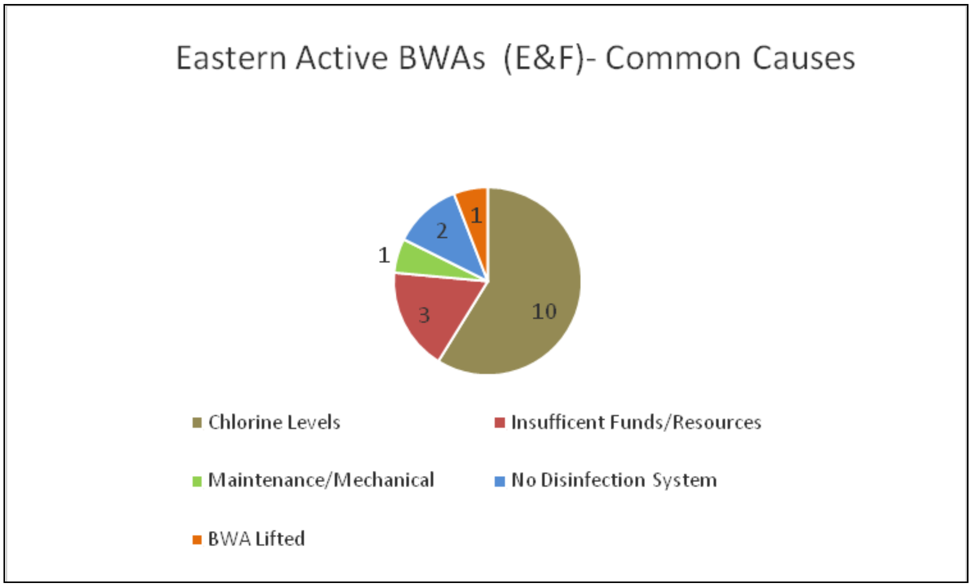

Figure 3.4: Eastern Active BWAs (Codes E and F) – Common Causes

3.2.1.3 Active BWAs in western region.

A summary of the 76 active BWAs for the Western region is provided in *Figure 3.5*, of which 45 were for reason codes E and F. Eight of the C1 and six of the B3 codes were noted as being caused by insufficient funding to operate a system and hire an operator. One drinking water system was coded as B4, while it is on NCO due to arsenic levels (note: B4 code was not included in the 21 codes provided for this study). One of the BWAs was lifted.

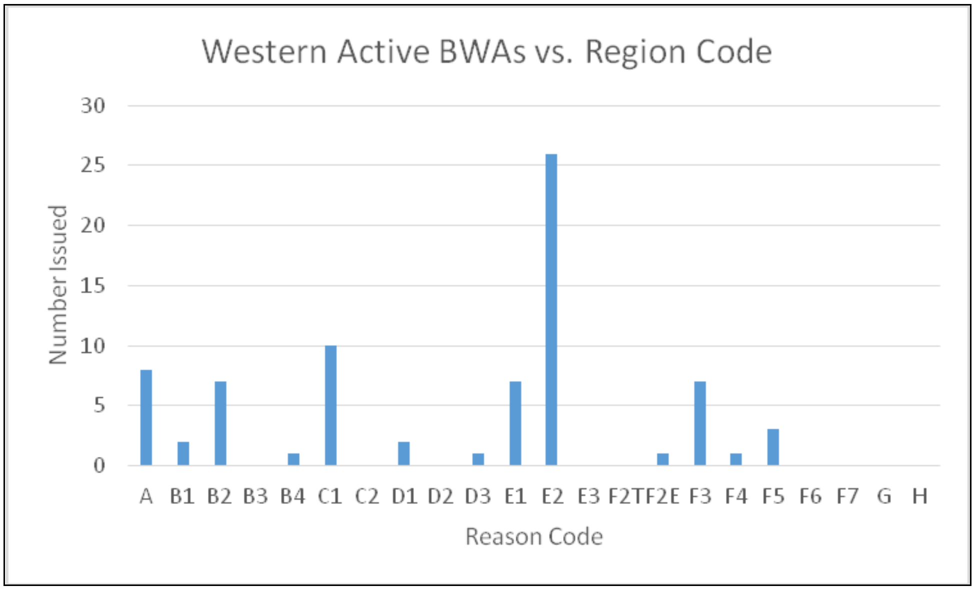

Figure 3.5: Western Active BWAs vs. Reason Code

Figure 3.6 provides an overview of the causes of BWAs for the 45 code E & F BWAs. 18 of the 45 were caused by chlorine levels; two for the same drinking water system serving a population of over 1500 people and two serving over 500 people. Nine BWAs caused by insufficient funds to operate a system and hire an operator, and two with no disinfection systems at all. The Western region had 12 code F active BWAs, of which two were lifted, nine in place for duration of one year or less, and one in place for duration of approximately three years. Generally the cause of the code F BWAs was noted as being due to chlorine residuals.

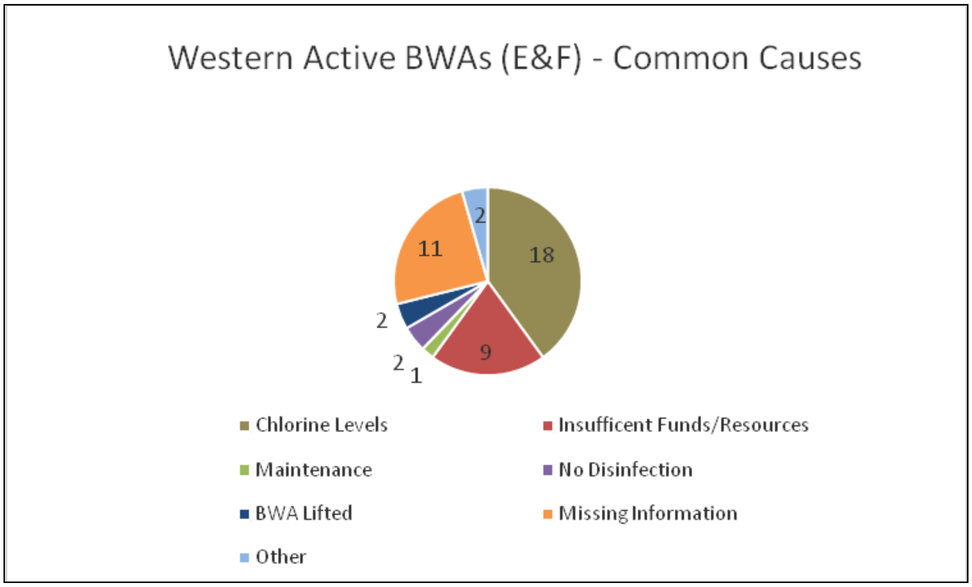

Figure 3.6: Western Active BWAs (Codes E & F) – Common Causes

3.2.1.4 Active BWAs in central region.

The Central region had 45 active BWAs which are summarized in *Figure 3.7*, of which 24 were code E and F. Five of the drinking water systems are code A, having no disinfection system. While eight code B, C, and D BWAs were issued in 2015, with one recently lifted.

The most common cause noted for the code E and F was chlorine residuals, accounting for 33% (*Figure 3.8*). In four cases, the reason for the problem with chorine residuals was due to flows; two suspected to be impacted by high flows from fish plant operations, one due to high flow from watermain breaks, and one for low flow combined with possible contamination of source due to birds. One E2 was noted as not having a disinfection system and two code F3 noted as having Total Coliforms (source not identified).

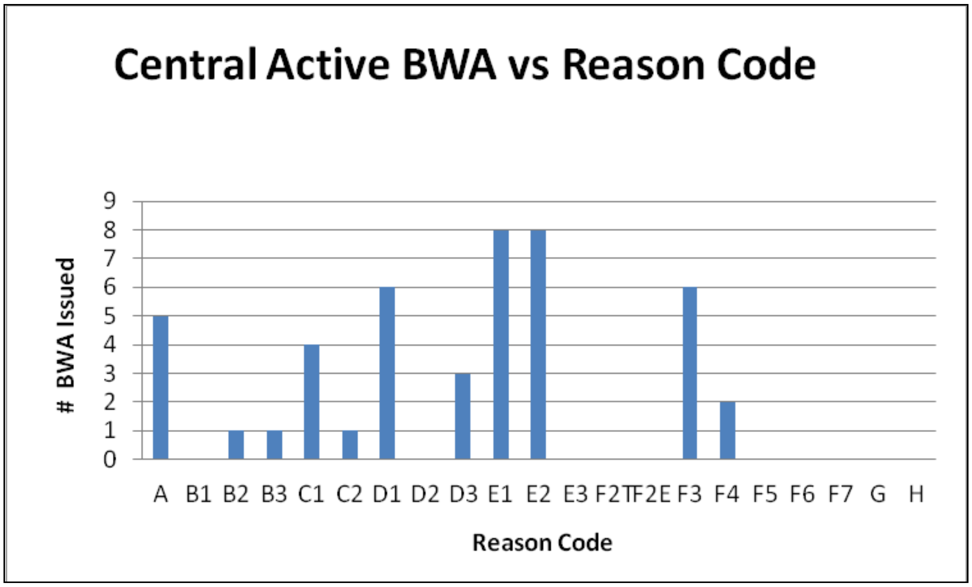

Figure 3.7: Central Active BWAs vs. Reason Code

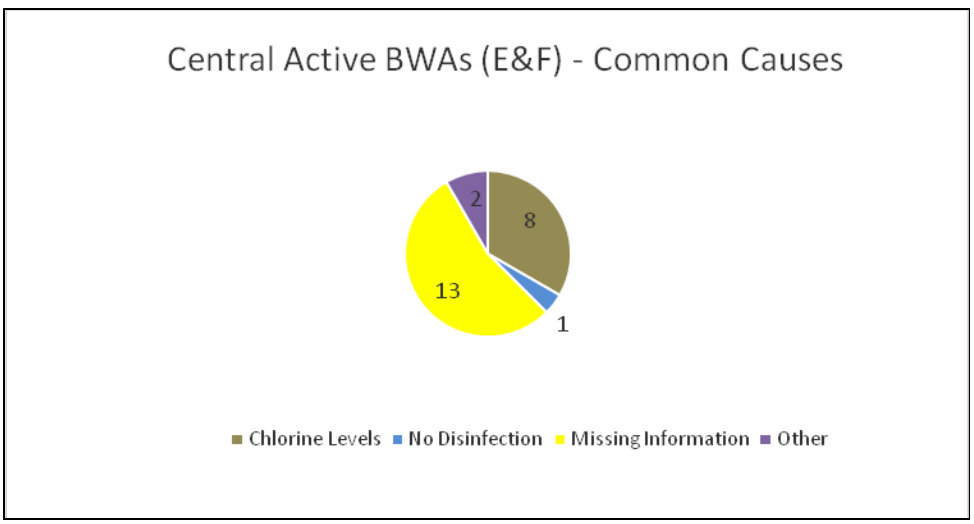

Figure 3.8: Central Active BWAs (Codes E and F) – Common Causes

3.2.1.5 Active BWAs in Labrador region.

A summary of the 17 active BWAs for the Labrador region is provided in *Figure 3.9*, of which seven were for reason codes E and F. Three code D3 BWAs have been lifted in one community and one C1 has also been lifted. Four of the lifted BWAs were under maintenance or repairs for less than three months. There are a number of BWAs that have been in place for a number of years, one C1 and one D3 BWA have been in place for over nine years.

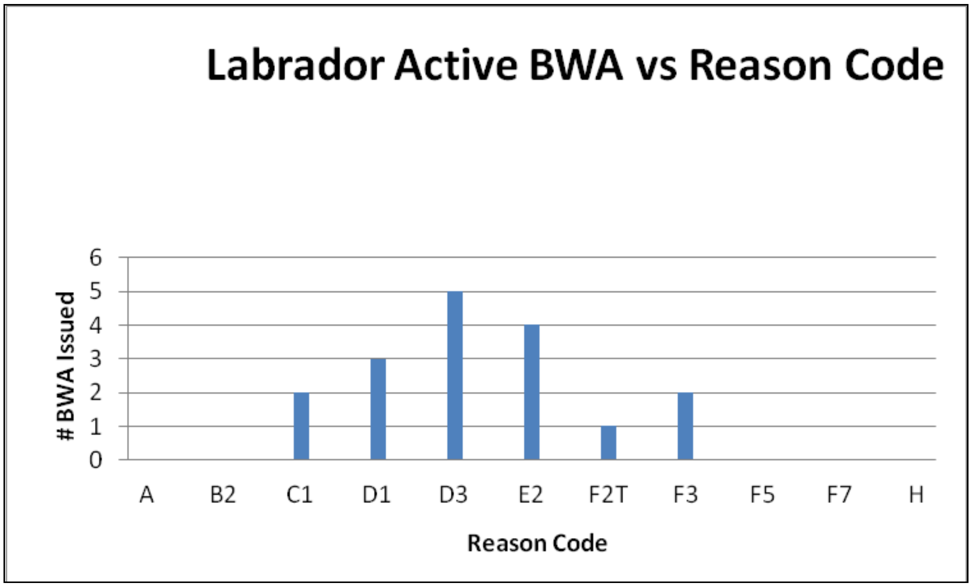

Figure 3.9: Labrador Active BWAs vs. Reason Code

Figure 3.10 provides an overview of the causes of BWAs for the seven code E & F BWAs. Two of these have been lifted, one code E and F. One code E2 BWA has been in effect for a duration of more than 20 years, and another was noted as having no disinfection system. From the information provided from Service NL there could be four drinking water systems with no disinfection systems in Labrador, one confirmed and three long term BWAs.

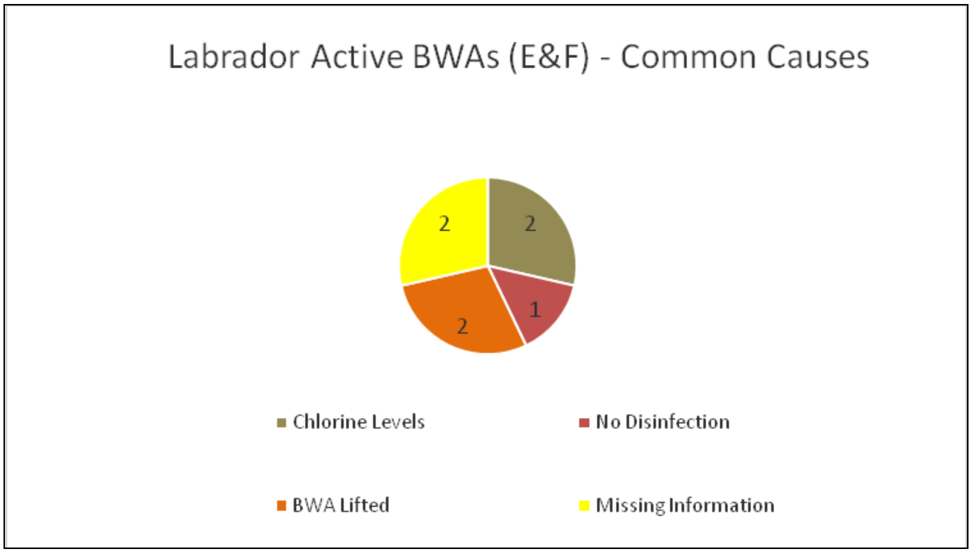

Figure 3.10: Labrador Active BWAs (E&F) – Common Causes

3.2.1.6 Summary.

A summary of all the responses from Service NL for the province is provided in *Figure 3.11* for the 110 code E & F active BWAs. Approximately 38% of the causes were identified as being chlorine residuals not at acceptable levels to meet provincial standards and/or to kill pathogens in the water. For a significant number of BWAs, there was no information provided or updates available on the cause of the BWA. The next highest cause (15%) was insufficient funds or staffing resources to maintain and operate the disinfection system.

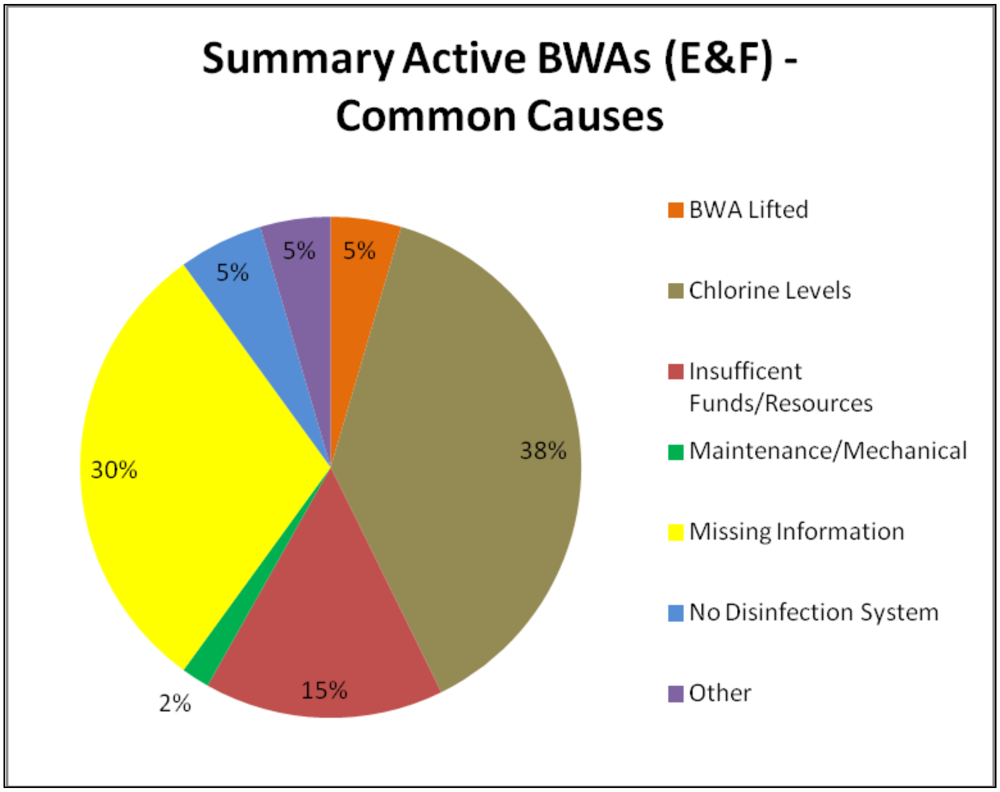

Figure 3.11: Summary of Active BWAs (Codes E and F) – Common Causes

3.2.2 Common causes for BWA reason code F and H.

Reason codes F and H indicate unwanted and potentially dangerous pathogenic microorganisms in the drinking water system. Once indicator pathogens have been detected in a water sample, it is imperative to locate how the pathogens got into and distributed throughout the system.

The US EPA report "Revised Total Coliform Rule Assessments and Corrective Actions Guidance Manual" (US EPA 2014) identifies common causes for Total Coliforms in a drinking water system. Generally, bacteria may be present in the water distribution system if there is a source of bacteria, a pathway into the distribution system, and a mechanism that allows bacteria to be carried into distribution system. This indicates that three conditions must exist for a code F and H to exist. Elimination of all three conditions would significantly reduce the risk of bacteriological contamination, while leaving any of the conditions present will increase risk to the system. Therefore, it is important to undertake an assessment of the various components of the system once a code F or H BWA is issued.

Commonly, the source of the bacteria may include one or more of the following:

- soil and water that surrounds distribution system infrastructure,
- biofilms within the distribution system which may protect bacteria from disinfectants, and eventually detach into the water,
- corrosion tubercles within the distribution system, which may protect bacteria from disinfectants,
- cross-connections – backflow event occurs and contamination is drawn back or pushed into water distribution system via connections,
- materials used in distribution system – materials contaminated prior to installation (not disinfected prior to installation), or materials that support growth of bacteria, and/or
- sediments accumulate and provide habitat for growth and shield bacteria from disinfectants.

Potential pathways that may allow bacteria to enter the distribution system include deficiencies within finished water storage facilities, cross-connections, leaks/holes in pipe (may allow contaminants to enter the system during low/negative pressure events), and inadequate protection and precaution while undertaking system maintenance, replacement or repairs.

The following mechanisms may allow bacteria to enter/proliferate within the distribution systems:

- weather-related events, such as heavy rainfall or snowmelt,
- treatment breakthrough – failure of treatment barrier (none or insufficient disinfection),
- backflow,
- low pressure in system piping, which may allow intrusion,
- operations – sudden velocity or flow changes releasing biofilm/sediment,
- poor maintenance practices,

- changes in retention times - an increase which may reduce disinfectant residual and allow for deposition/accumulation of sediment, and/or
- presence of nutrients in the system may support bacteria growth.

3.3 BWA System Assessment Form

The BWA System Assessment form is a form that was developed to be used by drinking water system operators and owners to identify the probable root cause of a BWA. The form can be applied to any size drinking water system, as sections such as treatment systems and storage tanks which may not be applicable for smaller drinking water systems need not be completed. The form may also prove useful for owners to identify risks and vulnerability of the drinking water system, especially with regards to the three conditions (previously mentioned) required for pathogens to be present in the system. The form is based on Level 2 assessment outlined in the US EPA report "Revised Total Coliform Rule Assessments and Corrective Actions Guidance Manual" (US EPA 2014). Additional details were added based on common causes identified in previous sections of this report for NL, and to help with the identification of causes for reason codes other than total coliform.

The assessment form should be completed by a certified operator and with an individual knowledgeable of the drinking water system that is being assessed. Depending on the education and experience of the owner and operator, a third party resource with expertise in the operation and assessment of drinking water systems may also be engaged to help with completion of the assessment form. It is important that the entire assessment form be completed, even if a risk area has already been identified as there is often more than one area of concern evident following a complete assessment. Completing the entire form ensures that if multiple risk areas exist, they will be identified.

The assessment form (Appendix A2) is comprised of four sections:

- Cover Page: provides details on the community, assessor, dates, and summarizes the root causes for current BWAs.

- Summary *Tables 1.1* and *1.2*, which provide a log of disinfection parameters and disinfectant residual trends.
- Assessment Worksheets: detailed questions with yes/no responses for the following areas - sampling location, sampling protocol, disinfectant residuals, drinking water system, operational changes, distribution system, water storage tank(s), disinfection/treatment processes, source- well, source- surface water, and environmental events. The results for each question are assessed as 'OK/Serious/Critical'. 'Critical' meaning root cause for current BWA and 'Serious' meaning as issue which makes the system prone to re-occurring BWA.
- Areas of Concern: provides a summary of areas which are of concern as identified in the assessment worksheets.

All 'Critical' and 'Serious' issues identified in the assessment worksheets should then be summarized on the 'Areas of Concern' sheet. This would allow for a quick assessment of the overall system, identification of likely root cause(s) for a BWA, and the overall vulnerability of the system. The 'Critical' issues, which identify the root cause of the current BWA, are summarized on the cover page of the assessment form. Once the root cause(s) has been identified, a corrective action plan can be developed to remove the BWA.

It is important that the results of the assessment form are recorded by the owner of the system to provide a historical record of issues with the drinking water system. These records may also prove useful to owners for planning their operation and maintenance priorities, highlight vulnerabilities which may require corrective measures, and training requirements for operators. The completed assessment forms should also be made available to the applicable regulatory stakeholders for historical documentation of BWA common causes, trend analysis, and prioritizing funding initiatives.

4.0 POTENTIAL CORRECTIVE MEASURES

Section 4 is prepared in accordance with Task #3 (Section 4.3) of the TOR. Using information collected on common causes for BWAs in Section 3, a detailed summary of corrective measures which may be implemented to lift a BWA is provided. The corrective measures include "short-term" measures that may help to lift the BWA and "long–term" measures that may reduce potential for the BWA reoccurring. With the exception of educating operators to bring them up to provincial standards of certification, most long term measures involve capital work funding, which may require funding under a number of programs delivered through the Department of Municipal and Intergovernmental Affairs (MIGA).

Order of magnitude cost estimates are given for each corrective measure. The costs for many of these measures will be site specific; depending on the extent of the problem, complexity of the system and construction, etc. Estimates should be used by the owner as a guide to the expected costs and the decision making process on which corrective measure may be feasibly implemented.

For each corrective measure, there is a list of stakeholders identified, who may be required to take some action or be consulted by the owner. It is acknowledged that the users of the water (e.g., residents and commercial/industrial users) are stakeholders. However, only those directly involved in taking action or providing a service are included in the list of stakeholders below.

4.1 Corrective Measures - Reason Code A

Reason code A is used when there is no primary and/or secondary disinfection system on a public drinking water system. As such, there is non-compliance with the provincial disinfection standards outlined in the draft Drinking Water Treatment Standards for Newfoundland and Labrador, (ENVC 2015) and Drinking Water Manual – Bacteriological Water Quality (HCS, 2012).

4.1.1 Common causes.

No disinfection system may be due to lack of financial and staffing resources available to construct, operate and maintain the system. Also the lack of knowledge of community leaders and residents on the importance of disinfecting the drinking water may be a contributing issue which may lead to some communities refusing to disinfect.

4.1.2 Corrective measures.

1. Government agencies to educate the community leaders and council on the importance of disinfecting the public water supply.
   a. Stakeholders: Owner, HCS, SNL, ENVC, and MIGA.
   b. Costs: N/A
2. Owner to educate residents and water users of the importance of disinfecting the public water supply. Distribute educational pamphlets.
   a. Stakeholders: Owner (government agencies such as HCS, SNL, ENVC, and MIGA may provide technical assistance to owner upon request).
   b. Costs: $500
3. Owner to have the existing water system evaluated for recommended upgrades.
   a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
   b. Costs: $20,000 for evaluation of existing infrastructure and identification of sustainable options. Consideration may be given for the installation of a new/alternative disinfection system, PWDU system, or connection to nearby public drinking water systems that may be available.
4. Owner to apply for funding through MIGA's various funding programs for disinfection system and associated appurtenances.
   a. Stakeholder: Owner, MIGA, ENVC, SNL, HCS, engineering consultants
   b. Costs: $25,000 to $500,000 (depending on system)

Associated costs will vary greatly depending on the size of the community, existing infrastructure, and the water quality issues being addressed. As such, rough cost estimates of $25,000 for a simple hypo-chlorination system, to more than $500,000 for a large system using gas chlorination. The Municipal Capital Works program, Multi-Year Capital Works program, and Building Canada Fund have been developed to help offset the cost of installing treatment systems as shown below. Information on funding can be obtained by contacting MIGA. Generally, funding for disinfection systems in small communities would fall under the MCW program or other specially designated programs, such as the Disinfection Funding Program. MCW is a cost-shared program for municipal infrastructure, including public drinking water systems. Eligible funds are allocated based on the following ratios:

- 90/10 for populations less than 3,000
- 80/20 for populations between 3,000 and 7,000
- 70/30 for populations greater than 7,000

Local Service Districts in the province would also qualify for funding supports on approved projects usually under the 90/10 arrangement.

Step #1: Contact the nearest MIGA regional office and ENVC to initiate system evaluation for recommended upgrades:

MIGA St. John's Region:	Phone	(709) 729-5020 or (709) 729-7390
MIGA Eastern Region:	Phone	(709) 729-5020 or (709) 729-7390
MIGA Central Region:	Phone	(709) 256-1061 or (709) 637-2332
MIGA Western Region:	Phone	(709) 637-2491 or (709) 637-2332
MIGA Labrador Region:	Phone	(709) 896-2941 or (709) 637-2332
ENVC:	Phone	(709) 729-4048 or (709) 729-1158

Step #2: Work with stakeholders (MIGA, ENVC & consultants) to evaluate the system and to identify sustainable options.

Step #3: Once a sustainable option has been identified, the Owner may make an application to MIGA for project funding.

Online applications: First time users may contact MIGA to set up an account by phoning (709) 729-5498 or (709) 729-5846 or email: MA-InforMgmt@gov.nl.ca. Once an account is setup, applications may be completed online at URL: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f. Video instructions on logging into the system and completing the form is available at the following link: https://www.youtube.com/watch?v=T1foy1UMTT0&feature=youtu.be

Paper applications: Applications may be submitted in hardcopy by completing the application shown in Appendix 4.1. Contact the nearest MIGA regional office if you have any questions while completing the form.

4.2 Corrective Measures - Reason Code B

Reason code B applies to a public drinking water system which has a disinfection system however the system has been turned off by the owner/operator for one of three reasons, which are represented by codes B1, B2, and B3 (described below).

4.2.1 Reason codes B1 and B2.

Corrective measures for reason codes B1 and B2 are very similar. Both are results of disinfection system being turned off by the operator:

- B1 due to taste, and
- B2 due to perceived health risks.

4.2.1.1 Common causes.

The following may result in the disinfection system being turned off by system owner/operator:

- Perceived taste or odour complaints from residents, including smell of bleach or “bog” in water – code B1.
- Perceived health risks associated with chlorine usage, especially if disinfection by-products are an issue – code B2.

4.2.1.2 Corrective measures.

1. Owner to assess existing equipment, replace non-operational equipment and turn disinfection system on.
    a. Stakeholders: Owner, engineering consultants (government agencies such as HCS, SNL, ENVC, and MIGA may provide technical assistance to owner upon request).
    b. Costs: $1000 - $25,000 depending on condition of existing equipment.
2. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner
    b. Costs: N/A
3. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A
4. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A
5. Owner to educate residents and water users on the importance of disinfecting water prior to drinking. Distribute educational pamphlets.

    a. Stakeholders: Owner, HCS, SNL, ENVC, and MIGA.
    b. Costs: $500

6. Owner to contact government agencies (ENVC, HCS, and SNL) to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water and the health risks associated with pathogens versus DBPs.
    a. Stakeholders: Owner (government agencies such as HCS, SNL, ENVC, and MIGA may provide technical assistance to owner upon request).
    b. Costs: N/A
7. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500
8. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000
9. Owner to assess water treatment to remove or reduce disinfection by-products.
    a. Stakeholders: Owner, MIGA, ENVC, SNL, engineering consultant
    b. Costs: $25,000 plus (funding through MCW)

4.2.2 Reason code B3.

Reason code B3 indicates the chlorination system is turned off by the operator due to lack of funds to operate the system.

4.2.2.1 Common causes.

This may be due to the owner’s lack of understanding of the importance of chlorination and not allocating sufficient funds for this item. It could also be due to the lack of funds to hire operator(s), provide supplies and spare parts to operate the system. Funding may be an issue for communities with a small population base or with low water tax rates, or combination of both.

4.2.2.2 Corrective measures.

1. Owner to assess existing equipment, replace non-operational equipment and turn disinfection system on.
    a. Stakeholders: Owner, engineering consultants (government agencies such as HCS, SNL, ENVC, and MIGA may provide technical assistance to owner upon request)
    b. Costs: $1000 - $25,000 depending on condition of existing equipment.
2. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner
    b. Costs: N/A
3. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A
4. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A
5. Owner to contact government agencies to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water.
    a. Stakeholders: Owner, HCS, SNL, ENVC, and MIGA.
    b. Costs: N/A

6. Owner to educate residents and water users of the importance of disinfecting the public water supply. Distribute educational pamphlets.
    a. Stakeholders: Owner (government agencies such as HCS, SNL, ENVC, and MIGA may provide technical assistance to owner upon request).
    b. Costs: $500
7. Owner to undertake full cost accounting/ full cost recovery to understand what it costs to operate and maintain the water system.
    a. Stakeholders: Owner, engineering consultants, ENVC, MIGA
    b. Costs: $15,000
8. Increase water taxes collected, use gas tax money and increase priority for disinfecting drinking water to ensure funds are available to operate disinfection system.
    a. Stakeholders: Owner
    b. Costs: N/A
9. If treatment and disinfection system is more than a basic hypo-chlorination system, then the owner should contact engineering consultants, MIGA and ENVC regional offices to re-evaluate the system and identify sustainable options based on current operating funds (possibly installing a PWDU system).
    a. Stakeholders: Owner, engineering consultant, ENVC, MIGA, SNL, HCS
    b. Costs: $25,000 to $350,00 (for basic hypo-chlorination system or PWDU, funding though MCW)
10. Owner may obtain services from regional operator(s) if they are available in the region (province has initiated a pilot program with regional operators in a number of regions of the province).
    a. Stakeholders: Owner, ENVC, MIGA, regional operator(s)
    b. Costs: $10,000
11. Owner may undertake an assessment for their drinking water system to become part of a regional operation, if available.
    a. Stakeholders: Owner, engineering consultants, ENVC, MIGA, SNL, nearby communities
    b. Costs: $25,000 (to undertake a regionalization study)

12. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500
13. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1,000

4.3 Corrective Measures - Reason Code C

Reason code C indicates the disinfection system is off due to operational issues and is sub-divided into C1 and C2 (described below).

4.3.1 Reason code C1.

Code C1 is for a disinfection system turned off due to maintenance or mechanical failure.

4.3.1.1 Common causes.

Maintenance may be planned as part of preventative maintenance program which normally would result in a BWA of short duration. Unplanned maintenance due to mechanical failure

may be due to poor preventative maintenance or unforeseen issues, which may result in a long duration BWA if there are no spare parts or if funds are not available to obtain the parts and complete repairs quickly.

4.3.1.2 Corrective measures.

1. Owner to undertake necessary maintenance, fix mechanical issues and turn disinfection system on.
    a. Stakeholders: Owner

   b. Costs: N/A

2. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
   a. Stakeholders: Owner
   b. Costs: N/A
3. Owner to ensure adequate funds available to operate and maintain disinfection system.
   a. Stakeholders: Owner
   b. Costs: Varies depending on system
4. Owner to order spare parts to have redundant critical parts available for the disinfection system.
   a. Stakeholders: Owner, engineering consultants, MIGA, ENVC
   b. Costs: $20,000 for spares and redundant equipment/parts (e.g., valves, hypo pump)
5. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
   a. Stakeholders: Owner
   b. Costs: N/A
6. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
   a. Stakeholders: Owner, SNL
   b. Costs: N/A
7. Owner to replace or upgrade disinfection system.
   a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
   b. Costs: $25,000 plus depending on system (funding through MCW)
8. Implement preventative maintenance programs to minimize mechanical failure.
   a. Stakeholders: Owner
   b. Costs: $5,000 assuming operator already on staff

9. Owner may obtain services from regional operator(s) if available in the region (province has initiated a pilot program with regional operators in a number of regions of the province).
    a. Stakeholders: Owner, ENVC, MIGA, regional operator(s)
    b. Costs: $10,000
10. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500
11. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000

4.3.2 Reason code C2.

Code C2 indicates the disinfection system is turned off due to lack of chlorine or other disinfectant.

4.3.2.1 Common causes.

If the disinfection system is turned off due to lack of chlorine or other disinfectant. This may be due to:

- Owner's lack of knowledge of the importance of disinfection and not allocating sufficient funds for this item,
- Community is located in remote area with limited supply/transportation options available,
- Lack of administrative/logistical capacity to ensure chemicals are ordered as needed.

4.3.2.2 Corrective measures.

1. Owner to order in disinfectant and start up disinfection system. Also, ensure adequate disinfectant is available on site but also that quantities are such that the chemicals do not degrade while in storage. Plan orders based on demand and shelf life. Ensure the product is stored properly to minimize degradation (see manufacturer's instructions for storage).
    a. Stakeholders: Owner
    b. Costs: $1,000 (for bulk hypo-chlorination and/or gas cylinders)
2. Owner to contact government agencies to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water.
    a. Stakeholders: Owner, HCS, SNL, ENVC, and MIGA.
    b. Costs: N/A
3. Owner to educate residents and water users of the importance of disinfecting the public water supply. Distribute educational pamphlets.
    a. Stakeholders: Owner (government agencies such as HCS, SNL, ENVC, and MIGA may provide technical assistance to owner upon request).
    b. Costs: $500
4. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner
    b. Costs: N/A
5. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A
6. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A

7. Owner should identify alternate suppliers for disinfectant in case of emergencies or existing suppliers are no longer available. Owner may also confirm what nearby communities use same disinfectant and make arrangements or agreement for loan/purchase in event of emergency. Disinfectant used must be NSF 60 certified.
    a. Stakeholder: Owner, other communities
    b. Costs: N/A
8. Owner to undertake full cost accounting/full cost recovery to understand what it costs to operate and maintain the water system.
    a. Stakeholders: Owner, engineering consultants, ENVC, MIGA
    b. Costs: $15,000
9. Owner may evaluate the feasibility of an on-site chlorine generator.
    a. Stakeholders: Owner, ENVC, MIGA, SNL, engineering consultants
    b. Costs: $160,000 to $200,000 (funding through MCW)
10. Owner may obtain services from regional operator(s) if they are available in the region (province has initiated a pilot program with regional operators in a number of regions of the province).
    a. Stakeholders: Owner, ENVC, MIGA, regional operator(s)
    b. Costs: $10,000
11. Owner may obtain services from regional operator(s) if they are available in the region (province has initiated a pilot program with regional operators in a number of regions of the province).
    a. Stakeholders: Owner, ENVC, MIGA, regional operator(s)
    b. Costs: $10,000
12. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500

13. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500
14. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000

4.4 Corrective Measures Reason Code D

Reason code D indicates a potential problem with the distribution system and is sub-divided into D1, D2, and D3 (described below).

4.4.1 Reason code D1.

Code D1 indicates the distribution system is undergoing planned or unplanned maintenance or repairs.

4.4.1.1 Common causes.

Water distribution system is undergoing maintenance or repairs, such as replacement of leaky or broken pipes, valves, flushing water mains, cleaning storage tanks, etc. In some cases the maintenance may be unforeseen while in other cases it may be part of planned programs to improve the system integrity. The duration of a BWA may be longer for unplanned maintenance if no spare parts and funding are readily available.

4.4.1.2 Corrective measures.

1. Repair or replace malfunctioning/broken component and have redundant critical spare parts available for the distribution system.
   a. Stakeholders: Owner
   b. Costs: $20,000 for spare components (e.g., valves, couplings, pipes for water main) and repair costs
2. Owner to maintain positive water pressure and proper sanitary conditions (follow proper sanitary techniques when undertaking maintenance) within the distribution system at all times including when undertaking repairs or during flushing.
   a. Stakeholders: Owner, ENVC, SNL
   b. Costs: $2000 for pressure monitoring equipment and associated operator training
3. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
   a. Stakeholders: Owner
   b. Costs: N/A
4. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
   a. Stakeholders: Owner
   b. Costs: N/A
5. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
   a. Stakeholders: Owner, SNL
   b. Costs: N/A
6. Owner to ensure adequate funds available to operate and maintain distribution system.
   a. Stakeholders: Owner
   b. Costs: Varies depending on system
7. Implement preventative maintenance programs to minimize mechanical failure.
   a. Stakeholders: Owner
   b. Costs: $5,000 assuming operator already on staff

8. Owner may obtain services from regional operator(s) if they are available in the region (province has initiated a pilot program with regional operators in a number of regions of the province).
    a. Stakeholders: Owner, ENVC, MIGA, regional operator(s)
    b. Costs: $10,000
9. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500
10. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000

4.4.2 Reason code D2.

Code D2 indicates a cross-connection is discovered in the distribution system. A cross-connection is an actual or potential connection between a potable water supply and a non-potable water source, where it is possible for a contaminant to enter the drinking water system. During a negative pressure event in the water supply system there is the potential for back siphonage to occur which may draw water from a contaminated source into the water system.

4.4.2.1 Common causes.

Potential cross-connections within a drinking water system may include:

- connection to an unapproved water supply or emergency supply,
- private water supplies (e.g., wells) being interconnected to the public water system,
- water filling hose for the hypo-chlorination solution tank being left on floor or in a bucket,

- garden hoses with a dispenser setup connected to drinking water system with no backflow preventer in place (either on the hose bib or on the service line),
- watermain flush pipe discharging into a sanitary manhole or submerged in a roadside ditch,
- waterline going through an active septic field,
- valve in a chamber being submerged under water,
- a boat taking on potable water, may force non-potable water back into the public drinking water system when their booster pumps kick in,
- loss of water pressure during periods of high flow such as fire flows, flushing, and major watermain break causing negative pressure and back siphoning of contaminated groundwater into the distribution system, and/or
- industrial or recreational water filling station interconnection.

4.4.2.2 Corrective measures.

1. Owner to eliminate cross-connections and educate water users about impacts of cross-connections.
    a. Stakeholders: Owner, MIGA, ENVC, SNL, engineering consultants
    b. Costs: $5000 to eliminate connections and $1000 to educate users on implications of cross-connections
2. Owner to repair any leaks in the water distribution system.
    a. Stakeholders: Owner, ENVC, MIGA, engineering consultants
    b. Costs: $1000 to 100,000 depending on number of leaks (funding through MCW)
3. Upon removing cross-connections owner should flush system (unidirectional).
    a. Stakeholders: Owner
    b. Costs: $1000
4. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner
    b. Costs: N/A

5. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A
6. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A
7. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A
8. Owner to install backflow prevention assemblies and devices and maintain as required.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
    b. Costs: $5000 to $50,000 to install appropriate backflow prevention devices and $50,000 for backup generator to maintain adequate pressure to prevent backflows
9. Owner to implement cross-connection control and backflow prevention (CCCBFP) program.
    a. Stakeholders: Owner, MIGA, ENVC, SNL, HCS
    b. Costs: $5000 to $150,000 to survey distribution system for cross-connections
10. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000
11. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.

   a. Stakeholders: Owner, ENVC
   b. Costs: $500

12. Maintain adequate pressure in the system to prevent backflow and back-siphonage by installing booster pumping stations, variable frequency drive pumps (VFD's), elevated storage facilities, surge tanks and relief valves, and modify high service pumps. Install automatic pressure monitoring and control.
    a. Stakeholders: Owner, MIGA, ENVC
    b. Costs: $3000 to $999,000 to install booster pumps and storage facilities (funding through MCW)

4.4.3 Reason code D3.

Code D3 indicates inadequately treated water was introduced into the system due to fire flows, flushing operation, minor power outages, pressure loss or interconnections to un-chlorinated water supplies.

4.4.3.1 Common causes.

Inadequately disinfected water may be introduced into the system due to fire flows, flushing operations, interconnections, minor power outages, or pressure loss. Power outages may result in treatment systems not being operational; fire flows and flushing may increase flows above the capacity of the disinfection system or without a flow pace disinfection system resulting in lower disinfectant residuals; low pressures may allow back siphonage; and interconnections may introduce untreated water into the system. In some cases, inadequately treated water may be introduced by connecting to an alternate or unapproved water source, especially when the main source is unable to meet the demand.

4.4.3.2 Corrective measures.

1. Owner to eliminate interconnections.
   a. Stakeholders: Owner, MIGA, ENVC, SNL

    b. Costs: $5000 to eliminate interconnections and $1000 to educate users on implications of interconnections

2. Owner to confirm existing disinfection equipment is in flow proportioning mode if this function is available on the unit.
    a. Stakeholders: Owner, ENVC, MIGA
    b. Costs: N/A
3. Upon correcting interconnections and restoring pressure to distribution system flush the system (unidirectional).
    a. Stakeholders: Owner
    b. Costs: $2000
4. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner
    b. Costs: N/A
5. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A
6. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A
7. Owner to install a flow proportioning disinfection system (if not already installed) so disinfection system keeps pace with the increase in flows during flushing and fire flows. Note: alternatively disinfectant dosages may be increased manually during the flushing and fire flow event.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultant
    b. Costs: $5000 to install flow paced chlorination system
8. Owner to install backflow prevention assemblies and devices and maintain as required.

a. Stakeholders: Owner, MIGA, ENVC
b. Costs: $5000 to $50,000 to install appropriate backflow prevention devices and $50,000 for backup generator to maintain adequate pressure to prevent backflows

9. Owner to provide new disinfection system for the interconnection of new water sources, while unapproved water sources should be disconnected and an approved solution to water shortages should be identified.
   a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
   b. Costs: $25,000 to $100,000 depending on system (funding through MCW)
10. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000
11. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500
12. Owner to maintain adequate pressure in the system to prevent backflow and back-siphonage by installing booster pumping stations, VFD's, elevated storage facilities, surge tanks and relief valves, and modify high service pumps. Install automatic pressure monitoring and control.
    a. Stakeholders: Owner, MIGA, ENVC
    b. Costs: $3000 to $999,000 to install booster pumps and storage facilities (funding through MCW)
13. Owner to install back up power for disinfection system to ensure system operates during power outages.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
    b. Costs: $25,000 to $50,000 depending on system (funding through MCW)

4.5 Corrective Measures - Reason Code E

Reason code E indicates there is insufficient residual free chlorine or disinfectant within the distribution system and is sub-divided into E1, E2, and E3, (described below).

4.5.1 Reason code E1.

Code E1 indicates water entering the distribution system or facility, after 20 minute contact time does not have a free chlorine residual of at least 0.3mg/L or equivalent CT value.

4.5.1.1 Common causes.

Some common causes may include:

- change in water quality affecting the chlorine demand,
- increased flows (demand) on the distribution system and the disinfection system is operating in manual mode,
- disinfectant strength weak due to long storage beyond shelf life,
- design of system did not provide for adequate contact time, and/or
- insufficient chlorine dosages.

4.5.1.2 Corrective measures.

1. Check that disinfection system is operational.
    a. Stakeholders: Owner
    b. Costs: N/A
2. Check that the shelf life of the disinfectant has not expired or test the strength of the chemical for any deterioration.
    a. Stakeholders: Owner
    b. Costs: N/A
3. Owner to confirm existing equipment is in flow proportioning mode if this function is available on the unit.

   a. Stakeholders: Owner, ENVC, MIGA
   b. Costs: N/A
4. Owner should increase free chlorine residual in the distribution system. This may be accomplished by either increasing the chlorine dosage rate using the pump's stroke or frequency settings or increasing the strength of the chlorine solution. It is recommended that the dosage rate method be attempted first as it faster and easier.
   a. Stakeholders: Owner, ENVC, SNL
   b. Costs: $500 for extra chlorine
5. Owner to increase free chlorine residual testing at end of chlorine contact chamber (if available) and throughout the distribution system. If no contact chamber, test at first user. Testing should be conducted at locations to be representative of the system, such as at the end of all main distribution lines.
   a. Stakeholders: Owner, ENVC, SNL
   b. Costs: $1000 for additional labour
6. Monitor raw water quality, especially during periods of high rainfall and snowmelt. Adjust chlorine dosage rates accordingly.
   a. Stakeholders: Owner
   b. Costs: $5000 for additional labour
7. Monitor water usage, particularly during peak demand periods and when larger water users such as fish plant start-up/shut down operations for the season. Adjust disinfection system as required to meet changing demands.
   a. Stakeholders: Owner
   b. Costs: $500 for additional labour
8. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
   a. Stakeholders: Owner
   b. Costs: N/A
9. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

   a. Stakeholders: Owner, SNL
   b. Costs: N/A
10. Owner to determine where in the distribution system the required 20 minute contact time at peak flow occurs.
    a. Stakeholders: Owner, engineering consultants, ENVC, SNL, MIGA
    b. Costs: $500
11. Owner to initiate a leak detection and repair program if flows are higher than expected based on number of users or there are known leaks in the system.
    a. Stakeholders: Owner, engineering consultant, ENVC, MIGA
    b. Costs: $10,000 plus depending on number of leaks in system (funding through MCW)
12. Owner should install a flow proportioning disinfection system (if not already installed) so chlorination system keeps pace with the increase in flows during flushing and fire flows. Note: alternatively chlorine dosage may be increased manually during the flushing and fire flow event.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultant
    b. Costs: $5000 to install flow paced chlorination system
13. Install chlorine residual analyzer; operate, maintain, and calibrate as directed by manufacturer.
    a. Stakeholders: Owner, MIGA, ENVC
    b. Costs: $10,000 to $30,000
14. Install contact chamber if none currently exists on the system and adequate contact time is not available in the pipes to the first user.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultant
    b. Costs: $10,000 plus depending on size of chamber required (funding through MCW)
15. Initiate water conservation strategy for users.
    a. Stakeholders: Owner

   b. Costs: $1000 for communication to water users

16. Owner to assess water treatment options to address changes in raw quality to reduce impacts on chlorine demand.
    a. Stakeholders: Owner, MIGA, ENVC, SNL, engineering consultants
    b. Costs: $25,000 or greater (funding through MCW)
17. Owner to assess alternate disinfectant methods.
    a. Stakeholders: Owner, engineering consultants, ENVC, MIGA
    b. Costs: $25,000 plus depending on system (funding through MCW)
18. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000
19. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500

4.5.2 Reason code E2.

Code E2 indicates no free chlorine residual detected in the water distribution system.

4.5.2.1 Common causes.

Some common causes for no free chlorine residual detected in the water distribution system include:

- disinfection system was shut off or not working properly,
- not enough chlorine being added by the disinfection system due to chlorination being in manual mode and unable to keep pace with flow,
- not enough chlorine being added to meet the chlorine demand as a result of changes in raw water quality,

- rapid drop in free chlorine residual throughout the distribution system due to chlorine demand from pipe wall and demand from bulk water (e.g., water quality iron and manganese), and/or
- water age in the distribution system is not being managed.

4.5.2.2 Corrective measures.

1. Check that disinfection system is operational.
    a. Stakeholders: Owner
    b. Costs: N/A
2. Owner to confirm existing equipment is in flow proportioning mode if this function is available on the unit.
    a. Stakeholders: Owner, ENVC, MIGA
    b. Costs: N/A
3. Check that the shelf life of the disinfectant has not expired or test the strength of the chemical for any deterioration.
    a. Stakeholders: Owner
    b. Costs: N/A
4. Monitor raw water quality, especially during periods of high rainfall and snowmelt. Adjust chlorine dosage rates accordingly.
    a. Stakeholders: Owner
    b. Costs: $5000 for additional labour
5. Monitor water usage, particularly during peak periods or when larger water users (e.g., fish plant start-up/shut down operations for the season).
    a. Stakeholders: Owner
    b. Costs: $500 for additional labour
6. Owner should increase free chlorine residual in the distribution system in accordance with provincial standards. This may be accomplished by either increasing the chlorine dosage rate using the pump stroke or frequency settings or increasing the strength of the chlorine solution. It is recommended that the dosage rate be attempted first.

   a. Stakeholders: Owner, ENVC, SNL
   b. Costs: $500 for extra chlorine

7. Owner to increase free chlorine residual testing at end of chlorine contact chamber (if available) and throughout the distribution system. If no contact chamber, test at first user. Testing should be conducted at locations to be representative of the system, such as at the end of all main distribution lines and throughout the system.
   a. Stakeholders: Owner, ENVC, SNL
   b. Costs: $1000 for additional labour
8. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
   a. Stakeholders: Owner
   b. Costs: N/A
9. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
   a. Stakeholders: Owner, SNL
   b. Costs: N/A
10. Owner to initiate water conservation strategy for users.
   a. Stakeholders: Owner
   b. Costs: N/A
11. As part of normal operations, owner should manage water age by looping dead ends, increasing volume turnover, installing appropriately sized watermains, or installing automatic flushing/mixing devices.
   a. Stakeholders: Owner, MIGA, ENVC, engineering consultant
   b. Costs: $2000 to $50,000 for pipe upsizing and installing automatic flushing devices
12. Owner to initiate leak detection and repair program if flows are higher than expected based number of users or there are known leaks in the system.

   a. Stakeholders: Owner, engineering consultant, ENVC, MIGA
   b. Costs: $10,000 plus depending on number of leaks in system (funding through MCW)

13. Owner to install a flow proportioning disinfection system (if not already installed) so chlorination system keeps pace with the increase in flows during flushing and fire flows. Note: alternatively chlorine dosage may be increased manually during the flushing and fire flow event.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultant
    b. Costs: $5000 to install flow paced chlorination system
14. Install chlorine residual analyzer; operate, maintain, and calibrate as directed by manufacturer.
    a. Stakeholders: Owner, MIGA, ENVC
    b. Costs: $10,000 to $30,000
15. Owner to assess water treatment options to decrease bulk water chlorine demand.
    a. Stakeholders: Owner, MIGA, ENVC, SNL, engineering consultants
    b. Costs: $25,000 plus (funding through MCW)
16. Owner to replace or reline old cast iron and ductile iron water pipes to reduce chlorine demand.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
    b. Costs: $10,000 plus depending on system (funding through MCW)
17. Owner to assess alternate disinfectant methods.
    a. Stakeholders: Owner, engineering consultants, ENVC, MIGA
    b. Costs: $25,000 plus depending on system (funding through MCW)
18. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000

19. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500

4.5.3 Reason code E3.

Code E3 indicates insufficient residual disinfectant in water system disinfected by means other than chlorine.

4.5.3.1 Common causes.

This reason code is not used often in NL, as there are very few systems which use a secondary disinfectant other than chlorine (currently only chloramines and hydrogen peroxide being used). Common causes are same as for code E2 and include:

- disinfection system was shut off or not working properly,
- not enough disinfectant being added to the system to keep pace with flow and equipment operating in manual mode,
- not enough disinfectant being added to meet the demand of changes in raw water quality,
- rapid drop in disinfectant throughout the distribution system due to disinfectant demand from pipe wall and demand from bulk water (e.g., water quality iron and manganese), and/or
- water age in the distribution system is not being managed.

4.5.3.2 Corrective measures.

1. Check that disinfection system is operational.
    a. Stakeholders: Owner
    b. Costs: N/A

2. Check that the shelf life of the disinfectant has not expired or test the strength of the chemical for any deterioration.
    a. Stakeholders: Owner
    b. Costs: N/A
3. Owner to confirm existing equipment is in flow proportioning mode, if this function is available on the unit.
    a. Stakeholders: Owner, ENVC, MIGA
    b. Costs: N/A
4. Monitor raw water quality, especially during periods of high rainfall and snowmelt. Adjust disinfectant dosage rates accordingly.
    a. Stakeholders: Owner
    b. Costs: $5000 for additional labour
5. Monitor water usage, particularly during peak demand periods and when larger water users such as fish plant start-up/shut down operations for the season. Adjust disinfection system as required to meet changing demands.
    a. Stakeholders: Owner
    b. Costs: $500 for additional labour
6. Owner should increase disinfectant residuals in the distribution system in accordance with provincial standards. This may be accomplished either increasing the dosage rate of the disinfectant solution or the strength of the disinfectant solution. It is recommended that the dosage rate be attempted first.
    a. Stakeholders: Owner, ENVC, SNL
    b. Costs: $500 for extra disinfectant
7. Owner to increase disinfectant residual testing at end of contact chamber (if available) and throughout the distribution system. If no contact chamber test at first user. Testing should be conducted at locations to be representative of the system, such as at the end of all main distribution lines and throughout the system.

   a. Stakeholders: Owner, ENVC, SNL
   b. Costs: $1000 for additional labour

8. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
   a. Stakeholders: Owner
   b. Costs: N/A
9. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
   a. Stakeholders: Owner, SNL
   b. Costs: N/A
10. Manage water age by looping dead ends, increasing volume turnover, installing appropriately sized watermains, or installing automatic flushing/mixing devices.
    a. Stakeholders: Owner, MIGA, ENVC
    b. Costs: $2000 to $50,000 for pipe upsizing and installing automatic flushing devices
11. Owner to initiate leak detection and repair program if flows are higher than expected based number of users or there are known leaks in the system.
    a. Stakeholders: Owner, engineering consultant, ENVC, MIGA
    b. Costs: $10,000 plus depending on number of leaks in system (funding through MCW)
12. Owner to initiate water conservation strategy for users.
    a. Stakeholders: Owner
    b. Costs: N/A
13. Owner to install a flow proportioning disinfection system (if not already installed) so system keeps pace with the increase in flows during flushing and fire flows. Note: alternatively disinfectant dosage may be increased manually during the flushing and fire flow event.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultant

    b. Costs: $5000 to install flow paced disinfection system

14. Install appropriate disinfectant residual analyzer; operate, maintain, and calibrate as directed by manufacturer.
    a. Stakeholders: Owner, MIGA, ENVC
    b. Costs: $10,000 to $30,000
15. Owner to assess water treatment options to decrease bulk water disinfectant demand.
    a. Stakeholders: Owner, MIGA, ENVC, SNL, engineering consultants
    b. Costs: $25,000 plus (funding through MCW)
16. Owner to replace or reline old cast iron and ductile iron water pipes to reduce disinfectant demand.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
    b. Costs: $10,000 plus depending on system (funding through MCW)
17. Owner to assess alternate disinfectant methods.
    a. Stakeholders: Owner, engineering consultants, ENVC, MIGA
    b. Costs: $25,000 plus depending on system (funding through MCW)
18. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000
19. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500

4.6 Corrective Measures - Reason Code F3

Total coliforms are bacteria that are naturally present in the environment. Their presence in a drinking water system does not mean that there is pathogenic contamination of the system, however it does indicate that the drinking water system is vulnerable because a pathway is present which may allow pathogens into the system. Reason code F2T has not been included as it will be dropped from the list of codes effective April 1, 2016.

4.6.1 Common Causes

In many causes inadequate disinfection may allow bacteria to proliferate within a drinking water system, once a source and pathway exist. So it is important to ensure the provincial disinfection standards are being met.

Common sources and pathways that may allow total coliforms into a drinking water system include:

- non-potable water intrusion into the distribution system (e.g., via pressure loss, cross-connections, firefighting/flushing activities),
- treatment breakthrough,
- sediment build-up in pipes and/or storage tanks,
- pipe wall biofilms and corrosion tubercles,
- lack of vermin proof well caps, tank vents, etc.,
- exposure of water infrastructure components (e.g., pipes, valves, pumps, etc.) to bacteria sources during construction or repairs, and/or
- vandalism, and/or
- lack of preventative maintenance.

In addition, sampling errors and site deficiencies may also cause the issuance of a reason code F3 BWA. Sampling errors may occur when proper sampling protocols are not followed (e.g. tap not flushed, aerator not removed, etc.). Sampling site deficiencies may occur when there are unsanitary conditions at sampling location, recent repairs or maintenance work at the sampling site or site is located on a long service line.

4.6.2 Corrective Measures

1. Owner to assess performance of treatment processes and remedy causes of breakthrough.
    a. Stakeholders: Owner, ENVC, MIGA, engineering consultants
    b. Costs: $5,000 for assessment
2. Once problem causing treatment breakthrough has been rectified, flush system (unidirectional).
    a. Stakeholders: Owner
    b. Costs: $1000
3. Owner to eliminate any cross-connections and educate users about impacts of cross-connections.
    a. Stakeholders: Owner, MIGA, ENVC, SNL, engineering consultants
    b. Costs: $5000 to eliminate cross-connections
4. Owner to restore normal pressures in the distribution system.
    a. Stakeholders: Owner
    b. Costs: N/A
5. Owner to restore normal pressures in the distribution system.
    a. Stakeholders: Owner
    b. Costs: N/A
6. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner
    b. Costs: N/A

7. Drain and flush tanks or reservoir.
    a. Stakeholders: Owner
    b. Costs: $2000
8. Unidirectional flushing of the distribution system away from the treatment system and storage tanks to end of lines.
    a. Stakeholders: Owner
    b. Costs: $1000
9. Owner to confirm existing equipment is in flow proportioning mode, if this function is available on the unit.
    a. Stakeholders: Owner, ENVC, MIGA
    b. Costs: N/A
10. Repair broken or damaged parts of the storage tank or reservoir (e.g., vents, hatches, etc.).
    a. Stakeholders: Owner
    b. Costs: $5000 to $50,000
11. Owner to repair and install screens at openings to storage facilities in order to prevent animals/birds to enter facilities.
    a. Stakeholders: Owner
    b. Costs: $3000
12. Owner to disinfect tank or reservoir in accordance with AWWA C652.
    a. Stakeholders: Owner, ENVC, SNL, HCS
    b. Costs: $5000
13. Install improved security measures such as locks, lighting, signage, fencing and cameras to storage facilities.
    a. Stakeholders: Owner
    b. Costs: $1000 to $10,000
14. Pig lines to remove biofilms and sediment in pipes within the distribution system.

    a. Stakeholders: Owner
    b. Costs: Depends on length and size of pipes.

15. Replace/rehabilitate pipes where sloughing of biofilm is occurring.
    a. Stakeholders: Owner, MIGA, ENVC, engineering consultants
    b. Costs: $2000 to $50,000 depending on site and extent of work
16. Develop or incorporate threat and response into owner's Emergency Response Plan (ERP).
    a. Stakeholders: Owner, FES-NL (Fire and Emergency Services – Newfoundland and Labrador)
    b. Costs: $5000
17. Owner to provide training to samplers on proper sampling protocol for site preparation, flushing service line/tap, sample collection, sample handling, and transport.
    a. Stakeholders: Owner, SNL, ACWWA, On-line courses
    b. Costs: $500 Sanitize sample coolers and ice packs.
18. Ensure samples are shipped properly and secure (e.g. bottles do not tip and become contaminated in transport).
    a. Stakeholders: Owner
    b. Costs: $200
19. Owner to ensure appropriate sampling sites have been selected for bacteriological testing. If in doubt owner may consult with SNL and ENVC.
    a. Stakeholders: Owner, SNL, ENVC
    b. Costs: NA
20. Owner to install dedicated sampling taps.
    a. Stakeholders: Owner, ENVC, SNL
    b. Costs: $200 per sampling tap
21. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A

22. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A
23. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000

4.7 Corrective Measures - Reason Codes F2E, F4, F5, F6, F7, and H

Reason codes F2E, F4, F5, F6, F7 and H have been grouped together in this section because they have the same corrective measures.

The following provides a brief description for the codes:

- Code F2E indicates *E. coli* detected and repeat samples cannot be taken as required.
- Code F4 indicates *E. coli* detected in an initial sample(s) is considered extensive and the water system has other known problems.
- Code F5 indicates *E. coli* detected and confirmed in repeated sample.
- Code F6 indicates viruses detected (e.g., Hepatitis A, Norwalk).
- Code F7 indicates protozoa detected (e.g., Giardia, Cryptosporidium).
- Code H indicates waterborne disease outbreak in the community.

4.7.1 Common causes.

Generally the causes for codes F2E, F4, F5, F6, F7 and H are due to contamination of the water via human or animal wastes. This may include contamination from sewage pipe leaks and private septic systems, which may provide sources of pathogens and bacteria for entry into the water distribution system. Animal wastes in the water supply may also provide a source of contamination. Drinking contaminated water may result in users experiencing severe diarrhea, stomach cramps, vomiting, headaches, etc.

In addition, sampling errors and site deficiencies may also cause the issuance of a reason code F2E BWA. Sampling errors may occur when proper sampling protocols are not followed (e.g. tap not flushed, aerator not removed, etc.). Sampling site deficiencies may occur when there are unsanitary conditions at sampling location, recent repairs or maintenance work at the sampling site or site is located on a long service line.

4.7.2 Corrective measures.

1. Municipalities are required to have Emergency Preparedness Plans under the *Emergency Services Act* administered by the Department of Municipal and Intergovernmental Affairs (MIGA). Scenarios for drinking water related emergencies are typically included in these plans and enacted by municipalities as needed.
    a. Stakeholders: Owners, MIGA, ENVC, SNL, HCS, FES-NL
    b. Costs: N/A
2. Take appropriate emergency responses (review applicable emergency response plan) in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013 http://www.health.gov.nl.ca/health/publichealth/cdc/health_pro_info.html#disease) and input from other government departments.
    a. Stakeholders: Owner, HCS, ENVC, SNL, MIGA, FES-NL
    b. Costs: $20,000

3. Investigate source water and distribution system for sources of pathogenic contamination from faecal; on-site septic systems, cross-connections, sewer overflows, animal feces (domestic, wildlife), storm water runoff, broken sewer mains/services and other sources of sewage. After sources have been identified correct the problem.
    a. Stakeholders: Owner, HCS, ENVC, SNL, engineering consultants
    b. Costs: $2000
4. Remove source of contamination
    a. Stakeholders: Owner, ENVC, SNL, HCS, MIGA, engineering consultants
    b. Costs: Varies depending on extent of problem
5. Eliminate pathways for pathogens into the drinking water system. As was noted for reason code F3, pathways may include non-potable water intrusion into the distribution system (e.g. via pressure loss, cross-connections, fire fighting/flushing activities), treatment breakthrough, pipe wall biofilms and corrosion tubercles, sediment buildup in pipes and storage tanks, lack of vermin proof well caps and tank vents, vandalism, exposure of water infrastructure components (e.g. pipes), and lack of preventative maintenance.
    a. Stakeholders: Owner, ENVC, SNL, HCS, MIGA, engineering consultants
    b. Costs: Varies depending on extent of problem
6. Owner should assess performance of treatment process to determine if additional treatment processes are required.
    a. Stakeholders: Owner, ENVC, MIGA, engineering consultants
    b. Costs: $10,000
7. Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner
    b. Costs: N/A
8. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A

9. Owner to ensure primary and secondary disinfection systems meet Drinking Water Treatment Standards log inactivation requirements for target pathogens.
    a. Stakeholders: Owner, ENVC, SNL, engineering consultants
    b. Costs: Dependent on pathogen and existing disinfection system
10. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A
11. Owner to provide training to samplers on proper sampling protocol for site preparation, flushing service line/tap, sample collection, sample handling, and transport.
    a. Stakeholders: Owner, SNL, ACWWA, On-line courses
    b. Costs: $500 Sanitize sample coolers and ice packs.
12. Ensure samples are shipped properly and secure (e.g. bottles do not tip and become contaminated in transport).
    a. Stakeholders: Owner
    b. Costs: $200
13. Owner to ensure appropriate sampling sites have been selected for bacteriological testing. If in doubt owner may consult with SNL and ENVC.
    a. Stakeholders: Owner, SNL, ENVC
    b. Costs: NA
14. Owner to install dedicated sampling taps.
    a. Stakeholders: Owner, ENVC, SNL
    b. Costs: $200 per sampling tap
15. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000

16. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500

4.8 Corrective Measures - Reason Code G

Reason code G indicates the water supply system integrity is compromised due to disaster, such as contamination of water source from flooding, gross contamination, major power failures, etc.

4.8.1 Common Causes

Water supply system integrity may be comprised due to many causes, some examples are:

- Severe flooding from tropical storms and hurricanes (e.g. Hurricane Igor) which may result in contaminants such as sewage, fuels, farm runoff, debris, dead animals, etc. in the water supply.
- Major power outages during winter storms or events such as "Dark NL" in January 2014. Major and/or extended power outages may result in pressure loss and intrusion of contaminants into the distribution system.
- Spill of chemicals, fuels or other materials into a water supply system.

4.8.2 Corrective measures.

1. Owner to take appropriate emergency response (review applicable emergency response plan) in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013) and input from other government departments.
    a. Stakeholders: Owner, HCS, ENVC, SNL, MIGA, FES-NL
    b. Costs: $20,000

2. Municipalities are required to have Emergency Response Plans under the *Emergency Services Act* administered by MIGA. Owners are to ensure the scenarios for drinking water related emergencies are included in these plans and enacted by owner as needed.
    a. Stakeholders: Owner, MIGA, engineering consultants
    b. Costs: N/A
3. Owner to assess extent and severity of source water contamination.
    a. Stakeholders: Owner, HCS, ENVC, SNL, engineering consultants
    b. Costs: $10,000
4. If necessary, owner to identify an alternative drinking water source.
    a. Stakeholders: Owner, HCS, ENVC, SNL, MIGA, FES-NL, engineering consultants
    b. Costs: $5,000 to $50,000 (plus more for infrastructure to connect to new supply)
5. Owner to assess and correct impact of event on treatment process and all components.
    a. Stakeholders: Owner, ENVC, MIGA, engineering consultants, suppliers
    b. Costs: $10,000
6. Owner to assess and correct impact on distribution system and all components.
    a. Stakeholders: Owner, ENVC, SNL, MIGA, engineering consultants
    b. Costs: $10,000
7. Once treatment and distribution system impact have been addressed and suitable water supply obtained, owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.
    a. Stakeholders: Owner, ENVC, HCS, SNL, MIGA
    b. Costs: $1000
8. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
    a. Stakeholders: Owner
    b. Costs: N/A

9. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.
    a. Stakeholders: Owner, SNL
    b. Costs: N/A
10. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.
    a. Stakeholders: Owner, ENVC
    b. Costs: $1000
11. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, on-line courses and ENVC Operator Education, Training, and Certification.
    a. Stakeholders: Owner, ENVC
    b. Costs: $500

5.0 POTENTIAL PREVENTATIVE MEASURES

Section 5 is prepared in accordance with Task #4 (Section 4.4) of the TOR; providing a detailed summary of potential preventative measures that may be implemented to further reduce BWAs that are issued in NL. This includes recommendations to communities regarding:

- proper operation and maintenance practices, and
- collection and recording of operational data.

In addition, example data log forms are provided which may be used by owners and operators of public drinking water systems for recording key operation and maintenance data. Note: a discussion on public education and barriers and challenges that may inhibit the resolution or reduction of BWAs is provided in Section 8 of this report.

Proactively managing the water supply systems with industry best practices will allow communities to provide a higher level of service with fewer BWAs and a lower total cost of operation. Section 5.1 describes the benefits of preventative maintenance programs and the MIGA Maintenance Assurance Manuals. Section 5.2 provides a recommended maintenance schedule and checklist for four components of a drinking water system. Section 5.3 discusses unplanned maintenance and operational issues, while Sections 5.4 and 5.5 discuss data collection and operator training, respectively.

5.1 Preventative Maintenance

A proactive approach to operating and maintaining a drinking water system based on industry best practices will result in lower total cost of operation and higher level of service. Preventative maintenance is the continual effort to assess the condition of an asset, identify existing and potential issues, and put a concise plan in place to ensure all required maintenance has been completed with the end-goal of achieving the highest level of service from the asset and prolonging its useful life. Asset management programs endeavour to indicate where and when to allocate resources to the maintenance, repair, and replacement of system assets such that the highest overall level of service is maintained at the lowest overall cost. With intelligently timed maintenance of system components, their overall utility can be rejuvenated and preserved to a level near that of a new component thus extending the life of the asset.

Having recognized the importance of maintenance of the water infrastructure to ensure the reliability and sustainability of these systems, MIGA funded a pilot project from 2009-2012 in which Maintenance Assurance Manuals (MAM) were prepared for water systems at four communities following the "Guidelines to Develop a Maintenance Assurance Manual" (Kendall and Kirby 2006). MAMs outline a set of procedures and forms which document the operation and maintenance of a community's potable water system from source to the service laterals. Generally the MAMs were divided into four sections:

- Main Body providing a description of a community's water infrastructure.
- Standard Operating Procedures for common activities such as watermain flushing, disinfection, chlorine testing procedures (if it includes total and free chlorine testing procedures), and water sampling collection procedure.
- Site Specific Equipment which would be depending on the water infrastructure setup for each community. This may include pH adjustment equipment, storage tanks, gas chlorination, and water treatment processes.
- General forms section with generic forms, water distribution forms, and water treatment forms.

Four municipalities implemented the policies and procedures outlined in the manuals in 2011. "Findings indicated that the maintenance assurance manuals improved maintenance records and practices, as well as better informed municipal councils about their water system operations" (MIGA, 2011-12 Annual Report). More information on the MAMs can be found at the following website: www.miga.gov.nl.ca. Information for the remainder of this section is aligned with the intent of MAMs and where applicable references are made to forms developed in the MAMs.

5.1.1 Operation and maintenance practices.

Operation and maintenance (O&M) is central to preventative measures aimed at reducing BWAs. All components of the water supply system are subject to wear, corrosion, fatigue, and misuse. Additionally, vandalism and extreme weather events can negatively impact the level of service a system is able to provide. A suitable O&M plan will help address these impacts by providing a two-pronged approach – both reactive and proactive maintenance. An O&M plan will react to current conditions using the tools to assess the condition of all assets, identify present or upcoming issues, and recommend remediation. An O&M plan will also proactively prescribe maintenance activities on recurring schedules based on industry best practices designed to eliminate issues prior to development.

Asset management may be broken into three components;

- condition inspection and assessment,
- maintenance and replacement planning, and
- municipal budgeting.

5.1.1.1 Condition inspection and assessment.

Condition inspection and assessment serves two functions within an asset management system. Immediately, the inspection will flag conditions of concern which require near-term attention. In the mid and long-term time frames, inspections will produce aggregate data. The condition and operation of every component of the system will degrade with time. The rate of condition degradation will vary with each component, but this aggregate data can be used to predict the upcoming issues within that type of component (e.g., pumps), and then suggest proactive maintenance aimed to eliminate failures leading to system in-operation.

5.1.1.2 Maintenance and replacement planning.

The planning of maintenance and replacement follows condition inspection and assessment. Maintenance is prioritized based on the cost of the maintenance, asset importance, and asset condition to determine the type and timing of maintenance or replacement. Industry best practices will outline typical maintenance intervals which can be used as a rough guide in the absence of more tailored data, and in conjunction with condition assessments. Good reference documents include the "Guidelines to Develop a Maintenance Assurance Manual" (Kendall and Kirby 2006), MAM forms, sample MIGA MAMs prepared for pilot communities (www.miga.gov.nl.ca), and "Best Practices Manual for Small Drinking Water Systems" (Genivar, 2007).

5.1.1.3 Community budgeting.

Community budgeting is closely related to the 'Maintenance and Replacement Planning' component, and serves to predict the funds required in the near, mid, and long-term time frames to continue to offer an acceptable level of service. The mid and long-term budgets will also serve as advance notice of upcoming expenditures which require capital investment or government funding.

5.2 Preventative Operations and Maintenance

Preventative operations and maintenance (POM) are planned at intervals set either by industry best practices or specific intervals communities have developed over time which better represent the requirements of the system. Typical POM tasks for a drinking water system can be divided into four main categories: raw water supply, treatment and disinfection, distribution and water storage. The individual tasks are assigned at a recommended interval, which varies between one day and five years. POM task checklists are described below for daily, weekly, monthly, 3 month, 6 month, annual, and 5 year frequencies (forms are attached in Appendix A3).

5.2.1 Raw water supply.

The raw water supply includes surface water and groundwater sources, watershed, surface water intake, and intake pumping systems. Protection of the watershed and wellhead areas from potential risks due to activity or development is critical to ensure adverse impacts on the water quality are avoided. Water supplies protected under the *Water Resources Act* (2002) are identified as Protected Public Water Supply Areas, which requires developers to obtain development permits under the *Act* and input from the local authority. If not already done, communities are encouraged to contact Water Resources Management Division of ENVC to initiate the process of having their water supply protected under this provincial legislation. Routine inspections of the complete watershed may not be possible where the watershed is very large. However, routine monitoring should be conducted in close proximity to the intake and wellhead. As per MAMs, a 2km radius up gradient and 1km radius from the intake are recommended for surface and groundwater supplies, respectively. In addition to human activity and developments (e.g., excavations, septic fields, fuel or chemical storages, etc.), monitoring should also be conducted for beavers, muskrats, large concentrations of birds, or other animals in the area. Surface water intakes should be inspected for damage and debris, and in order to clean intake screens. Inspections and maintenance at pumping systems, watershed/wellhead sources, and intakes should be conducted at frequencies as noted below:

Daily:

- Conduct visual inspection for leaks, unusual noise and excess vibration of pumps, valves, and motors.
- Log pump cycle times, operational hours, and flow meter readings
- Measure and log flow rates at source pump.
- Complete a daily security check of facilities to assess locks, hatches, doors, windows, vents, security lighting, and alarms to ensure proper operation.
- In winter, check that heating system is working properly to prevent freezing of equipment.

Monthly:

- Measure source pump bearing temperature and conduct a visual inspection of the wellhead for surface water ponding near the intake, development activity, and any storage of chemicals, equipment, fuels, etc. in the area.
- Lubricate pumps, valves, and motors throughout the system.
- Measure and log the static pumping head levels at each well (if applicable).
- Inspect and clean intake structure, intake screens, and intake pipeline. Repair as required.
- Record surface water intake water levels and temperature readings.

6 Months:

- Visually inspect cables and associated electronics for damage.
- Tighten glands on pumps and controllers as required.
- Inspect the watershed area for possible contamination. Identify any new development and activity including storage of fuels, chemicals, equipment, camping activity, use of motorized boats, snowmobiles, cottage developments, etc. Identify any animal activity near the intake such as beavers, birds, etc.
- Inspect watershed protection signs and replace as required.
- Conduct safety review to evaluate potential hazard and review emergency response plan.

Annual:

- Have an electrician measure and log running amperage of each source pump, as well as conduct a 'megger test' on winding insulation.
- Dismantle, inspect, and rebuild pumps as required.
- Inspect dam/reservoir structure for signs of deterioration (cracking, erosion, shifting), spillway blockages/debris, mechanical function, and public safety (if applicable).

- Pipe supports and hangers should be inspected for damage to reduce possibility of damage to piping.
- Paint should be applied where necessary once a year to prevent corrosion.
- Before winter, system should be prepared for operations at lower temperatures.

5.2.2 Treatment and disinfection.

The level of water treatment varies from community to community with some having complex treatment plants while others may have disinfection as the only form of treatment. To ensure the equipment is operating properly, monitoring operations, and routine maintenance must be conducted of the facilities. An operations and maintenance log should be kept to document and monitor compliance with the manufacturer's recommended procedures. A copy of operation manuals and drawings for layout of facility should be kept for trouble shooting the system, ordering parts or contacting the manufacturer or supplier for assistance. Material Safety Data Sheet (MSDS) should also be kept at the facility along with appropriate personal protective equipment (e.g., protective gloves, goggles, face shield, breathing apparatus as appropriate). Below is a summary of the recommend maintenance and frequency at treatment and disinfection facilities.

Daily:

- Measure and record as a minimum at treatment/disinfection facility:
  - Free chlorine residual (mg/L)
  - Total chlorine residual (mg/L)
  - Chlorine quantity in storage (L)
  - Amount of chlorine gas in tank (kg)
  - Calculate chlorine dosage rates (L/cubic metre of water produced)

  - Chlorine solution usage (L/day)
  - Flows into the distribution system (USGPM, m3/d)
  - Pressure on water system (psi)
  - Turbidity (NTU)
  - Visual inspection of chlorine gas equipment rooms

- Conduct visual inspection of chemical feed pumps and chemical feed lines (sometimes these get blocked with air bubbles or the chemical), backwash rates for filters, and pH adjustment chemical usage.
- Measure and record pH levels pre and post adjustment, as well as pH adjustment chemical usage.
- For systems with filtration, check and log filter influent and effluent turbidity where filters are being used for removal of particulate matter to ensure filters are effectively removing suspended material, and also measure and record filter backwash rates.
- Complete a daily security check at all relevant assets to assess locks, hatches, doors, windows, vents, security lighting, and alarms to ensure proper operation.
- In winter, check that heating system is working properly to prevent freezing of equipment.

Weekly:

- Conduct a visual inspection of the chlorine injector and chlorine residual analyzer for leaks and to ensure operating normal.
- Measure and log filter backpressure to provide evaluation of the filter's condition.

Monthly:

- Measure and log chemical pump bearing temperature, as well as conduct a visual inspection of the pumps.

- Inventory all consumables and order as required.
- For systems with filtration; perform a manual backwash and flush of backwash line to increase flow rate, decrease turbidity, and decrease head loss. A visual inspection and lubrication of backwash pumps should be completed to ensure proper pump performance.
- Filters should be visually inspected for damage.
- Control valves should be exercised to prevent seizure.
- Verify operational status of chlorine gas sensors by exposing them to a given amount of chlorine gas according to the method outlined in the operator training section of the DOEC website and replace as required: http://www.env.gov.nl.ca/env/waterres/training/operator_onsite_training/index.html.

3 Months:

- Clean chemical feed lines and solution tanks, as well as calibrate chemical feed pumps.
- Visually inspect pH mixers.
- For systems with filtration, measure and log backwash pump bearing temperature to evaluate trends. If temperature is increasing, then it is an indication that bearings are beginning to wear and should be serviced or replaced.
- A visual inspection of backwash waste water holding tank should be completed to ensure there are no damages.

6 Month:

- Visual inspection of filter vessels to ensure no apparent corrosion inside vessels.
- Calibrate chlorine gas sensors according to manufacturer instructions.

Annual:

- Dismantle, inspect, and rebuild treatment pumps as required.

- Remove filter from process - if media is not easily accessible, plan for filter shutdown in advance. Verify media is uniformly graded and distributed, and each gradation layer of media is the proper depth.
- Pipe supports and hangers should be inspected for damage to reduce possibility of damage to piping.
- Paint should be applied where necessary once a year to prevent corrosion.
- Before winter, system should be prepared for operations at lower temperatures.
- Many communities have an emergency response plan which should include potential issues with the drinking water system. In any event, an emergency drill should be conducted annually to ensure workers know proper procedure should a contamination, chlorine gas leak or fire scenario occur.

5.2.3 Distribution system.

In order to properly operate and maintain the distribution system, as-built drawings should be kept and made readily available in case they are required for emergency maintenance. As the distribution system ages, it may become more prone to leaks and breakages. Leaks increase the water demand and treatment/disinfection of larger than necessary volumes of water. Water usage monitoring at the treatment/disinfection facility will help identify if there are leaks in the system. A good leak detection program, for locating and repairing leaks as they develop is an important part of maintaining the distribution system. Exercising isolation valves, flushing hydrants, removing stagnant water at dead ends and checking disinfectant residuals within the distribution system are all important maintenance and monitoring activities. Some distribution systems may have pumping stations along the distribution system to maintain adequate pressures throughout the system. The recommended maintenance and frequency for water distribution systems is outlined below.

Daily:

- Measure and log minimum free chlorine residual, total chlorine, and pH at set points throughout distribution system to ensure the provincial disinfection standard are met. Testing should be conducted at the first user, at the ends of the water main and end of all branch lines with dead ends.
- Visual inspection of booster pump(s) for wear, breakage, and/or leakage.

Weekly:

- Record pump cycle times and compare with past readings to help identify potential problems.

Monthly:

- Inspect visible piping, connections, and fittings.
- Check for leaks and breakages, complete repairs as soon as possible.
- Measure and record booster pump bearing temperature and compare with previous readings. Higher temperatures may indicate wear.
- Control valves should also be exercised to prevent seizure.

6 Months:

- Have an electrician inspect cables and tighten glands on pumps and controllers as required.

Annual:

- Exercise system valves following a prescribed valve exercising program to prevent seizing and check for damaged valves; repair as required.
- Distribution system should be flushed at a minimum annually (twice per year if possible) to eliminate biofilm and sediment build up within the distribution system.

- Fire hydrants should be exercised during flushing to prevent valve seizure, and any necessary repairs should be implemented.
  - An electrician should be brought in to measure and log running amperage of each source pump. They should also complete a 'megger test' to measure winding insulation. Operators should conduct an annual inspection on pump impellers and replace as required.
  - Dismantle, inspect, and rebuild booster pumps.

5.2.4 Water storage.

Not all water systems have water storage facilities. For those that do, they generally are either steel or concrete tanks. Routine inspections of these facilities should be conducted in accordance with the following recommended frequency:

Daily:

- Measure and log water levels in storage tanks to ensure they are within normal operating range.

Weekly:

- Check for evidence of overflow and leaks such as corrosion or staining. If tank is overflowing, there may be a problem with the pump, water level measurement, and/or control system. If it is below normal, there may be a capacity or control problem, or large leak.
- All openings should be properly screened and checked for tears or blockages to prevent entry of animals and organic matter.
- Weekly chlorine residual measurements should be undertaken and recorded.

Annual:

- Visually inspect all components of the storage tank to identify coating deterioration, shell cracking, concrete deterioration and anchor bolt tension.
- Verify no low points exist on roof which may pool water and accelerate corrosion. Repair sections and coatings as required.
- Pipe supports and hangers should be inspected for damage to reduce possibility of damage to piping.
- Paint should be applied where necessary once a year to prevent corrosion.
- Before winter, system should be prepared for operations at lower temperatures.

5 Years:

- Drain and clean storage tanks and reservoirs. Any substance used to clean, disinfect, recoat, or repair the interior of a drinking water storage tank must be certified as 'safe for use with potable water' (NSF 60/61).
- Complete a thorough inspection of all components including tank shell thickness, metals content of coatings and tank wall biofilm.
- Test and calibrate all sensors gauges. Disinfect before putting back into use according to AWWA C652 and confirm microbiological safety by taking two samples 24 hours apart.

5.3 Unplanned Maintenance

Unplanned maintenance is inevitable in any system, and it is important to have a plan in place to address maintenance arising from unexpected events. In addition to the work required to repair the immediate fault in the system, unplanned maintenance should be used as an opportunity to inspect and/or service any components which would normally require a system shutdown or extensive effort to expose.

Unplanned maintenance poses three areas of critical interest; spare parts and consumables, repair task planning, and documentation.

5.3.1 Spare parts and consumables.

Unlike planned maintenance, unexpected system failures do not afford the opportunity to procure the spare parts and consumables anticipated for the task. In contrast, it is not financially practical to maintain extensive inventories of every component possibly necessary over the lifetime of the system. As such, the operator, in conjunction with the owner's manual or product representative, should develop a list of components and consumables which commonly require replacement, have long supplier lead-times, or are used in common operation (e.g., seals, O-rings, etc.).

Spare parts and consumables are also used during routine maintenance, therefore depleting the inventory under normal operations. The maintenance checklists and logs, found in Appendix A3, have incorporated prompts to ensure operators inventory and re-supply components following all planned and un-planned maintenance.

5.3.2 Repair task planning.

Unplanned maintenance is inherently hasty, and is often conducted without work task plans which outline the anticipated steps for a given task and outline the resources, tools and materials required to complete the task in a timely manner. Completing work task plans prior to commencing repairs ensures that tasks and individual steps are documented and followed, required components and consumables are retrieved, and health, safety, and environmental concerns have been considered and mitigated accordingly. Work task planning should incorporate manufacturer's recommendations or industry best-practices (such as AWWA Standards: C651, C652, C653, and C654 related to disinfection water infrastructure).

5.3.3 Documentation.

The accurate documentation of unplanned maintenance is of particular interest to an asset management system, which may use this data to better predict future failures of similar components. All maintenance information should be documented in the maintenance data logs. Sample logs can be found at MIGA MAMs (www.miga.gov.nl.ca).

5.4 Collecting and Recording Data

Operational data comes from day-to-day activities and light maintenance conducted on a daily basis, as well as the various metrics taken from the system regularly, such as water levels and intake inspections. Suggestions on the operational data to collect and suitable measurement and logging intervals can be found by referring to the tasks within the planned operations and maintenance data forms in Appendix A3. It is important to log operational data in a consistent and accessible manner to ensure adoption of data logging processes. Furthermore, by logging this data within a spreadsheet it can easily be analyzed to display trends indicative of hidden or developing issues.

A summary of the forms included with this document are provided in Table 5.1. Additional forms are available from MAMs at MIGA website: www.miga.gov.nl.ca.

Table 5.1 Summary of Checklist, Forms, and Logs in Appendix A3

Form ID	Description
BCL1	Daily - Preventative O&M Task Checklist
BCL2	Weekly - Preventative O&M Task Checklist
BCL3	Monthly - Preventative O&M Task Checklist
BCL4	3 Month - Preventative O&M Task Checklist
BCL5	6 Month - Preventative O&M Task Checklist
BCL6	Annual - Preventative O&M Task Checklist
BCL7	5 Year - Preventative O&M Task Checklist
BDL1	Daily Log – pH Levels
BDL2	Daily Log – Well Pumping
BDL3	Daily Log – Gas Chemical Usage
BDL4	Daily Log – Liquid/Powder Chemical usage
BDL5	Daily Log – Storage Systems
BDL6	Daily Log – Disinfectant Residual Levels

5.5 Operator Training

As the system operator is involved in the daily operations and maintenance, it is critical to the overall utility of the system that the operator has received adequate training in the operations, inspection, and maintenance of the water system components. Operators should be trained and certified to the classification level required for the type of system they are operating in accordance with the NL Water and Wastewater Operator Certification Program (http://www.env.gov.nl.ca/env/waterres/training/operator_certification/requirements.html). Operators may obtain training through equipment suppliers, ACWWA, on-line courses. In addition, ENVC offers training/education courses related to water distribution and water treatment throughout the province providing operators with the opportunity to take part in training close to their communities. ENVC has 3 Mobile Training Units which allows them to provide hands on training sessions to the operators while they are in their communities.

6.0 STANDARD OPERATING PROCEDURES TO REMOVE BWAS

In accordance with Task #5 (Section 4.6) of the TOR, SOPs have been developed in response to each BWA reason code. They are designed as a field-level guide that outlines the various steps the system operator may undertake to have a BWA lifted or rescinded. Appendix A contains all SOPs for each BWA code, as well as a BWA System Assessment form, preventative maintenance forms and checklists, government contact information, and MCW funding process. As such, Appendix A can be used as a stand-alone document by operators when working to resolve BWAs.

Following research of other relevant districts, no other jurisdiction was found to have SOPs developed to outline the process to have a BWA lifted or rescinded for specific root cause or reason code.

Each SOP has been tailored such that it can be understood and used by individuals of various backgrounds, ranging from municipal government officials to system operators. Each SOP is arranged on a single page flowchart with three main sections:

- BWA cause identification,
- Recommended steps to address BWA,
- Prevent reoccurring BWA,

With the exception of BWA reason code A, all other codes may follow the flow chart outlined in *Figure 6.1* below. The first step is to complete the assessment tool in Appendix A2, and then based on root cause, select the correct short term corrective measures which should be considered in addressing the issue that resulted in the BWA. Once the corrective measures have been implemented, the owner should confirm the system is meeting provincial disinfection standards. Once the disinfection standards are being met, the owner would contact Service NL to re-sample the system for compliance with disinfection and bacteriological standards. If the BWA is removed, then the owner would implement the recommended preventative maintenance plans and proceed with assessment of any long term measures to improve the system. If the BWA is not removed and the code remains the same, the owner would implement any additional corrective measures to resolve the issues. If the BWA is not removed and a new code is used, then the owner would refer to the SOP for the new code and administer the appropriate corrective measures.

Developing SOPs for systematic processes is relatively straight forward. However, when there are many levels of complexities and potential for site specific nuances, developing a SOP becomes more complex. For codes A, B, C, and D, the SOPs are relatively straight forward and should be easy to follow. For more complex BWAs, such as codes E and F, the SOPs become more complex and not all potential causes may be identified due to these complexities. As the SOPs are applied in practice the lessons learnt may be used to further expand and improve the SOPs.

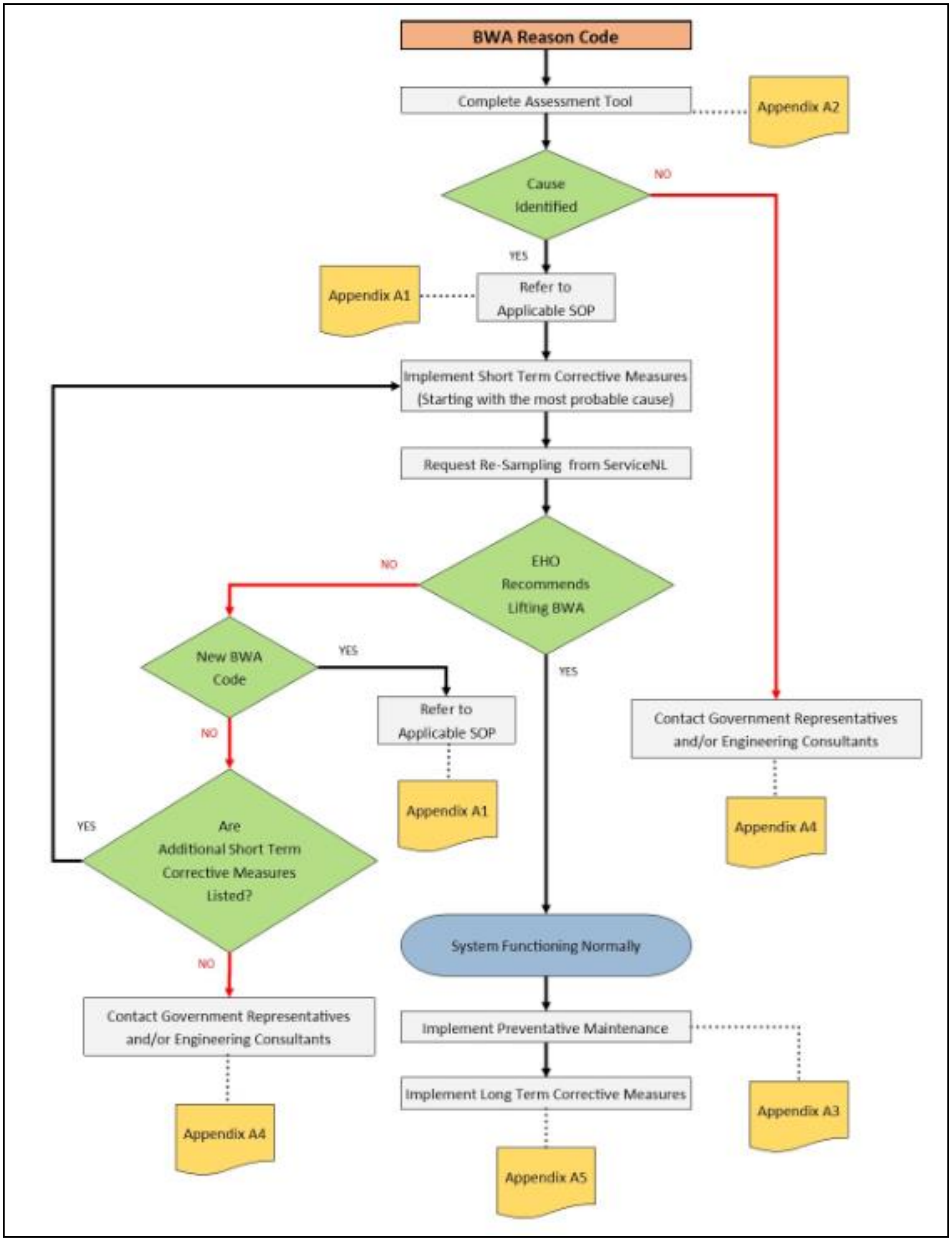

Figure 6.1: Flowchart for SOPs

Table 6.1 below provides a listing of the SOPs that have been developed and each of these are provided in Appendix A1 along with relevant information. SOP #14 is used to address a number of BWA codes that have the same corrective measures. No SOP was developed for reason code F2T as this code will no longer be used as of April 1, 2016.

Table 6.1 Listing of SOPs (see Appendix A1 for SOPs)

SOP Number	Reason Code(s)
1	A
2	B1
3	B2
4	B3
5	C1
6	C2
7	D1
8	D2
9	D3
10	E1
11	E2
12	E3
13	F3
14	F2E, F4, F5
15	F6
16	F7
17	G
18	H

Application of the SOPs for a specific BWA code requires that the BWA code be representative of the situation, which may require updates to the BWA codes over time. For example, if the disinfection system is shut down for maintenance (code C1) for longer than 1 year, than there may be another reason for the BWA other than maintenance issue. Generally, longer duration shut downs may be due to lack of funding (code B3), or the community has no intention of operating the equipment. In some cases, it may be due to lack of available operators to run the system. Section 7 provides guidance on using the SOPs for two pilot communities that are on BWAs.

7.0 IMPLEMENTATION OF SOP ON PILOT COMMUNITIES

Section 7 is prepared in accordance with Task #6 (Section 4.8) of the TOR; to demonstrate the implementation of the SOPs using two pilot communities. One community was to have been on a BWA for over 5 years and one that has been on a BWA for a reason code F due to detection of *E. coli*. In consultation with ENVC the following communities were chosen:

a) Portugal Cove South (PCS), and

b) Gander Bay South (GBS).

7.1 Pilot Community #1 – Portugal Cove South (PCS)

PCS has been on a BWA since January 1, 1984 for reason code E1 (water entering the distribution system or facility, after a 20 minute contact time does not have a free chlorine residual of at least 0.3mg/L or equivalent CT value). In May 2015 a new hypo-chlorination system was installed and upgrades to the water supply intake were completed. According to the 2011 Census the population of PCS was 160 people.

7.1.1 Application of the BWA system assessment form.

The first step of the SOP for code E1 is to apply the BWA System Assessment form. The assessment should be completed by someone knowledgeable about the municipal infrastructure being assessed and if they are not a certified operator or operator with training and experience, an additional resource with the necessary background with drinking water systems may be required (e.g., regional operator, engineering consultant, government official, etc.).

A site visit was completed on October 1,2015, attended by the system operator and helper (both volunteers). The results of the assessment are provided in Appendix B1. Appendix B1 - Table 1.1 was completed based on the available information during the site visit. The flows recorded from the period August 19 to September 19, 2015 ranged from 45-53 USGPM, with peak recorded value of 64 USGPM. The flows observed at the time of the site visit were in the range of 53-57 USGPM. Based on a population of 160 people and using 340L/p/d (theoretical flow for small communities as per NL Guidelines for Design, Construction and Operation of Water and Sewerage Systems) the theoretical average flows should be around 10 USGPM. Free chlorine residuals for the period September 3 to October 1, 2015 were recorded in Appendix B1 - Table 1.2. One of the first users is approximately 200m from the disinfection system. The eastern and western ends of the water main are approximately 900m and 1200m, respectively from the disinfection system. Residuals up to September 13th were recorded to be in compliance with the disinfection standards. A 3-day rain event occurred from September 14 -16, 2015 which reportedly resulted in high sediment loading in the raw water. No adjustments were made to the chlorine dosage rate and it appears the chlorine demand may have been affected by the water quality, as the free chlorine residual at the first user dropped below 0.3mg/L. It should be noted that only one of the two chlorine solution tanks were installed in the plant and that on September 16th the system was shutdown to allow for cleaning of the chlorine tank. After the storm event, it wasn't until September 26, 2015 that the free chlorine residuals at the first user was recorded above 0.3mg/L, however residuals at the end of the water mains remained at or just above the detection limits of the chlorine testing unit.

The system operator provided information to complete the remaining forms on the assessment sheets. Notable issues which may impact the system performance are listed below:

- Long term BWA in place since 1984.
- During heavy rainfall events the water colour and sediment loading increases in the raw water.
- There are a couple of known water main leaks that have not been fixed.
- There may be additional leaks in the eastern end of the watermain as the pipes are 50mm diameter plastic pipes installed by local people over 30 years ago.
- All residents are on private septic tanks and fields which may provide sources of contamination for broken lines or when pressure in the distribution system is low.

- No chlorine residual analyzer was on the system.
- No treatment of the raw water which would remove suspended sediments during rainfall events.
- System was shut down to clean chlorine solution tank as only one tank installed on the disinfection system.
- Flow rates on the system are much higher than expected for the population being serviced. Average flows approximately 5 times theoretical.
- Three beavers have been reported frequenting the water supply intake area.
- The intake reservoir is a very small system with two small drainage networks feeding it. Algae growth was observed in the intake reservoir.
- No pressure gauge on the system.

Some positive notables include:

- new functioning disinfection system,
- even with high flow rates, the 20 minute contact time is being achieved,
- system has flow proportion chlorinator,
- free chlorine residual results are being logged,
- flows and chlorine solution records are being logged in book at the disinfection facility,
- disinfection facility is clean,
- flushing of the water system has been conducted,
- regular cleaning of the screens at the intake is being conducted,
- chlorine tank is being cleaned when necessary, and

- water supply drainage area did not appear to have any development activity which would impact the water quality.

Based on the assessment, four areas of concerns were identified:

A. Critical Issues Resulting in Root Cause of Current BWA

1. Environmental and Treatment Issues: during heavy rainfall events the raw water quality deteriorates resulting in an increase chlorine demand. Without adequate treatment the dosage rate for the disinfection system needs to be manually adjusted to address the changes in water quality. The operator of the system is a new volunteer with limited training in operating drinking water systems.

B. Serious Issues Which May Result in Re-occurring BWAs

1. Serious Issues Which Result in Re-occurring BWAs: the demand on the system suggests there are a number of major leaks in the distribution system which is resulting in flows being over 5 times theoretical flow. This is resulting in higher chlorine usage and more operating costs to treat water which may be flowing into the ground.
2. Source Issue: a number of beavers have been reported using the small intake reservoir, which may contaminate the water supply. There is also some algae growth in the reservoir which may impact raw water quality.
3. Treatment Issue: with only one chlorine tank, it makes it difficult to clean the tank without shutting down the disinfection or distribution system, both options will make system prone to future BWAs.

7.1.2 Corrective measures.

Below is a list of applicable short term measures that have been extracted from SOP #10 for BWA code E1.

1. Check that disinfection system is operational.
2. Check that the shelf life of the disinfectant has not expired.

3. Owner should increase free chlorine residual in the distribution system. This may be accomplished by either increasing the dosage rate of the chlorine solution or the strength of the chlorine solution. It is recommended that the dosage rate be attempted first.
4. Owner to increase free chlorine residual testing at end of chlorine contact chamber (if available) and throughout the distribution system. If no contact chamber test at first user. Testing should be conducted at locations to be representative of the system, such as at the end of all main distribution lines.
5. Continue to monitor raw water quality, especially during periods of high rainfall and snowmelt. Adjust chlorine dosage rates accordingly.
6. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
7. Once owner confirms compliance with above standards contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological standards and treatment standards identified above.
8. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, online courses, suppliers, and ENVC Operator Education, Training and Certification.

In addition to the above short term measures the following long term measures have been selected from SOP #10 and deemed appropriate for PCS.

1. Owner to install chlorine residual analyzer.
2. Owner to assess water treatment options to address changes in raw water quality impacting chlorine demand.
3. Owner to install backup chlorination solution tank.
4. Install pressure gauge.
5. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, online courses, suppliers, and ENVC Operator Education, Training and Certification.

6. Initiate water conservation strategy for users.

7.1.3 Preventative measures.

The community of PCS is recommended to implement preventative measures in accordance with Appendix A3 for water infrastructure. Based on existing water infrastructure the following preventative maintenance is recommended:

Table 7.1 PCS Preventative Maintenance Summary

System Component	Activity	Frequency
Raw Water Supply	Measure and record flow rates.	Daily
	Inspect and clean intake structure, intake screens and pipeline. Repair as required.	Monthly
	Measure and record water levels and temperature.	Monthly
	Visual inspection of cables and associated electronics for damage.	6 Month
	Inspect watershed for possible contamination.	6 Month
	Inspect watershed for signs of animal activity near the intake.	6 Month
	Conduct safety review to evaluate potential hazards and review emergency response.	6 Month
	Inspect dam/intake & spillway for signs of deterioration, blockages, malfunction and public	Annual

	safety.	
Treatment and Disinfection	Complete daily disinfection and treatment logs.	Daily
	Visual inspection of chemical feed pumps and feed lines.	Daily
	Measure and record chemical usage.	Daily
	Visual inspection of chlorine injector for leaks and to ensure normal operation.	Weekly
	Visual inspection of chemical pumps.	Monthly
	Inventory all consumables. Order supplies as necessary.	Monthly
	Clean chemical feed lines and solution tanks.	3 Months
	Calibrate chemical feed tanks.	3 Months
Distribution System	Measure and record free and total chlorine residuals, as well as pH at set points throughout the distribution system (first user, end of mains, and branch lines)	Daily
	Visual inspection of visible piping, connections and fittings for leaks, corrosion or breakage.	Monthly
	Exercise system valves.	Annual
	Flush distribution system.	Annual
	Exercise and lubricate fire hydrants.	Annual

7.2 Pilot Community #2 – Gander Bay South (GBS)

GBS has been on a BWA since July 24, 2015 for reason code F4 (*E. coli* detected in an initial sample is considered extensive and the water systems has other known problems). Records indicate that this has been a recurring issue with numerous BWAs for this reason over the past two years. According to the 2011 Census the population of PCS was 311 people.

7.2.1 Application of the BWA system assessment form.

The first step of the SOP for code F4 is to apply the assessment form. The assessment should be completed by someone knowledgeable about the municipal infrastructure being assessed and if they are not a certified operator or operator with suitable training and experience, an additional resource with the necessary background with drinking water systems may be required (e.g., regional operator, consultant, government official, etc.).

A site visit was completed on October 9, 2015, attended by the system operator (volunteer) and LSD committee chair. The results of the assessment are provided in Appendix B2. Appendix B2 - Table 1.1 was completed based on the available information during the site visit. The flows recorded from period September 4 to October 9, 2015 generally ranged from 21 to 37USGPM, except for a value of 104USGPM on September 30, 2015 (note: there were extensive flow records available prior to September 4, 2015). Based on a population of 311 people and using 340L/p/d (theoretical flow for small community as per NL Guidelines for Design, Construction and Operation of Water and Sewerage Systems) the theoretical average flows should be around 20USGPM.

Although chlorine residuals were being measured by the community, they were not being logged. As such, SNL records were used to complete Table 1.2. One of the first users (Riverview Retirement Home – "GBPCH") is approximately 200m from the disinfection system. The far end of the water main ends in Harris Point approximately 2200m from the disinfection system. Records show that for the 9 samples collected from April 8 to October 22, 2015 free chlorine residuals were above 0.3mg/L at first users (taken to be GBPCH) for all except the July

22 sample. Free chlorine residuals at the end of the distribution system have varied from 0.01 to 0.58mg/L. Total coliforms were detected twice at the far end of the distribution system when free chlorine residuals dropped to 0.04mg/L. Both *E. coli* and total coliforms were detected in the water sample at the GBPCH on July 22, 2015.

The system operator then provided information to complete the remaining forms on the assessment sheets. Notable issues which may impact the system performance are listed below:

- Many leaks in two branch lines with old water pipes.
- Practice has been to shut down all water system when performing repairs on branch lines which results in pressure loss throughout the system. This is occurring on a monthly basis.
- BWAs have been recurring issue in the community.
- All residents have on-site septic systems. When completing repairs on broken water lines, it is suspected that surrounding soils may be contaminated with sewage.
- No chlorine residual analyzer on the system.
- Flow rates on the system increase when there are breaks in the water lines.

Some positive notables include:

- functioning disinfection system,
- system has flow proportion chlorinator,
- flows and chlorine solution records are being logged in book at the disinfection system,
- disinfection facility is clean,
- flushing of the water system has been conducted,
- regular cleaning of the stilling well is being conducted,

- water supply drainage area did not appear to have any development activity which would impact the water quality,
- water is taken from a stream with good aeration and a large watershed,
- with the exception of the two branch lines the distribution system has been upgraded within the past 10 years,
- the volunteer operator has been operating the system for past 4 years and is knowledgeable of the system, and
- disinfection building and access to intake is secured.

Based on the assessment, three areas of concerns were identified:

A. <u>Critical Issues Resulting Cause of Current BWA</u>

1. Operational Distribution Issue: some service lines or old branch lines may go through areas suspected to be contaminated from septic fields.
2. Operational Distribution Issue: two branch lines that are old have frequent leaks and need repairs on monthly basis. The practice of shutting down the whole system when completing repairs results in pressure loss in the distribution system and may allow intrusion of untreated or contaminated water into the system.
3. Operational Distribution Issue: the distribution system is long which requires high free chlorine residuals at the front end of the system to ensure adequate free chlorine residuals at the far end of the distribution system.

The main causes of the code F4 BWA is due to low chlorine residuals within the distribution system, occasional low pressure within the distribution system and source of *E. coli* possibly from intrusion of groundwater near a septic field.

7.2.2 Corrective measures.

Below is a list of applicable short term measures that have been extracted from SOP #14 for BWA code F4.

1. Take appropriate emergency responses in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013) and input from other government departments (including SNL, ENVC, and MIGA)
2. Investigate source water and distribution system for sources of contamination and pathway into the water system.
3. Remove source of contamination.

   Since *E. coli* has been detected at the front end of the distribution system near the retirement home as well as at the far end of the main lines, at least one source of contamination is suspected in the proximity of the front end of the distribution system. When *E.coli* is detected again in the water system a detailed bacteriological program should be conducted to try and find the source of the contamination. In the meanwhile, an assessment should be conducted on the area identifying locations of water main, service lines, septic fields, search for cross-connections, etc. Service NL may also inspect septic tanks and identify those that need to be upgraded.
4. Eliminate pathways for pathogens into the drinking water system. Many of these pathways are identified in SOP for code F3.

   Replacement of two chronic problem branch lines should be conducted as soon as possible. In the meanwhile, when repairs are completed on the water distribution system the area should be isolated using existing valves to ensure the pressure on the main lines are not affected and to minimize the potential for intrusion of untreated water into the water system.
5. Owner should assess performance of treatment process to determine if additional treatment processes are required.
6. Owner should increase disinfection residuals in accordance with provincial standards.

   The free chlorine residuals should be kept high enough at the front end of the distribution system to ensure adequate free chlorine residual on the end of the main lines.

7. Owner to test disinfectant residuals to confirm compliance with the draft Drinking Water Treatment Standards for Newfoundland and Labrador (ENVC, 2015).
8. Owner to contact SNL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water disinfection and bacteriological standards.
9. Owner to provide operator training to increase knowledge with associated cause and corrective measures. Operator training may be obtained via ACWWA, online courses, suppliers, and ENVC Operator Education, Training and Certification.

As long term measures the following is recommended:

1. Owner to ensure all operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards.

7.2.3 Preventative measures.

The community of GBS is recommended to implement preventative measures in accordance with Appendix A3 for water infrastructure. Based on existing water infrastructure the following preventative maintenance is recommended:

Table 7.2: GBS Preventative Maintenance Summary

System Component	Activity	Frequency
Raw Water Supply	Measure and record flow rates.	Daily
	Inspect and clean intake structure, intake screens and pipeline. Repair as required.	Monthly
	Measure and record water levels and temperature.	Monthly
	Visual inspection of cables and associated electronics for	6 Month

	damage.	
	Inspect watershed for possible contamination.	6 Month
	Inspect watershed for signs of animal activity near the intake.	6 Month
	Conduct safety review to evaluate potential hazards and review emergency response.	6 Month
Treatment and Disinfection	Complete daily disinfection and treatment logs.	Daily
	Visual inspection of chemical feed pumps and feed lines.	Daily
	Measure and record chemical usage.	Daily
	Visual inspection of chlorine injector for leaks and to ensure normal operation.	Weekly
	Visual inspection of chemical pumps.	Monthly
	Inventory all consumables. Order supplies as necessary.	Monthly
	Clean chemical feed lines and solution tanks.	3 Months
	Calibrate chemical feed tanks.	3 Months
Distribution System	Measure and record free and total chlorine residuals, as well as pH at set points throughout the distribution system (first user, end of mains, and branch lines)	Daily
	Visual inspection of visible piping, connections and fittings for leaks, corrosion or	Monthly

	breakage.	
	Exercise system valves.	Annual
	Flush distribution system.	Annual
	Exercise and lubricate fire hydrants.	Annual

8.0 CHALLENGES AND BARRIERS TO REDUCING BWAS

This section provides a discussion of challenges and barriers that may inhibit the resolution or reduction of BWAs and fulfills a requirement under Task #4 (Section 4.4) of the TOR. Given that the number of Active BWAs (as of August 6, 2015) was 238 out of the 521 public drinking water distribution systems (as reported end fiscal year 2013/4); there are an obvious number of challenges to reducing BWAs. This section will discuss a number of those challenges and barriers.

8.1 Funding

As was noted in Section 2 of this report, 86% of the active BWAs were for communities with populations less than 500 people. From the analysis of the BWA codes and the common causes reported on BWAs, it appears that funding may be one of the main challenges to operate and maintain the disinfection systems, especially for communities with populations of less than 500 people. This is due to a number of factors including declining and aging populations, insufficient tax revenues collected to operate and maintain the drinking water system, and higher costs for operating drinking water systems with aging infrastructure.

8.2 Trained and Certified Operators

Having trained and certified operators to maintain and operate public drinking water systems has been identified as a key issue to reducing BWAs. Finding and retaining such operators can be difficult in small communities with limited resources to pay competitive wages to the operators. In some cases the operators are volunteers and may not be available full time to operate the system. Section 2 determined that of the active BWAs, only 12% were for communities with certified operators. Sections 3 and 4 outlined many corrective measures and preventative maintenance requirements for operating and maintaining a drinking water system. Each water system may have its challenges, including factors such as poor raw water quality, changing water quality, lack of treatment processes, aging infrastructure, leaks in the distribution system, bulk water demand on disinfectant residuals, long distribution lines, and changes in demand from large users. Every drinking water system in NL will have some of these challenges from time to time. Trained operators are required to monitor and respond to these challenges; otherwise the system may become non-compliant with provincial disinfection and bacteriological standards.

8.3 Understanding Importance of Disinfecting Drinking Water

From analysis of the codes in Section 2, it appears that the duration of BWAs issued for codes B, C, and E (related to disinfection issues or disinfection systems shut off) are longer than codes related to bacteriological standards. This may be due to lack of understanding of the role and importance of disinfecting drinking water. Prior to building water infrastructure, many people were on private wells or collected water from nearby streams, springs, or ponds to drink, and are not used to the taste of chlorine in their drinking water. Many people believe that NL has safe drinking water and they continue to drink water from a public system even with no disinfection without boiling the water. This may be due to the average water user not understanding the risks associated with drinking water that is not disinfected. In addition, the distribution system itself may increase the risks to the water users unless there are disinfection processes in the system. Without disinfectant residuals within the distribution system the inside walls of the pipes may have biofilms and rust which can harbour bacteria and allow regrowth. The lack of a disinfectant could also allow the intrusion of bacteria from an untreated source to grow.

8.4 Liability on Owner and Operators

Since the Walkerton, Ontario *E. coli* outbreak in May 2000, the responsibility and liabilities associated with owning and operating a public drinking water has become well understood. For communities relying on volunteer operators, the potential liabilities and demands of operating a water system may deter people from taking on such roles. This is especially the case if they are not being provided with adequate training, equipment, and supplies to perform the duties. The issuance of a BWA may be seen by the owner and operators as way of removing the liability.

8.5 Communication/Education

Boiling water for cooking, drinking, and brushing teeth takes a considerable effort and would be a huge inconvenience, even for a short duration BWA. In 2010, K. Butt completed a thesis study related to the public perceptions of public drinking water in NL and found that there was low compliance with BWA notifications from focus groups and surveys conducted as part of the study (Butt, 2010). Although public education materials are readily available on HCS and SNL websites, the message may need to be sent out via another media to reach a broader audience. Messages which may need to be communicated to the public include:

- roles of disinfection in water treatment,
- sources of drinking water contamination, and
- why it is important to boil water when a BWA is in effect.

8.6 Use of CT Value in Lieu of 0.3mg/L at First User

The present design criteria for public water systems (Guidelines for the Design, Construction, and Operation of Water and Sewerage Systems) requires 0.3mg/L of free chlorine residual after 20 minutes of contact time at peak hourly flows using the worst case scenario of a water temperature of 0.5°C and pH of between 6-9. This equates to a CT value of 6 or an equivalent log 2 inactivation for viruses. In practice, a free chlorine residual of 0.3mg/L is required at the first user; otherwise a reason code E1 is issued. The use of 0.3mg/L requirement at first user simplifies the application of the CT value of 6, and in many cases, may be on the conservative side. However, it may also result in more BWAs being issued, than if the log method was considered. For example, warmer water temperatures in the summer and improved effectiveness of the disinfectant are not considered when using the 0.3mg/L at the first user, and as such, a higher CT value of 6 may be achieved at free chlorine residuals of 0.3mg/L. Use of the CT value during summer months may reduce the number of BWAs issued. However, this may be more applicable for small distribution systems.

9.0 RECOMMENDATIONS

The main focus of this report was to prepare a set of SOPs for use by operators and owners of public drinking water systems to help them understand the corrective measures that may be taken to have BWAs rescinded. In preparing the SOPs an analysis of historical and active BWAs was conducted, a review undertaken of common causes identified based on responses from government regulators, identification of corrective measures that may be implemented to remedy the causes of a BWA and recommendations outlined for a preventative maintenance programs that owners may use to keep their water systems running smoothly and to remain off BWAs. Based on the work completed for this study a number of recommendations are outlined below which may help reduce the number of BWAs:

9.1 Recommendation 1: Use of SOPs to Remove BWA

Through the use of government resources and external consultants, the SOPs developed as part of this study should be implemented by any community which is on a BWA. On a go-forward basis, a completed BWA System Assessment form should be submitted by the community to regulatory agencies to aid in documentation of the root cause(s) for each BWA and any deficiencies within the water infrastructure system. The completed assessment forms should be maintained at communities' offices. The owner should take the necessary corrective measures outlined in the SOPs to remedy the cause and have the BWA removed. Enforcement of applicable regulatory legislation should be implemented by the province to encourage owners to take the necessary actions in a timely manner and submit the completed BWA System Assessment forms.

9.2 Recommendation 2: Public Education on Disinfection Process

Public education and awareness on the importance of disinfection processes in providing safe potable water and the importance of boiling water when a BWA is in effect is a critical process in reducing the number of BWAs in NL and reducing potential health risks. Until the consumers believe that they should boil water that is not disinfected and want to have the service providers supply water that has been disinfected, the service will be at the discretion of the providers. When competing for money from small budgets, spending money on disinfection processes may not be high priority, especially if the consumers are not demanding this service and there is little enforcement of regulatory legislation. Once educated, consumers may be more willing to pay additional taxes to support the costs associated with operating and maintaining a potable public water system. Public education should be a province wide initiative, using many media types to reach a broader audience.

9.3 Recommendation 3: Operating Training

The province should continue to support and encourage operator education, training and certification for operators of water systems in the province. Results from this study and previous studies indicate that public water infrastructure is better operated and maintained when there are trained and certified operators running the systems. This results in fewer BWAs and if a BWA is issued it is usually rescinded much more quickly. Public water system operators should meet the minimum requirements as outlined under the ENVC's Water and Wastewater System Classification.

9.4 Recommendation 4: Use of CT Value in Lieu of 0.3mg/L at First User

This recommendation may be more applicable to systems with small distribution systems. However, the use of the CT concept and the required CT value for viruses in lieu of 0.3mg/L at first user may also reduce the number of BWAs on smaller systems with short distribution systems. By taking into account the water temperature, as well as the time the water has been in the distribution system at the location of the first user (or sample location), the CT value can be determined in accordance with and in compliance with the *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems* (ENVC, 2005).

9.5 Recommendation 5: Pilot Study Implementation of SOPs

The assessment form and SOPs were found to be useful tools for assessing water infrastructure and identifying corrective measures at two pilot communities as part of this study. It is recommended that the province undertake a pilot study of 10 or more communities, to apply the BWA System Assessment form and use the SOPs to prepare corrective measures work plans, preventative maintenance plans, and to work with the communities to remove the BWAs. The SOPs and BWA System Assessment form should be further refined (as necessary) based on the results and findings from future pilot communities.

10.0 REFERENCES

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APPENDIX A1

STANDARD OPERATING PROCEDURES

BOIL WATER ADVISORY

List of Standard Operating Procedures

SOP No.	Standard Reasons for Issuing Boil Water Advisories	BWA Code
1	Water supply has no disinfection system	A
2	Chlorination system is turned off by the operator, due to taste or other aesthetic considerations	B1
3	Chlorination system is turned off by operator, due to perceived health risks	B2
4	Chlorination system is turned off by operator, due to lack of funds to operate	B3
5	Disinfection system is off due to maintenance or mechanical failure	C1
6	Disinfection system is off due to lack of chlorine or other disinfectant	C2
7	Water distribution system is undergoing maintenance or repairs	D1
8	A cross connection is discovered in the distribution system	D2
9	Inadequately treated water was introduced into the system due to fire flows, flushing operations, interconnections, minor power outage or other pressure loss	D3
10	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
11	No free chlorine residual detected in the water distribution system	E2
12	Insufficient residual disinfectant in water system disinfected by means other than chlorination	E3
13	Total coliforms detected and confirmed in repeat sample	F3
14	Escherichia coli (E. coli) detected AND repeat samples cannot be taken as required Escherichia coli (E. coli) detected in an initial sample(s) is considered extensive and the water system has other known problems Escherichia coli (E. coli) detected and confirmed in repeat sample	F2E F4 F5
15	Viruses detected (egg, Hepatitis A, Norwalk)	F6
16	Protozoa detected (ex, Giardia, Cryptosporidium)	F7
17	Water supply system integrity compromised due to disaster (ex. contamination of water source from flooding, gross contamination, major power failure, etc.)	G
18	Waterborne disease outbreak in the community	H

STANDARD OPERATING PROCEDURE

SOP #	1	REASON CODE:	A — *Water supply has no disinfection system*	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

↓

Identify Potential Cause(s)

↓

Cause #1

No disinfection system.

Cause #2

Lack of financial/staffing resources or knowledge of importance of disinfection.

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Owner to contact government agencies (ENVC, HCS, and Service NL) to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water.
- ☐ Owner to educate residents and water users on the importance of disinfecting the water prior to drinking. Distribute educational pamphlets.
- ☐ Owner to have the existing water system evaluated for recommended upgrades.
- ☐ Owner to apply for funding through MIGA's various funding programs for disinfection system and associated appurtenances. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f
- ☐ Install and operate disinfection system.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure (including screens).
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	2	REASON CODE:	B1—*Chlorination system is turned off by the operator, due to taste or other aesthetic conditions.*	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

↓

Identify Potential Cause(s)

↓

Cause #1

Chlorine taste or odor complaints from residents

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Owner to assess existing equipment, replace non-operational equipment and turn disinfection system on.
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to contact government agencies (ENVC, HCS, and Service NL) to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water.
.
- ☐ Owner to educate residents and water users on the importance of disinfecting the water prior to drinking. Distribute educational pamphlets
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	3	REASON CODE:	B2—Chlorination system is turned off by operator, due to perceived health risks.	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

↓

Identify Potential Cause(s)

↓

Cause #1

Perceived health risks associated with chlorine usage

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Owner to assess existing equipment, replace non-operational equipment and turn disinfection system on.
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to contact government agencies (ENVC, HCS, and Service NL) to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water and the health risks associated with pathogens versus DBPs.
- ☐ Owner to assess water treatment options to remove or reduce disinfection by products.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

Implement Preventative Maintenance

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	4	REASON CODE:	B3—Chlorination system is turned off by operator, due to lack of funds to operate.	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

↓

Identify Potential Cause(s)

↓

Cause #1

Lack of funds

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Owner to assess existing equipment, replace non-operational equipment and turn disinfection system on.
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to educate residents and water users on the importance of disinfecting the public water supply. Distribute educational pamphlets.
- ☐ Owner to contact government agencies (ENVC, HCS, and Service NL) to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water.
- ☐ Owner to undertake full cost accounting/ full cost recovery to understand what it costs to operate and maintain the water system.
- ☐ Increase water taxes collected, use gas tax money and increase priority for disinfecting drinking water to ensure funds are available to operate disinfection system
- ☐ If treatment and disinfection system is more than a basic hypo-chlorination system, owner should contact engineer consultants, MIGA and ENVC to re-evaluate the system and identify sustainable options based on current operating funds (possibly installing a PWDU system).
- ☐ Owner may obtain services from regional operator(s) if available.
- ☐ Owner to examine options to become part of a regional drinking water system.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure .
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	5	REASON CODE:	C1—Disinfection system is off due to maintenance or mechanical failure		0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Disinfection system turned off for planned preventative maintenance

Cause #2

Disinfection system turned off due to component failure

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Unique Short Term Corrective Measures

- ☐ Owner to order new parts to complete repairs, turn disinfection system on and have redundant critical spare parts available for the disinfection system.
- ☐ Upon completing maintenance, owner to turn disinfection system on.

- ☐ Upon completing maintenance, owner to turn disinfection system on.

Implement Short Term Corrective Measures

- ☐ Owner to flush distribution system.
- ☐ Owner to increase disinfectant residual in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner may replace or upgrade disinfection system (as required).
- ☐ Owner to ensure adequate funds available to operate and maintain disinfection system.
- ☐ Implement preventative maintenance programs to minimize mechanical failure.
- ☐ Owner may obtain services from regional operator(s) if available.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	6	REASON CODE:	C2—Disinfection system is off due to lack of chlorine or other disinfectant		0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Owners lack of knowledge of the importance of disinfection and not allocating sufficient funds for this item

Cause #2

Community is located in a remote area with limited supply/transportation options available

Cause #3

Lack of administrative/ logistical capacity to ensure chemicals are ordered as needed.

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Unique Short Term Corrective Measures

- ☐ Owner to contact government agencies (ENVC, HCS, and Service NL) to request assistance in educating stakeholders on the importance of disinfection processes in providing safe drinking water.
- ☐ Owner to educate residents and water users on the importance of disinfecting the public water supply. Distribute educational pamphlets.

Implement Short Term Corrective Measures

- ☐ Owner to order in disinfectant and start up disinfection system.
- ☐ Owner to ensure adequate chlorine is available on site but also that quantities are such that the chemicals do not degrade while in storage. Plan orders based on demand and shelf life. Ensure the product is stored properly to minimize degradation (see manufacturer's instructions for storage).
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to undertake full cost accounting/ full cost recovery to understand what it costs to operate and maintain the water system.
- ☐ Owner may obtain services from regional operator(s) if available.
- ☐ Owner should identify alternate suppliers for disinfectant. Owner may also confirm what nearby communities use same disinfectant and make arrangements or agreement for loan/purchase in event of emergency. Disinfectant used should be NSF 60 certified and not be beyond shelf life.
- ☐ Owner may evaluate the feasibility of an on-site chlorine generator if their community is remote.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.

Implement Long Term Corrective Measures (cont'd)

- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	7	REASON CODE:	D1—Water distribution system is undergoing maintenance or repairs	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

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Identify Potential Cause(s)

↓

Cause #1

Water distribution system is undergoing planned maintenance or repairs.

Cause #2

Water distribution system is undergoing unplanned maintenance or repairs.

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Owner to repair or replace malfunctioning/broken component and have redundant critical spare parts available for the distribution system.
- ☐ Owner to maintain positive water pressure and proper sanitary conditions (follow proper sanitary techniques when undertaking maintenance) within the distribution system when undertaking repairs or during flushing.
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to ensure adequate funds available to operate and maintain distribution system.
- ☐ Implement preventative maintenance programs to minimize mechanical failure.
- ☐ Owner may obtain services from regional operator(s) if available.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	8	REASON CODE:	D2—A cross-connection is discovered in the distribution system	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Discovery of a cross-connection between the potable water system and non-potable water source.

Some common cross-connections:
A) Connection to unapproved water supply.
B) Private wells.
C) Water line going through septic field.
D) Garden hose or other pipe connected to water distribution system with no back flow preventer and submerged in untreated water or other liquids.
E) Loss of water pressure in the distribution system resulting in back siphoning of untreated water into the system.

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Owner to eliminate cross-connections and educate water users about impacts of cross-connections.
- ☐ Upon removing cross-connections owner should flush system (unidirectional).
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to repair any leaks in the water distribution system.
- ☐ Owner to install backflow prevention assemblies and devices and maintain as required.
- ☐ Owner to implement cross-connection control and backflow prevention (CCCBFP) program.
- ☐ Maintain adequate pressure in the system to prevent backflow and back siphonage by installing booster pumping stations, variable frequency drive pumps (VFD's), elevated storage facilities, surge tanks and relief valves, and modify high service pumps. Install automatic pressure monitoring and control.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	9	REASON CODE:	D3—Inadequately treated water was introduced into the system due to fire flows, flushing operations, interconnections, minor power out age, or other pressure loss.	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Inadequately disinfected water introduced into system due to fire flows, flushing operations, interconnections, power outages, or pressure loss.

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Owner to confirm existing equipment is in flow proportioning mode if this function is available on the unit.
- ☐ Owner to eliminate interconnections that may introduce inadequately treated water into the distribution system.
- ☐ Upon correcting interconnections and restoring pressure to distribution system, flush the system (unidirectional).
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to install a flow proportioning disinfection system (if not already installed) so chlorination system keeps pace with the increase in flows during flushing and fire flows. Alternatively, chlorine dosage may be increased manually during flushing and fire flow events.
- ☐ Owner to install backflow prevention assemblies and devices and maintain as required.
- ☐ Owner to provide new disinfection system for any new water sources.
- ☐ Maintain adequate pressure in the system to prevent backflow and back siphonage by installing booster pumping stations, variable frequency drive pumps (VFD's), elevated storage facilities, surge tanks and relief valves, and modify high service pumps. Install automatic pressure monitoring and control.
- ☐ Owner to install back up power for disinfection system to ensure system operates during power outages.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	10	REASON CODE:	E1—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.	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1
Increased flows (demand) on the distribution system and the disinfection system is operating in manual mode

Cause #2
Change in water quality affecting the chlorine demand

Cause #3
Disinfectant strength weak due to long storage beyond shelf life

Cause #4
Design of system did not provide for adequate contact time

Cause #5
Insufficient chlorine dosages

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Unique Short Term Corrective Measures

- ☐ Continue to monitor water usage, particularly when larger water users have high flows (e.g., fish plant start-up/shut down operations for the season). Adjust chlorine dosage rates accordingly.
- ☐ Owner to switch equipment to flow proportioning mode if this function is available on the unit.

- ☐ Owner to increase free chlorine residual testing at end of chlorine contact chamber (if available) and throughout the distribution system. If no contact chamber test at first user. Distribution system testing should be conducted at locations to be representative of the system, such as at the end of all main distribution lines.
- ☐ Confirm disinfectant has not expired or test the strength of the chemical for any deterioration.
- ☐ Continue to monitor raw water quality, especially during periods of high rainfall and snowmelt, or when larger water users typically have high flows (e.g., fish plant start-up/shut down operations for the season). Adjust chlorine dosage rates accordingly.

Implement Short Term Corrective Measures

- ☐ Check that disinfection system is operational.
- ☐ Owner should increase free chlorine residual in the distribution system. This may be accomplished by either increasing the dosage rate using the pump stroke, frequency settings, or increasing the strength of the chlorine solution. It is recommended that the dosage rate be attempted first.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with applicable disinfection and treatment standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Install chlorine residual analyzer; operate, maintain, and calibrate as directed by manufacturer.
- ☐ Owner to determine where in the distribution system the required 20 minute contact time at peak flow occurs.
- ☐ Install a flow proportioning disinfection system (if not already installed).
- ☐ Install contact chamber (if none currently exists on the system and adequate contact time is not available).

Implement Long Term Corrective Measures (cont'd)

- ☐ Initiate water conservation strategy for users.
- ☐ Owner to assess alternate disinfectant methods.
- ☐ Owner to assess water treatment options to address changes in raw water quality impacting chlorine demand.
- ☐ Owner to initiate leak detection and repair program if flows are higher than expected based on number of users or there are known leaks on the system.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	11	REASON CODE:	E2—No free chlorine residual detected in the water distribution system.	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1
Not enough chlorine being added by the disinfection system in manual mode and unable to keep pace with flow

Cause #2
Not enough chlorine being added to meet the chlorine demand as a result of changes in raw water quality

Cause #3
Water age in the distribution system is not being managed

Cause #4
Disinfection system was shut off or not working properly

Cause #5
Rapid drop in free chlorine residual throughout the distribution system due to chlorine demand from pipe wall and demand from bulk water

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Unique Short Term Corrective Measures

- ☐ Owner to switch existing equipment to flow proportioning mode if this function is available on the unit.
- ☐ Monitor water usage, particularly during peak periods or when larger water users are in operation (e.g., fish plant startup shut down operations for the season). Adjust chlorine rates accordingly if in manual mode.
- ☐ Continue to monitor raw water quality, especially during periods of high rainfall and snowmelt. Adjust chlorine dosage rates accordingly.
- ☐ Owner should conduct a recurring flushing program throughout the area in question and at the end of any watermain lines.

Implement Short Term Corrective Measures

- ☐ Check that disinfection system is operational.
- ☐ Check that the shelf life of the disinfectant has not expired or test strength of chemical.
- ☐ Owner should increase free chlorine residual in the distribution system in accordance with provincial standards. This may be accomplished by either increasing the dosage rate using the pump stroke, frequency settings, or increasing the strength of the chlorine solution. It is recommended that the dosage rate be attempted first.

Confirm Operation and Lift BWA

- ☐ Owner to increase free chlorine residual testing at end of chlorine contact chamber (if available) and throughout the distribution system. If no contact chamber test at first user. Distribution system testing should be conducted at locations to be representative of the system, such as at the end of all main distribution lines.
- ☐ Owner to test disinfectant residuals to confirm compliance with applicable disinfection and treatment standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to install a flow proportioning disinfection system (if not already installed).
- ☐ Owner to assess alternate disinfectant methods.
- ☐ Initiate water conservation strategy for users.
- ☐ Owner to initiate leak detection and repair program if flows are higher than expected based on number of users or there are known leaks in the system.
- ☐ Install chlorine residual analyzer; operate, maintain, and calibrate as directed by manufacturer.
- ☐ Owner to assess water treatment options to decrease bulk chlorine demand.

Implement Long Term Corrective Measures (cont'd)

- ☐ Owner to replace or reline old cast iron and ductile iron water pipes to reduce chlorine demand.
- ☐ Owner should manage water age by looping dead ends, increasing volume turnover, installing appropriately sized watermains, or installing automatic flushing/mixing devices.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation on existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	12	REASON CODE:	E3—Insufficient residual disinfectant in water system disinfected by means other than chlorination	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Not enough disinfectant being added by the disinfection system in manual mode and unable to keep pace with flow

Cause #2

Not enough disinfectant being added to meet the disinfectant demand as a result of changes in raw water quality

Cause #3

Water age in the distribution system is not being managed

Cause #4

Disinfection system was shut off or not working properly

Cause #5

Rapid drop in free disinfectant residual throughout the distribution system due to disinfectant demand from pipe wall and demand from bulk water

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Unique Short Term Corrective Measures

- ☐ Owner to switch existing equipment to flow proportioning mode if this function is available on the unit
- ☐ Monitor water usage, particularly during peak periods or when larger water users are in operation (e.g., fish plant startup shut down operations for the season). Adjust disinfection rates accordingly if in manual mode.
- ☐ Continue to monitor raw water quality, especially during periods of high rainfall and snowmelt. Adjust disinfectant dosage rates accordingly.
- ☐ Owner should conduct a recurring flushing program throughout the area in question and at the end of any watermain lines.

Implement Short Term Corrective Measures

- ☐ Check that disinfection system is operational.
- ☐ Check that shelf life of the disinfectant has not expired or test strength of disinfectant chemicals.
- ☐ Owner should increase disinfectant residual in the distribution system in accordance with provincial standards. This may be accomplished by either increasing the dosage rate using the pump stroke, frequency settings, or increasing the strength of the chlorine solution. It is recommended that the dosage rate be attempted first.

Implement Short Term Corrective Measures (cont'd)

- ☐ Owner to increase disinfectant residual testing at end of disinfectant contact chamber (if available) and throughout the distribution system. If no contact chamber test at first user. Distribution system testing should be conducted at locations to be representative of the system, such as at the end of all main distribution lines.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with applicable disinfection and treatment standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner to install a flow proportioning disinfection system (if not already installed).
- ☐ Owner to assess alternate disinfectant methods.
- ☐ Initiate water conservation strategy for users.
- ☐ Owner to initiate leak detection and repair program if flows are higher than expected based on number of users or there are known leaks in the system.
- ☐ Install disinfectant residual analyzer; operate, maintain, and calibrate as directed by manufacturer.
- ☐ Owner to assess water treatment options to decrease bulk disinfectant demand.

Implement Long Term Corrective Measures (cont'd)

- ☐ Owner to replace or reline old cast iron and ductile iron water pipes to reduce disinfectant demand.
- ☐ Owner should manage water age by looping dead ends, increasing volume turnover, installing appropriately sized watermains, or installing automatic flushing/mixing devices.
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record disinfectant residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of disinfectant injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	13	REASON CODE:	F3—Total coliforms detected and confirmed in repeat sample	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

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Identify Potential Cause(s)

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Cause #1
Non-potable water intrusion into the distribution system (e.g., via pressure loss, cross-connections, firefighting/ flushing activities)

Cause #2
Treatment breakthrough

Cause #3 & #4
(3) Pipe wall biofilms and corrosion tubercles and (4) sediment buildup in pipes and/or storage tanks

Cause #5
Lack of vermin proof well caps, tank vents, etc.

Cause #6
Vandalism

Cause #7 & #8
(7) Sampling error and (8) sampling site deficiency

Cause #9
Lack of preventative maintenance

Cause #10
Exposure of water infrastructure components (e.g., pipes) to bacteria sources during construction or repairs

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Unique Short Term Corrective Measures

- ☐ Owner to eliminate any cross-connections.
- ☐ Owner to restore normal pressures in the distribution system
- ☐ Owner to switch existing equipment to flow proportioning mode (if this function is available on the unit).

- ☐ Owner to assess performance of treatment processes and remedy causes of breakthrough.

- ☐ Unidirectional flushing of the distribution system.

- ☐ Repair broken or damaged parts of the storage tank or reservoir (e.g., vents, hatches, etc.).
- ☐ Owner to repair and install screens at openings to storage facilities in order to prevent animals/birds from entering facilities.

- ☐ Install improved security measures such as locks, lighting, signage, fencing and cameras

- ☐ Owner to provide training to samplers on proper sampling protocol for site preparation, flushing service line/tap, sample collecting, handling, and transport.
- ☐ Ensure samples shipped properly and secure.
- ☐ Owner to ensure appropriate sampling sites have been selected for bacteriological testing. If in doubt, owner may consult with Service NL and ENVC.
- ☐ Owner to install dedicated sampling taps.

Implement Short Term Corrective Measures

- ☐ Check that disinfection system is operational.
- ☐ Once problem causing treatment breakthrough has been rectified, flush distribution system (unidirectional), drain and flush tanks as required.
- ☐ Owner to disinfect tank or reservoir in accordance with AWWA C652.
- ☐ Owner to increase disinfectant residuals in the distribution system in accordance with provincial disinfection standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with applicable disinfection and treatment standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Replace/rehabilitate pipes where sloughing of biofilm is occurring.
- ☐ Pig lines to remove biofilms and clean inside of pipes in distribution system.
- ☐ Develop or incorporate threat and response into owner's Emergency Response Plan (ERP).
- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	14	REASON CODE:	F2E—Escherichia coli (E. coli) detected AND repeat samples can not be taken as required F4—Escherichia coli (E.coli) detected in an initial sample(s) is considered extensive and the water system has other known problems. F5—Escherichia coli (E.coli) detected and confirmed in repeat sample.	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Fecal contamination of water from human waste (sewage pipe leaks and private septic fields) and animal waste (livestock and wildlife)

Cause #2

Sampling errors

Cause #3

Sampling site deficiency

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Municipalities are required to have Emergency Response Plans under the *Emergency Services Act* administered by the Department of Municipal and Intergovernmental Affairs (MIGA). Scenarios for drinking water related emergencies are typically included in these plans and enacted by municipalities as needed.
- ☐ Take appropriate emergency responses in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013) and input from other government departments (including Service NL, ENVC, and MIGA).

Implement Unique Short Term Corrective Measures

- ☐ Owner to provide training to samplers on proper sampling protocol for site preparation, flushing service line/tap, sample collecting, handling, and transport.
- ☐ Ensure samples shipped properly and secure.
- ☐ Owner to ensure appropriate sampling sites have been selected for bacteriological testing. If in doubt, owner may consult with Service NL and ENVC.
- ☐ Owner to install dedicated sampling taps.

Implement Short Term Corrective Measures (cont'd)

- ☐ Investigate source water and distribution system for sources of fecal contamination; on-site septic systems, cross-connections, sewer overflows, animal feces (domestic and wildlife), storm water runoff, broken sewer mains/ services, and other sources of sewage.
- ☐ Remove source of contamination.
- ☐ Owner should increase disinfection residuals in accordance with provincial standards.
- ☐ Owner to ensure primary and secondary disinfection systems meet Drinking Water Treatment Standard log inactivation requirements for target pathogens.
- ☐ Eliminate pathways for pathogens into the drinking water system. Pathways may include non-potable water intrusion into the distribution system (e.g., via pressure loss, cross-connections, fire fighting/flush activities) treatment breakthrough, pipe wall biofilms and corrosion tubercles, sediment buildup in pipes and storage tanks, lack of vermin proof well caps, tank vents, etc., vandalism, exposure of water infrastructure components (e.g., pipes), and lack of preventative maintenance.
- ☐ Owner should assess performance of treatment process to determine if additional treatment processes are required.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.

Confirm Operation and Lift BWA (cont'd)

- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	15	REASON CODE:	F6—Viruses detected (e.g., Hepatitis A, Norwalk).	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

↓

Identify Potential Cause(s)

↓

Cause #1

Virus contamination of water

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Take appropriate emergency responses in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013) and input from other government departments (including Service NL, ENVC, and MIGA).
- ☐ Investigate source water and distribution system for sources of pathogenic contamination via human or animal waste, such as on-site septic systems, cross-connections, sewer overflows, animal feces (domestic and wildlife), storm runoff, broken sewer mains/ services, and other sources of sewage.
- ☐ Remove source of contamination.
- ☐ Eliminate pathways for pathogens into the drinking water system. Pathways may include non-potable water intrusion into the distribution system (e.g., via pressure loss, cross-connections, fire fighting/flush activities) treatment breakthrough, pipe wall biofilms and corrosion tubercles, sediment buildup in pipes and storage tanks, lack of vermin proof well caps, tank vents, etc., vandalism, exposure of water infrastructure components (e.g., pipes), and lack of preventative maintenance.
- ☐ Owner should assess performance of treatment process to determine if additional treatment processes are required.
- ☐ Owner should increase disinfection residuals in accordance with provincial standards.
- ☐ Owner to ensure primary and secondary disinfection systems meet Drinking Water Treatment Standard log inactivation requirements for target pathogens.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	16	REASON CODE:	F7—Protozoa detected (e.g., Giardia, Cryptosporidium)	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Protozoal contamination of water

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Take appropriate emergency responses in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013) and input from other government departments (including Service NL, ENVC, and MIGA).
- ☐ Investigate source water and distribution system for sources of pathogenic contamination via human or animal waste, such as on-site septic systems, cross connections, sewer overflows, animal feces (domestic and wildlife), storm runoff, broken sewer mains/ services, and other sources of sewage.
- ☐ Remove source of contamination.
- ☐ Eliminate pathways for pathogens into the drinking water system. Pathways may include non-potable water intrusion into the distribution system (e.g., via pressure loss, cross-connections, fire fighting/flush activities) treatment breakthrough, pipe wall biofilms and corrosion tubercles, sediment buildup in pipes and storage tanks, lack of vermin proof well caps, tank vents, etc., vandalism, exposure of water infrastructure components (e.g., pipes), and lack of preventative maintenance.
- ☐ Owner should assess performance of treatment process to determine if additional treatment processes are required.
- ☐ Owner should increase disinfection residuals in accordance with provincial standards.
- ☐ Owner to ensure primary and secondary disinfection systems meet Drinking Water Treatment Standard log inactivation requirements for target pathogens.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	17	REASON CODE:	G—Water supply system integrity compromised due to disaster (e.g., contamination of water source from flooding, gross contamination, major power failure, etc.).	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

↓

Identify Potential Cause(s)

↓

Cause #1

Issues stemming from a disaster such as contamination of water source from flooding, gross contamination, major power failure, etc.

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Municipalities are required to have Emergency Response Plans under the *Emergency Services Act* administered by the Department of Municipal and Intergovernmental Affairs (MIGA). Scenarios for drinking water related emergencies are typically included in these plans and enacted by municipalities as needed.
- ☐ Take appropriate emergency responses in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013) and input from other government departments (including Service NL, ENVC, and MIGA).
- ☐ Owner to assess extent and severity of source water contamination.
- ☐ If necessary, owner to find an alternative drinking water source.
- ☐ Owner to assess and correct impact of event on treatment process and all components.
- ☐ Owner to assess and correct impact on distribution system and all components.
- ☐ Once treatment and distribution system impact have been addressed and suitable water supply obtained, owner should increase disinfection residuals in accordance with provincial standards.

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

STANDARD OPERATING PROCEDURE

SOP #	18	REASON CODE:	H—Waterborne disease outbreak in the community	REV:	0	DATE:	Dec. 2015

BWA CAUSE IDENTIFICATION

Complete Assessment Tool

Identify Potential Cause(s)

Cause #1

Waterborne disease contamination

RECOMMENDED STEPS TO ADDRESS BOIL WATER ADVISORY

Implement Short Term Corrective Measures

- ☐ Take appropriate emergency responses in conjunction with Department of Health and Community Services - Disease Control Manual (HCS, 2013) and input from other government departments (including Service NL, ENVC, and MIGA).
- ☐ Investigate source water and distribution system for sources of pathogenic contamination via human or animal waste, such as on-site septic systems, cross connections, sewer overflows, animal feces (domestic and wildlife), storm runoff, broken sewer mains/ services, and other sources of sewage.
- ☐ Remove source of contamination.
- ☐ Eliminate pathways for pathogens into the drinking water system. Pathways may include non-potable water intrusion into the distribution system (e.g., via pressure loss, cross-connections, fire fighting/flush activities) treatment breakthrough pipe wall biofilms and corrosion tubercles, sediment buildup in pipes and storage tanks, lack of vermin proof well caps, tank vents, etc., vandalism, exposure of water infrastructure components (e.g., pipes), and lack of preventative maintenance.
- ☐ Owner should assess performance of treatment process to determine if additional treatment processes are required.
- ☐ Owner should increase disinfection residuals in accordance with provincial standards

Confirm Operation and Lift BWA

- ☐ Owner to test disinfectant residuals to confirm compliance with the Drinking Water Treatment Standards.
- ☐ Owner to contact Service NL office to request an Environmental Health Officer to re-sample the drinking water system for compliance with provincial drinking water bacteriological and disinfection standards.

Implement Long Term Corrective Measures

- ☐ Owner should provide opportunities for training to increase operators knowledge associated with cause and corrective measures.
- ☐ Owner should ensure operators have appropriate level of training/education to allow operators to be eligible for certification in accordance with provincial standards. Operator training may be obtained via ACWWA, On-line courses and ENVC Operator Education, Training and Certification.

Capital Works Funding

- ☐ Contact nearest MIGA regional office and ENVC to initiate evaluation of existing water infrastructure.
- ☐ Owner to work with stakeholders (MIGA, ENVC, and engineering consultants) to identify sustainable options.
- ☐ Owner to make an application to MIGA for project funding. Online applications can be made at: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f.

IMPLEMENT PREVENTATIVE MAINTENANCE

DAILY

- ☐ Measure and record flow rates.
- ☐ Complete daily disinfection and treatment logs.
- ☐ Visual inspection of chemical feed pumps and feed lines.
- ☐ Measure and record chemical usage.
- ☐ Measure and record free and total chlorine residual throughout the distribution system (first user, end of main and branch lines).

WEEKLY

- ☐ Visual inspection of chlorine injector for leaks and ensure operating normal.

MONTHLY

- ☐ Inspect and clean intake structure, intake screens and pipeline.
- ☐ Inventory all consumables and order supplies as necessary.

3 MONTHS

- ☐ Clean chemical feed lines and solution tanks.

6 MONTHS

- ☐ Inspect watershed for potential sources of contamination (including development activity, storage of chemicals/fuels and animal activity).

ANNUAL

- ☐ Inspect dam and spillway for signs of deterioration, malfunction, blockages and public safety.

For more detailed information on preventative maintenance schedules for water infrastructure visit http://www.env.gov.nl.ca/env/waterres/waste/community.html

APPENDIX A2

BOIL WATER ADVISORY SYSTEM

ASSESSMENT FORMS

BOIL WATER ADVISORY SYSTEM ASSESSMENT FORM

Town Name			
Assessor Name			
Assessor Title			
Contact Phone #		Date of Assessment	

Boil Water Advisory Issue Date	
BWA Reason Code	

Cause(s) of BWA	1.	
	2.	
	3.	
	4	

This assessment tool is designed to identify possible issues and root causes of situations leading to a boil water advisory (BWA). It is designed as a field-level exercise and should be completed by or with the participation of the system operator. This assessment tool is designed to be used in conjunction with the Standard Operating Procedures (SOP) to identify the issue and then correct it.

Instructions

1. Tables 1.1 and 1.2 have been provided to log disinfection parameters and to identify disinfectant residual trends. For best results take readings at approximately the same time of day on a daily basis.

2. The main assessment worksheet asks a series of questions on the condition and operation of each component of the system. Responses are either Yes, No or NA and the Result is identified as being OK, Serious or Critical. 'Critical' indicates that it is a root cause for the current BWA, 'Serious' indicates issue makes system prone to re-occuring BWAs and 'OK' indicates no concerns. NOTE: Complete entire Assessment worksheet even if appears the cause has been identified.

3. The last page of this assessment tool (BWA System Assessment Summary) is used to document the 'Serious' and 'Critical' issues identified on the worksheet. This sheet is then used in conjunction with the appropriate SOP to mitigate the issue such that the BWA can be lifted.

Table 1.1	OVERALL SYSTEM OPERATION				
Rated Capacity of System:			Number of Users:		
Date	**Time of Day**	**Disinfectant Usage Rate**	**Strength of Mixed Disinfectant Solution**	**Free Residual Immediately After Disinfection**	**Produced Water Flow**
		Unit:	Unit:	Unit:	Unit:

Notes:

Table 1.2	CHLORINE RESIDUAL TREND		
Chlorine Measuring Device	Make:	Accuracy:	
	Model:		

Location	Distance from Disinfection System
Location 1.	
Location 2.	
Location 3.	
Location 4.	

Date & Time	**Location 1**		**Location 2**		**Location 3**		**Location 4**	
	Total	Free	Total	Free	Total	Free	Total	Free

Notes:

Code	System Aspects	CR - Critical Issue SR - Serious Issue	
		Response Yes/No/NA	**Result** CR / SR /OK
Drinking Water System Facility Events			
F-1	Has there been recent operations or maintenance that could introduce bacteria into the system?		
	Notes:		
F-2	Has system pressures dropped below 20psi recently?		
	Notes:		
F-3	Has there been a recent fire fighting, hydrant flushing or other high-flow event?		
	Notes:		
F-4	Is the disinfection system and surrounding area free of visible unsanitary conditions?		
	Notes:		
F-5	Has there been a indication from Department of Health and Community Services of a waterborne illness outbreak?		
	Notes:		
F-6	Has the facility been subject to additional BWAs within the past 12 months? List reason codes.		
	Notes:		
F-7	Were the last water samples results satisfactory? Explain below.		
	Notes:		
F-8	Has the facility been subject to unauthorized access?		
	Notes:		
F-9	Have maintenance logs been reviewed to identify possible causes?		
	Notes:		
F-10	Has an increased color been noted in the source water?		
	Notes:		
F-11	Has there been an increase in turbidity in source water or tap water?		
	Notes:		
F-12	Has there been complaints of water taste from residents?		
	Notes:		

Code	System Aspects	CR - Critical Issue SR - Serious Issue Response Yes/No/NA	Result CR / SR /OK
F-13	Has there been complaints of odor in tap water from residents?		
	Notes:		
Operational Change			
O-1	Has there been any additional or backup equipment added to system recently?		
	Notes:		
O-2	Has there been any significant changes in water demand (eg. additional large consumers such as fish plants)?		
	Notes:		
O-3	Have additional water sources been added recently?		
	Notes:		
Distribution System			
D-1	Do SCADA logs indicate a low pressure event (less than 20 PSI)?		
	Notes:		
D-2	Are there any known cross-connections on the system?		
	Notes:		
D-3	Were any unsanitary conditions identified at pump station?		
	Notes:		
D-4	Has there been recent pump maintenance conducted?		
	Notes:		
D-5	Are distribution assets secured against unauthorized access?		
	Notes:		
D-6	Have recent water main repairs followed AWWA 651 disinfection protocol?		
	Notes:		
D-7	Has there been a recent water main branch installation (street, subdivision, large consumer etc.)?		
	Notes:		
D-8	Has there been a recent water main break?		
	Notes:		

Code	System Aspects	CR - Critical Issue SR - Serious Issue	
		Response Yes/No/NA	**Result** CR / SR /OK
D-9	Is the system being regularly flushed (unidirectional, spot)?		
	Notes:		
D-10	Is there evidence of intentional contamination such as forced access?		
	Notes:		
D-11	Are there any components of the water distribution system near on-site septic systems?		
	Notes:		
D-12	Are there any known leaks in municipal sewage system (if applicable)?		
	Notes:		
D-13	Are there any high-volume users on system (ex. fish plant)?		
	Notes:		
D-14	List any known or suspected leaks within the distribution system		
	1		
	2		
	3		
Storage Tanks			
S-1	Are overflows and vents secured and screened?		
	Notes:		
S-2	Is the facility secured against unauthorized access?		
	Notes:		
S-3	Do openings, hatches and ports have gaskets as required?		
	Notes:		
S-4	Is tank in suitable condition without cracks or excessive rust?		
	Notes:		
S-5	Has prescribed maintenance and inspection been performed on storage tanks and pressure tanks?		
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue*	
		Response Yes/No/NA	**Result** CR / SR /OK
S-6	What maintenance has been conducted recently? Including painting or coating application.		
	Notes:		
S-7	Is there a maintenance plan in place, and if so was it followed?		
	Notes:		
S-8	Have leaks been observed from the tank or connections?		
	Notes:		
S-9	Is there evidence of intentional contamination such as forced access?		
	Notes:		
S-10	Are vents protected from debris and rainwater with a minimum 300 mm clearance between adjacent surfaces?		
S-11	Have chlorine residuals been measured at tank intake and output?		
	Notes:		
Treatment Processes (including disinfection)			
T-1	Does water treatment include an operational disinfection system? Describe system below.		
	Notes:		
T-2	Is there any water treatment processes beyond disinfection? Describe treatment processes below.		
	Notes:		
T-3	Are all treatment devices operational? List those out of service.		
	Notes:		
T-4	Is there adequate disinfectant chemicals in storage or have supplies been ordered?		
	Notes:		

Code	System Aspects	Response Yes/No/NA	Result CR / SR /OK
		CR - Critical Issue *SR - Serious Issue*	
T-5	Is there a maintenance plan in place, and if so was it followed?		
	Notes:		
T-6	Have there been any recent equipment installations?		
	Notes:		
T-7	Have there been any treatment interruptions? List their date and duration.		
	Notes:		
T-8	Is free chlorine residual measured immediately downstream from the point of application?		
	Notes:		
T-9	Are flow rates at or below the rated capacity of system?		
	Notes:		
T-10	Is the chlorine system flow-proportioning?		
	Notes:		
T-11	Have any changes in raw water quality been recently noted?		
	Notes:		
T-12	Have C x T requirements been met (free chlorine residual of at least 0.3 mg/l after 20 minutes or equivalent CT)?		
	Notes:		
Source - Well			
S-1.1	Is ground graded away from casing?		
	Notes:		
S-1.2	What is the typical flow?		
	Notes:		
S-1.3	Is the sanitary seal intact?		
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	**Result** CR / SR /OK
S-1.4	Are vents protected from debris and rainwater with a minimum 300 mm clearance between adjacent surfaces?		
	Notes:		
S-1.5	Does casing extend 600mm above ground?		
	Notes:		
S-1.6	Is there evidence of standing water at the wellhead?		
	Notes:		
S-1.7	Is the casing sealed with a bentonite, grout or other approved seal?		
	Notes:		
S-1.8	Is the wellhead secured to prevent unauthorized access?		
	Notes:		
S-1.9	What is the distance to nearest known septic field?		
	Notes:		
S-1.10	What is the distance to new excavations in area?		
	Notes:		
S-1.11	Has there been a recent spill in the area (septic or other)?		
	Notes:		
S-1.12	What is the distance to farms or livestock?		
	Notes:		
S-1.13	What is the general condition of the well?		
	Notes:		
Source - Surface Water			
S-2.1	Have there been any reports of beavers or muskrat in the water supply? Or concentration of wildlife or birds using the water supply?		
	Notes:		
S-2.2	Are there any on-site septic systems near the water source and intake?		
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	**Result** CR / SR /OK
S-2.3	Are there any new excavations or development activity in the water supply area?		
	Notes:		
S-2.4	Are there any farms or livestock in or near the water supply?		
	Notes:		
S-2.5	Has there been a recent spill in the area (septic or other)?		
	Notes:		
S-2.6	Is the reservoir/watershed area clean and free from potential sources of contamination?		
	Notes:		
S-2.7	Is there any new human activity in the reservoir/source area?		
	Notes:		
S-2.8	Have algal blooms been observed?		
	Notes:		
Environmental Event			
E-1	Has there been a heavy rainfall recently?		
	Notes:		
E-2	Has there been a rapid snow melt recently?		
	Notes:		
E-3	Has there been overland flooding recently?		
	Notes:		
E-4	Has there been a significant drop in available source water?		
	Notes:		
E-5	Has there been recent interruptions to treatment/distribution power supply?		
	Notes:		
E-6	Has there been extreme heat or cold recently?		
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue*	
		Response Yes/No/NA	**Result** CR / SR /OK
Sampling Location			
L-1	Is the tap from which sample collected clean, free of rust, have good flow?		
	Notes:		
L-2	Are there any potential nearby sources which could result in contamination of the sampling tap?		
	Notes:		
L-3	Is the tap used regularly?		
	Notes:		
L-4	Has there been repairs to components in area/system since last sampling?		
	Notes:		
L-5	Are any private treatment devices present? Sample taken: ☐ Upstream ☐ Downstream of treatment		
	Notes:		
L-6	Are backflow preventers installed and if so has the required maintenance been conducted?		
	Notes:		
L-7	Has there been a recent installation/repair of components within sampling building?		
	Notes:		
L-8	Has there been any documented/known low pressure events since last testing (main break etc.)?		
	Notes:		
Sampling Protocol			
P-1	Has the sampling protocol outlined in the Drinking Water Manual - Health and Community Services been followed?		
	Notes:		
P-2	Were aerators, swivels and/or remote hoses removed prior to sampling?		
	Notes:		

Code	System Aspects	CR - Critical Issue SR - Serious Issue **Response** Yes/No/NA	 **Result** CR / SR /OK
P-3	Were sterile sampling bottles used and adequate storage available at the prescribed temperatures?		
	Notes:		
P-4	Were clean gloves used to handle sample bottles and conduct sampling?		
	Notes:		
P-5	Was tap flushed 5 minutes before beginning to collect samples?		
	Notes:		
P-6	Was sampling completed by a person other than the normal collector?		
	Notes:		

GENERAL NOTES

BWA System Assessment Summary

Review results of the assessment worksheets to identify likely root cause(s) of the boil water advisory (Critical Issues) and areas of concern which may result in re-occuring BWA (Serious Issues).
Attach additional sheets as required.

Description of Deficiency

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational Issue	☐	Environmental Issue
☐	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☐
Serious Issue	☐

Description of Deficiency

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational Issue	☐	Environmental Issue
☐	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☐
Serious Issue	☐

Description of Deficiency

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational - Issue	☐	Environmental Issue
☐	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☐
Serious Issue	☐

SEE STANDARD OPERATING PROCEDURES TO ADDRESS THE AREAS OF CONCERN NOTED ABOVE

APPENDIX A3

PREVENTATIVE MAINTENANCE

CHECKLIST, FORMS AND LOGS

Summary of Checklist, Forms and Logs

Form ID	Description
BCL1	Daily - Preventative O&M Task Checklist
BCL2	Weekly - Preventative O&M Task Checklist
BCL3	Monthly - Preventative O&M Task Checklist
BCL4	3 Month - Preventative O&M Task Checklist
BCL5	6 Month - Preventative O&M Task Checklist
BCL6	Annual - Preventative O&M Task Checklist
BCL7	5 Year - Preventative O&M Task Checklist
BDL1	Daily Log – pH Levels
BDL2	Daily Log – Well Pumping
BDL3	Daily Log – Gas Chemical Usage
BDL4	Daily Log – Liquid/Powder Chemical usage
BDL5	Daily Log – Storage Systems
BDL6	Daily Log – Disinfectant Residual Levels

Form #:BCL1 Rev: 01

Preventative O&M Task Checklist			Daily
Town/LSD Name:			
Operator(s):			
Date:			
Task	**N/A (x)**	**Complete (x)**	**Operator Initials**
Raw Water Supply			
Visual inspection for leaks, unusual noise, excess vibration.			
Measure and record source pump cycle times and operational hours			
Measure and record flow rates at source pump			
Treatment and Disinfection			
Complete daily disinfection and treatment logs			
Visual inspection of chemical feed pumps and feed lines			
Measure and record backwash rates for filters			
Measure and record filter influent and effluent turbidity on particulate filters			
Measure and record pH chemical usage and readings pre and post adjustment			
Distribution System			
Measure and record free and total chlorine residual at set points throughout the distribution system (at first user and end of all branches)			
Visual inspection of booster pump(s) for wear, breakage and leakage			
Measure pH at set points throughout the distribution system			
Water Storage			
Measure and log water levels in each storage cell to ensure they are within normal operating range			
General			
In winter, check that heating system is working properly to prevent freezing of equipment			
Security check of all assets to assess locks, hatches, doors, windows, vents, security lighting and alarms to ensure proper operation			
Verify instrumentation (SCADA) alarms			
NOTES			

Operator(s) Signature:	Date
______________________________	

Preventative O&M Task Checklist

Weekly

Town/LSD Name:	
Operator(s):	
Week Ending:	

Task	**N/A (x)**	**Complete (x)**	**Operator Initials**
Treatment and Disinfection			
Visual inspection of chlorine injector and chlorine residual analyzer for leaks and to ensure normal operation			
Measure and record filter backpressure to evaluate filter condition			
Distribution System			
Record pump cycle times and compare with past readings to identify problematic trends			
Water Storage			
Visually inspect for signs of overflow or leakage such as corrosion or staining			
Verify openings are screened and all hatches secured as required			
Verify disinfectant residuals levels in tank			
General			
Clean pumphouse grounds			
Test controllers as recommended by manufacturer			

NOTES

Operator(s) Signature:	Date

Preventative O&M Task Checklist

Monthly

Town/LSD Name:	
Operator(s):	
Month:	

Task	**N/A (x)**	**Complete (x)**	**Operator Initials**
Raw Water Supply			
Measure source pump bearing temperature and conduct a visual inspection of the wellhead for surface water ponding near the intake, development activity and any storage of chemicals, equipment, fuels etc. in the area			
Measure and record the static pumping head levels at each well (if applicable)			
Inspect and clean intake structure, intake screens and intake pipeline. Clean and repair as required.			
Measure and record intake water levels and temperature			
Treatment and Disinfection			
Measure and record chemical and pH pump bearing temperature			
Visual inspection of chemical and pH pumps			
Inventory all consumables and order as required			
Visual inspection of filters for damage			
Verify operation of chlorine gas sensors as per method on DOEC website			
Conduct manual backwash of filter and flush backwash line			
Visual inspection and lubrication of backwash pumps			
Distribution System			
Visual inspection of visible piping, connections and fittings for leaks, corrosion or breakage. Correct issues as soon as possible			
Measure and record booster pump bearing temperature and compare with previous readings to identify problematic trends			
General			
Exercise control valves			

NOTES

Operator(s) Signature:	Date

Preventative O&M Task Checklist			3 Month
Town/LSD Name:			
Operator(s):			
Months:			
Task	**N/A (x)**	**Complete (x)**	**Operator Initials**
Treatment and Disinfection			
Clean chemical feed lines and solution tanks			
Calibrate chemical feed tanks			
Measure and record backwash pump bearing temperature to identify rising trends indicative of upcoming failure			
Visual inspection of backwash waste water holding tank			
NOTES			
Operator(s) Signature:			Date

Form #:BCL5 Rev: 01

Preventative O&M Task Checklist			6 Month
Town/LSD Name:			
Operator(s):			
Months:			

Task	N/A (x)	Complete (x)	Operator Initials
Raw Water Supply			
Visual inspection of cables and associated electronics for damage			
Tighten glands on pumps and controllers as required			
Inspect the watershed for possible contamination. Identify any new development and activity including storage of fuels, chemicals, equipment, camping activity, use of motorize boats, snowmobiles, cottage developments etc.			
Inspect watershed for signs of animal activity near the intake (beavers, birds etc.)			
Inspect watershed protection signs and replace as required.			
Conduct safety review to evaluate potential hazards and review emergency response plan			
Treatment and Disinfection			
Visual inspection of filter vessels to evaluate interior corrosion			
Calibrate chlorine gas sensors according to manufacturer instructions			
Distribution System			
Have an electrician inspect cables and tighten glands on pumps and controllers as required			
General			
Conduct review of unsafe conditions			

NOTES

Operator(s) Signature:	Date

Preventative O&M Task Checklist — Annual

Town/LSD Name:	
Operator(s):	
Year:	

Task	N/A (x)	Complete (x)	Operator Initials
Raw Water Supply			
Have an electrician measure and record running amperage of each source pump and meggar test winding insulation			
Dismantle, inspect and rebuild pumps as required			
Inspect dam/reservoir structure for signs of deterioration (cracking, erosion, shifting), spillway blockages/debris, mechanical function and public safety			
Treatment and Disinfection			
Dismantle, inspect and rebuild treatment pumps as required			
Remove filter from process to verify each media layer is well graded and of proper depth.			
Distribution System			
Exercise system valves following a scheduled program			
Flush distribution system (minimum annual flushing - 6 month intervals recommended)			
Exercise and lubricate fire hydrants			
Have an electrician measure and record running amperage of each source pump and meggar test winding insulation			
Dismantle, inspect and rebuild booster pumps as required			
Water Storage			
Visually inspect all components for coating deterioration, shell cracking, concrete deterioration and anchor bolt tension			
Verify no low points exist on roof which may pool water and accelerate corrosion			
General			
Conduct emergency drills to address contamination, chlorine gas leaks and fire scenarios			
Apply paint as required			
Inspect pipe supports and hangers for damage			
Prepare system for winter			

NOTES

Operator(s) Signature:	Date

Preventative O&M Task Checklist			5 Year
Town/LSD Name:			
Operator(s):			
5 Year Range:			
-	N/A (x)	Complete (x)	**Operator Initials**
Water Storage			
Drain and clean storage tanks and reservoirs with a substance certified as 'safe for use with potable water'			
Complete a thorough inspection of all components including tank shell thickness, metals content of coatings and HPC of tank wall biofilm			
Test and calibrate all sensors gauges			
Disinfect before put back into use according to AWWA C652 and confirm microbiological safety by taking two samples 24 hours apart			

NOTES

Operator(s) Signature:	Date
______________________________	

Daily Log - pH Levels

Town: ______________________ Month: __________ Year: __________

Chemical: ______________________

Form # BDL1
Rev. 1

Date	Time	Operator Initials	Water Temp ^oC	Flow uspgm	Location 1 ______ pH	Location 2 ______ pH	Location 3 ______ pH
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

Notes:

Daily Log - Well Pumping

Town: ____________________ Month: ____________ Year: __________

Location: ______________________________ Form # BDL2

Rev. 1

Date	Operator Initials	Produced Water	Pump # ____________			Pump # ____________		
			Description ____________			Description ____________		
				Run Time	Bearing Temp.		Run Time	Bearing Temp.
		Gallons	Starts	Hours	^oC	Starts	Hours	^oC
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								

Notes:

Daily Log - Gas Chemical Usage

Town: ______________________ Month: __________ Year: __________

Chemical: ______________________

Form # BDL3
Rev. 1

Date	(a) Weight of Chemical Consumed in 24 hrs		(b) Volume of Water Treated in 24 hrs		Dosage = a/b x1000 Dosage		Operator Initials
	Units	g/day	Units	L/day	Units	mg/L	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

Notes:

Daily Log - Liquid/Powder Chemical Usage

Town: ______________________ Month: __________ Year: __________

Chemical: ______________________ % of Chemical Available (See Label): __________

Form # BDL4
Rev. 1

Date	(a) Chemical Solution Used in 24hrs		(b) Concentration of Chemical Solution		(c) Volume of Water Treated in 24 hrs		Dosage = (a x b)/c Dosage		Operators Initials
	Units	L	Units	mg/L	Units	L	Units	mg/L	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
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27									
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29									
30									
31									

Notes:

Daily Log - Storage Tank(s)

Town: ______________________ Month: __________ Year: __________

Tank #: ______________

Form # BDL5
Rev. 1

Date	Operator Initials	Time of Reading	Tank Water Level Units ___	Time to Fill Tank (hrs)	Time to Empty Tank (hrs)	Any Observed Overflow (Y/N)	Water Temperature (^{o}C)	Any Ice Formation (Y/N)	Free Chlorine Residual (mg/L)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
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24									
25									
26									
27									
28									
29									
30									
31									

Notes:

Daily Log - Residual Levels

Town: ______________________ Month: __________ Year: __________

Chemical: ______________________

Form # BDL6
Rev. 1

Date	Time	Operator Initials	Water Temp °C	Flow uspgm	Location 1		Location 2		Location 3	
					____________		____________		____________	
					Free	Total	Free	Total	Free	Total
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
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31										

Notes:

APPENDIX A4

CONTACT INFORMATION

GOVERNMENT REPRESENTATIVES

Department of Environment and Conservation - Water Resources Management Division

St. John's Regional Office & Headquarters

Tel: (709) 729-2563

Fax: (709) 729-0320

Email: water@gov.nl.ca

Grand Falls-Windsor Regional Office

Tel: (709) 292-4997

Fax: (709) 292-4365

Corner Brook Regional Office

Tel: (709) 637-2034

Fax: (709) 637-2541

Happy Valley-Goose Bay Regional Office

Tel: (709) 896-7981

Fax: (709) 896-9566

Department of Municipal and Intergovernmental Affairs

Central Regional Office

Tel: (709) 256-1061

Fax: (709) 256-1060

Eastern Regional Office

Tel: (709) 729-5020

Fax: (709) 729-0477

Western Regional Office

Tel: (709) 637-2491

Fax: (709) 637-2548

Labrador Regional Office

Tel: (709) 896-2941

Fax: (709) 896-8847

Government Service Centers – Service NL

Clarenville

Tel: (709) 466-4060

Fax: (709) 466-4070

Corner Brook

Tel: (709) 637-2204

Fax: (709) 637-2681

Gander

Tel: (709) 256-1420

Fax: (709) 256-1438

Grand Bank

Tel: (709) 832-2326

Fax: (709) 832-1792

Grand Falls-Windsor

Tel: (709) 292-4206 or (709) 292-4259

Fax: (709) 292-4149

Harbour Grace

Tel: (709) 945-3107

Fax: (709) 945-3114

Happy Valley-Goose Bay

Tel: (709) 896-5428 or (709) 896-5430

Fax: (709) 896-4340

Labrador City

Tel: (709) 944-5282

Fax: (709) 944-5630

Lewisporte

Tel: (709) 535-0262

Fax: (709) 535-0284

Marystown

Tel: (709) 279-0837

Mount Pearl

Tel: (709) 729-3699

Fax: (709) 729-3980

Port aux Basques

Tel: (709) 695-2835

Fax: (709) 695-2393

St. Anthony

Tel: (709) 454-8833

Fax: (709) 454-3206

Stephenville

Tel: (709) 643-8650

Fax: (709) 643-8654

Springdale

Tel: (709) 673-4218

Fax: (709) 673-4232

APPENDIX A5

MUNICIPAL CAPITAL WORKS FUNDING PROCESS SUMMARY

The Municipal Capital Works program, Multi-Year Capital Works program, and Building Canada Fund have been developed to help offset the cost of installing public water infrastructure. Information on funding can be obtained by contacting MIGA. Generally, funding for water disinfection, treatment and distribution systems in small communities would fall under the Municipal Capital Works program or other specially designated programs, such as the Disinfection Funding Program. MCW is a cost-shared program for municipal infrastructure and eligible funds are allocated based on the following ratios:

- 90/10 for populations less than 3,000
- 80/20 for populations between 3,000 and 7,000
- 70/30 for populations greater than 7,000

Local Service Districts in the province would also qualify for funding supports on approved projects usually under the 90/10 arrangement.

Step #1: Contact the nearest MIGA regional office and ENVC to initiate the system evaluation for recommended upgrades:

MIGA St. John's Region: Phone (709) 729-5020 or (709) 729-7390

MIGA Eastern Region: Phone (709) 729-5020 or (709) 729-7390

MIGA Central Region: Phone (709) 256-1061 or (709) 637-2332

MIGA Western Region: Phone (709) 637-2491 or (709) 637-2332

MIGA Labrador Region: Phone (709) 896-2941 or (709) 637-2332

ENVC: Phone (709) 729-4048 or (709) 729-1158

Step #2: Work with government stakeholders (MIGA, ENVC & Consultants) to evaluate the system and to identify sustainable options.

Step #3: Once a sustainable option has been identified, the Owner may make an application to MIGA for project funding.

Online applications: First time users may contact MIGA to set up an account by phoning (709) 729-5498 or (709) 729-5846 or email: MA-InforMgmt@gov.nl.ca. Once an account is setup, applications may be completed online at URL: https://msis.gov.nl.ca/MSIS/Security/External/externaldefault.aspx?ReturnUrl=%2fMSIS%2f. Video instructions on logging into the system and completing the form is available at the following link: https://www.youtube.com/watch?v=T1foy1UMTT0&feature=youtu.be

Paper applications: Applications may be submitted in hardcopy by completing the application shown in Appendix 4.1. Contact the nearest MIGA regional office if you have any questions while completing the form.

APPENDIX B1

PILOT COMMUNITIES

PORTUGAL COVE SOUTH

BOIL WATER ADVISORY SYSTEM ASSESSMENT FORM

Town Name	**Portugal Cove South**		
Assessor Name	**Big East Engineering Inc**		
Assessor Title			
Contact Phone #		Date of Assessment	**02-Oct-0215**

Boil Water Advisory Issue Date	**01-Jan-84**
BWA Reason Code	**E1**

Root Cause(s) of Current BWA	1.	Raw water quality affected by rainfall events which impacts the chlorine demand.
	2.	Inability to maintain free chlorine residuals throughout distribution system during periods with poor water quality.
	3.	Inability to clean chlorine tank without shutting down system water supply to town or turning off disinfection system.

This assessment tool is designed to identify possible issues and root causes of situations leading to a boil water advisory (BWA). It is designed as a field-level exercise and should be completed by or with the participation of the system operator. This assessment tool is designed to be used in conjunction with the Standard Operating Procedures (SOP) to identify the issue and then correct it.

Instructions

1. Tables 1.1 and 1.2 have been provided to log disinfection parameters and to identify disinfectant residual trends. For best results take readings at approximately the same time of day on a daily basis.

2. The main assessment worksheet asks a series of questions on the condition and operation of each component of the system. Responses are either Yes, No or NA and the Result is identified as being OK, Serious or Critical. 'Critical' indicates that it is a root cause for the current BWA, 'Serious' indicates issue makes system prone to re-occuring BWAs and 'OK' indicates no concerns. NOTE: Complete entire Assessment worksheet even if appears the cause has been identified.

3. The last page of this assessment tool (BWA System Assessment Summary) is used to document the 'Serious' and 'Critical' issues identified on the worksheet. This sheet is then used in conjunction with the appropriate SOP to mitigate the issue such that the BWA can be lifted.

Table 1.1	OVERALL SYSTEM OPERATION				
Rated Capacity of System:			Number of Users:		140-160*
Date	Time of Day	Disinfectant Usage Rate (Unit: L/hr)	Strength of Mixed Disinfectant Solution (Unit: %)	Free Residual Immediately After Disinfection (Unit:)	Produced Water Flow (USGPM)
August 19, 2015 to					Average 45-53
Sept 19,2015					Peak 64
01-Oct-15		2.1	1.5		53-57

Notes: * 2011 Census population 160 people, operator indicated ~140 people. Based on 340L/p/d and using 160 people average flows should be approximately 10USGPM, however they are in 45-64 USGPM range. Appears to be very high demand for system possibly due to major leaks in the system.

Table 1.2	CHLORINE RESIDUAL TREND		
Chlorine Measuring Device	Make:	**Hach**	Accuracy: **0.01 mg/l**
	Model:	**Pocket Colorimeter II**	

Location	Distance from Disinfection System
Location 1. WC 1 user	**~200m**
Location 2. BW end of main east	**~900m**
Location 3. LC end of main east	**~900m**
Location 4. J&K end of main west	**~1200m**

Date & Time	Location 1 Total	Location 1 Free	Location 2 Total	Location 2 Free	Location 3 Total	Location 3 Free	Location 4 Total	Location 4 Free
3-Sep-15		**1.18**		**0.05**		**-**		**0.05**
8-Sep-15		**1.15**		0.04		**-**		**0.04**
11-Sep-15		**0.92**		0.06		**-**		**0.04**
Sept 13,2015 **		**0.43**		-		**0.03**		**0.02**
Sept 17,2015		**0.12**		-		**0.02**		**0.03**
Sept 20,2015		**0.06**		**-**		**0.01**		**0.01**
26-Sep-15		**0.56**		**-**		**0.02**		**0.01**
1-Oct-15		**0.88**		**0.03**				**0.02**

Notes: ** Sept 13,2015 start of 3 day rain event 108mm. Clean Cl tank on Sept 16,2015.

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* Response Yes/No/NA	Result CR / SR /OK
Drinking Water System Facility Events			
F-1	Has there been recent operations or maintenance that could introduce bacteria into the system?	**No**	**OK**
	Notes:		
F-2	Has system pressures dropped below 20psi recently?	**No**	**OK**
	Notes: no pressure gauge on system.		
F-3	Has there been a recent fire fighting, hydrant flushing or other high-flow event?	**Yes**	**OK**
	Notes: Start flushing lines in summer 2015		
F-4	Is the disinfection system and surrounding area free of visible unsanitary conditions?	**Yes**	**OK**
	Notes: **New hypo system installed in May 2015.**		
F-5	Has there been a indication from Department of Health and Community Services of a waterborne illness outbreak?	**No**	**OK**
	Notes:		
F-6	Has the facility been subject to additional BWAs within the past 12 months? List reason codes.	**Yes**	**SR**
	Notes: Long term BWA since 1984		
F-7	Were the last water samples results satisfactory? Explain below.	**Yes**	**OK**
	Notes: **CL resdiuals acceptable in early Sept 2015 before rainfall event**		
F-8	Has the facility been subject to unauthorized access?	**No**	**OK**
	Notes: **Disinfection building is locked.**		
F-9	Have maintenance logs been reviewed to identify possible causes?	**Yes**	**OK**
	Notes:		
F-10	Has an increased color been noted in the source water?	**Yes**	**CR**
	Notes:Yes during recent heavy rainfall		
F-11	Has there been an increase in turbidity in source water or tap water?	**Yes**	**CR**
	Notes: **Yes during recent heavy rainfall. Water currently clear.**		
F-12	Has there been complaints of water taste from residents?	**Yes**	**SR**
	Notes: **Sometimes tastes "boggy"**		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* Response Yes/No/NA	Result CR / SR /OK
F-13	Has there been complaints of odor in tap water from residents?	**Yes**	**SR**
	Notes: Occasionally		
Operational Change			
O-1	Has there been any additional or backup equipment added to system recently?	**Yes**	**OK**
	Notes: **New disinfection system added in May 2015**		
O-2	Has there been any significant changes in water demand (eg. additional large consumers such as fish plants)?	**No**	**OK**
	Notes:		
O-3	Have additional water sources been added recently?	**No**	**OK**
	Notes:		
Distribution System			
D-1	Do SCADA logs indicate a low pressure event (less than 20 PSI)?	**NA**	
	Notes:		
D-2	Are there any known cross-connections on the system?	**No**	**OK**
	Notes:		
D-3	Were any unsanitary conditions identified at pump station?	**No**	**OK**
	Notes:		
D-4	Has there been recent pump maintenance conducted?	**No**	**OK**
	Notes:		
D-5	Are distribution assets secured against unauthorized access?	**Yes**	**OK**
	Notes: **Disinfection building lock.**		
D-6	Have recent water main repairs followed AWWA 651 disinfection protocol?	**NA**	
	Notes: **Unknown**		
D-7	Has there been a recent water main branch installation (street, subdivision, large consumer etc.)?	**No**	**OK**
	Notes:		
D-8	Has there been a recent water main break?	**Yes**	**SR**
	Notes: **There are a number of known leaks and some suspected on an old line toward the east end of the main.**		

Code	System Aspects	CR - *Critical Issue* SR - *Serious Issue* Response Yes/No/NA	Result CR / SR /OK
D-9	Is the system being regularly flushed (unidirectional, spot)?	**Yes**	**OK**
	Notes: **Sporadic. Startes at ends and works toward disinfection system.**		
D-10	Is there evidence of intentional contamination such as forced access?	**No**	**OK**
	Notes:		
D-11	Are there any components of the water distribution system near on-site septic systems?	**No**	**OK**
	Notes: Residents use on-site septic systems.		
D-12	Are there any known leaks in municipal sewage system (if applicable)?	**NA**	
	Notes:		
D-13	Are there any high-volume users on system (ex. fish plant)?	**No**	**OK**
	Notes:		
D-14	List any known or suspected leaks within the distribution system	**Yes**	**SR**
	1. Suspected - at end of lines where old 2" pipe was installed 30 plus years ago.		
	2		
	3		
Storage Tanks			
S-1	Are overflows and vents secured and screened?	**NA**	
	Notes:		
S-2	Is the facility secured against unauthorized access?	**NA**	
	Notes:		
S-3	Do openings, hatches and ports have gaskets as required?	**NA**	
	Notes:		
S-4	Is tank in suitable condition without cracks or excessive rust?	**NA**	
	Notes:		
S-5	Has prescribed maintenance and inspection been performed on storage tanks and pressure tanks?	**NA**	
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* Response Yes/No/NA	Result CR / SR /OK
S-6	What maintenance has been conducted recently? Including painting or coating application.	**NA**	
	Notes:		
S-7	Is there a maintenance plan in place, and if so was it followed?	**NA**	
	Notes:		
S-8	Have leaks been observed from the tank or connections?	**NA**	
	Notes:		
S-9	Is there evidence of intentional contamination such as forced access?	**NA**	
	Notes:		
S-10	Are vents protected from debris and rainwater with a minimum 300 mm clearance between adjacent surfaces?	**NA**	
S-11	Have chlorine residuals been measured at tank intake and output?	**NA**	
	Notes:		
Treatment Processes (including disinfection)			
T-1	Does water treatment include an operational disinfection system? Describe system below.	**Yes**	**OK**
	Notes: Hypo chlorination system, using chlorine bleach Javex 12, mixing 15L @ 12% chlorine with 120L of water…~1.5% chlorine solution		
T-2	Is there any water treatment processes beyond disinfection? Describe treatment processes below.	**No**	**CR**
	Notes:		
T-3	Are all treatment devices operational? List those out of service.	**Yes**	**OK**
	Notes:		
T-4	Is there adequate disinfectant chemicals in storage or have supplies been ordered?	**Yes**	**OK**
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* Response Yes/No/NA	Result CR / SR /OK
T-5	Is there a maintenance plan in place, and if so was it followed?	**Yes**	**OK**
	Notes: Clean intake regularly (once per month), clean chlorine tank as required, flushing hydrants.		
T-6	Have there been any recent equipment installations?	**Yes**	**OK**
	Notes: New disinfection system added in May 2015		
T-7	Have there been any treatment interruptions? List their date and duration.	**Yes**	**SR**
	Notes: Shut down system to clean only chlorine tank in Sept 2015.		
T-8	Is free chlorine residual measured immediately downstream from the point of application?	**Yes**	**OK**
	Notes: Measured at first user		
T-9	Are flow rates at or below the rated capacity of system?	**No**	**SR**
	Notes: Based on population and recorded flows, demand is 5x what it should be for the community.		
T-10	Is the chlorine system flow-proportioning?	**Yes**	**OK**
	Notes:		
T-11	Have any changes in raw water quality been recently noted?	**Yes**	**CR**
	Notes: Yes during 3 day rainfall event and whenever there is lots of rain. Otherwise the water is normally clear.		
T-12	Have C x T requirements been met (free chlorine residual of at least 0.3 mg/l after 20 minutes or equivalent CT)?	**Yes**	**OK**
	Notes:		
Source - Well			
S-1.1	Is ground graded away from casing?	**NA**	
	Notes:		
S-1.2	What is the typical flow?	**NA**	
	Notes:		
S-1.3	Is the sanitary seal intact?	**NA**	
	Notes:		

Code	System Aspects	CR - Critical Issue SR - Serious Issue Response Yes/No/NA	Result CR / SR /OK
S-1.4	Are vents protected from debris and rainwater with a minimum 300 mm clearance between adjacent surfaces?	**NA**	
	Notes:		
S-1.5	Does casing extend 600mm above ground?	**NA**	
	Notes:		
S-1.6	Is there evidence of standing water at the wellhead?	**NA**	
	Notes:		
S-1.7	Is the casing sealed with a bentonite, grout or other approved seal?	**NA**	
	Notes:		
S-1.8	Is the wellhead secured to prevent unauthorized access?	**NA**	
	Notes:		
S-1.9	What is the distance to nearest known septic field?	**NA**	
	Notes:		
S-1.10	What is the distance to new excavations in area?	**NA**	
	Notes:		
S-1.11	Has there been a recent spill in the area (septic or other)?	**NA**	
	Notes:		
S-1.12	What is the distance to farms or livestock?	**NA**	
	Notes:		
S-1.13	What is the general condition of the well?	**NA**	
	Notes:		
Source - Surface Water			
S-2.1	Have there been any reports of beavers or muskrat in the water supply? Or concentration of wildlife or birds using the water supply?	**Yes**	**SR**
	Notes: **Reports of 3 beavers in the area and known to frequent the water intake area.**		
S-2.2	Are there any on-site septic systems near the water source and intake?	**No**	**OK**
	Notes:		

Code	System Aspects	CR - Critical Issue SR - Serious Issue Response Yes/No/NA	Result CR / SR /OK
S-2.3	Are there any new excavations or development activity in the water supply area?	**No**	**OK**
	Notes:		
S-2.4	Are there any farms or livestock in or near the water supply?	**No**	**OK**
	Notes:		
S-2.5	Has there been a recent spill in the area (septic or other)?	**No**	**OK**
	Notes:		
S-2.6	Is the reservoir/watershed area clean and free from potential sources of contamination?	**Yes**	**OK**
	Notes:		
S-2.7	Is there any new human activity in the reservoir/source area?	**No**	**OK**
	Notes:		
S-2.8	Have algal blooms been observed?	**Yes**	**SR**
	Notes: Some algae growth observed at intake pond and intake screens		
Environmental Event			
E-1	Has there been a heavy rainfall recently?	**Yes**	**CR**
	Notes: Yes 3 day event in September 2015		
E-2	Has there been a rapid snow melt recently?	**No**	**OK**
	Notes:		
E-3	Has there been overland flooding recently?	**No**	**OK**
	Notes:		
E-4	Has there been a significant drop in available source water?	**No**	**OK**
	Notes:		
E-5	Has there been recent interruptions to treatment/distribution power supply?	**No**	**OK**
	Notes:		
E-6	Has there been extreme heat or cold recently?	**No**	**OK**
	Notes:		

Code	System Aspects	Response Yes/No/NA	Result CR / SR /OK
		CR - Critical Issue *SR - Serious Issue*	
Sampling Location			
L-1	Is the tap from which sample collected clean, free of rust, have good flow?	**NA**	
	Notes:		
L-2	Are there any potential nearby sources which could result in contamination of the sampling tap?	**NA**	
	Notes:		
L-3	Is the tap used regularly?	**NA**	
	Notes:		
L-4	Has there been repairs to components in area/system since last sampling?	**NA**	
	Notes:		
L-5	Are any private treatment devices present? Sample taken: ☐ Upstream ☐ Downstream of treatment	**NA**	
	Notes:		
L-6	Are backflow preventers installed and if so has the required maintenance been conducted?	**NA**	
	Notes:		
L-7	Has there been a recent installation/repair of components within sampling building?	**NA**	
	Notes:		
L-8	Has there been any documented/known low pressure events since last testing (main break etc.)?	**NA**	
	Notes:		
Sampling Protocol			
P-1	Has the sampling protocol outlined in the Drinking Water Manual - Health and Community Services been followed?	**NA**	
	Notes:		
P-2	Were aerators, swivels and/or remote hoses removed prior to sampling?	**NA**	
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	**Result** CR / SR /OK
P-3	Were sterile sampling bottles used and adequate storage available at the prescribed temperatures?	**NA**	
	Notes:		
P-4	Were clean gloves used to handle sample bottles and conduct sampling?	**NA**	
	Notes:		
P-5	Was tap flushed 5 minutes before beginning to collect samples?	**NA**	
	Notes:		
P-6	Was sampling completed by a person other than the normal collector?	**NA**	
	Notes:		

GENERAL NOTES

BWA System Assessment Summary

Review results of the assessment worksheets to identify likely root cause(s) of the boil water advisory (Critical Issues) and areas of concern which may result in re-occuring BWA (Serious Issues).
Attach additional sheets as required.

Description of Deficiency During heavy rain water quality deteoriates and chlorine demand increases. Inadequate treatment to address this issue. Chlorine dosage or chlorine solution strenght may need to be increased manually to maintain free chlorine residuals throughout the distribution system during poor water quality events unless additional treatment processes are installed. No pressure gauge on treatment system. Only 1 chlorine tank makes it difficult to clean without shutting down the system.

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational Issue	☒	Environmental Issue
☐	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☒	Treatment Issue	☐	Not Identified

Critical Issue	☒
Serious Issue	☐

Description of Deficiency Very high water demand on the system for a population of 140-160 people. Appears to be 5 times higher than what should be for population. It is suspected that leaks may be contributing to the problem. Leak detection program should be implemented to identify leaks and complete repairs. Also when flushing water mains recommend unidirectional flushing starting from disinfection system and moving toward the end of the lines.

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational Issue	☐	Environmental Issue
☒	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☐
Serious Issue	☒

Description of Deficiency 3 beavers have been observed in water intake pond. Algae growth in water supply.

Assessed Risk			
☐	System Facility Issue	☒	Source Issue
☐	Operational - Issue	☐	Environmental Issue
☐	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☐
Serious Issue	☒

SEE STANDARD OPERATING PROCEDURES TO ADDRESS THE AREAS OF CONCERN NOTED ABOVE

BWA System Assessment Summary

Description of Deficiency With only one chlorine tank, it makes it difficult to clean tank without shutting down the distribution system (creating a low pressure event) or shutting down the disinfection system (releasing untreated water into the distribution system). A second chlorine tank should be installed.

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational - Issue	☐	Environmental Issue
☐	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☒	Treatment Issue	☐	Not Identified

Critical Issue	☐
Serious Issue	☒

APPENDIX B2

PILOT COMMUNITIES

GANDER BAY SOUTH

BOIL WATER ADVISORY SYSTEM ASSESSMENT FORM

Town Name	**Gander Bay South**		
Assessor Name	**Big East Engineering Inc**		
Assessor Title			
Contact Phone #		Date of Assessment	**09-Oct-15**

Boil Water Advisory Issue Date	**July 24,2015**
BWA Reason Code	**F4**

Cause(s) of BWA	1.	E.Coli source(s) & intrusion to watermain. Suspected sources from water lines in close proximity to septic fields
	2.	Chronic waterline breaks in two branch lines. Which increases flows and chlorine demand. Pressure reduce on distribution system when completing repairs.
	3.	Maintain CL residuals in long distribution system. Need high chlorine residuals on front end to have detectable residual at end of system.
	4	Note: As of Oct 14,2015 community requested to remain on BWA due to concerns with distrubtion system

This assessment tool is designed to identify possible issues and root causes of situations leading to a boil water advisory (BWA). It is designed as a field-level exercise and should be completed by or with the participation of the system operator. This assessment tool is designed to be used in conjunction with the Standard Operating Procedures (SOP) to identify the issue and then correct it.

Instructions

1. Tables have been provided on page 2 to log disinfection parameters and to identify disinfectant residual trends. For best results take readings at approximately the same time of day on a daily basis.

2. The main assessment worksheet asks a series of questions on the condition and operation of each component of the system. Responses are either Yes, No or NA and the Result is identified as being OK, Serious or Critical. 'Critical' indicates that it is a root cause for the current BWA, 'Serious' indicates issue makes system prone to re-occuring BWAs and 'OK' indicates no concerns. NOTE: Complete entire Assessment worksheet even if appears the cause has been identified.

3. The last page of this assessment tool (BWA System Assessment Summary) is used to document the 'Serious' and 'Critical' issues identified on the worksheet. This sheet is then used in conjunction with the appropriate SOP to mitigate the issue such that the BWA can be lifted.

Table 1.1		OVERALL SYSTEM OPERATION			
		Rated Capacity of System:		Number of Users:	311
Date	Time of Day	Disinfectant Usage Rate	Strength of Mixed Disinfectant Solution	Free Residual Immediately After Disinfection	Produced Water Flow
		Unit: L/hr	Unit:	Unit:	Unit: USGPM
Sept 4,2015					27
Sept 9,2015					35
Sept 15,2015					33
Sept 21.2015					37
Sept 30,2015					104
Oct 9,2015					21

Notes: Based on 340L/p/d flows for 311 people should average approximately 20 USGPM. Appears that flows not too bad until Sept 30 which may indicate a leak in the system. Flows back to 21 USGPM at time of site visit.Using ~140L of 12% hypochlorite solution per month

Table 1.2	CHLORINE RESIDUAL TREND		
Chlorine Measuring Device	Make: **Hach**	Accuracy:	**0.01 mg/l**
	Model: **Pocket Colorimeter II**		

Location	Distance from Disinfection System
Location 1. GBPCH	**~200m**
Location 2. AC	
Location 3. WC	
Location 4. RT	**~2200m**

Date & Time	Location 1		Location 2		Location 3		Location 4	
	Total	Free	Total	Free	Total	Free	Total	Free
April 8,2015		**<2.2**		**-**				**0.04**
May 19,2015		**1.39**		-				**0.58**
June 18,2015		**0.66**		-				**0.04 ***
July 22,2015		**0.02 ****		-				**0.1**
Aug 17,2015		**1.01**		-		**0.1**		**0.02 *****
Aug 26,2015		**1.78**		**0.6**				**-**
Sept 1,2015		**>2.2**		**1.33**		**1.17**		**0.04**
Oct 14,2015		**1.36**		**0.33**				**-**
Oct 22,2015		-		-				-

Notes: *** Total Colifom present. ** E. Coli and Total Coliform ***Total Coliforms present. Chlorine residuals are being tested but they were not being recorded by community. Above residuals were provided by SNL. Operator reports repairs on broken lines conducted on following dates in 2015: June 23, July 10, August 22, Sept 2, Sept 4, Sept 23, Sept 29 and Oct 15. (whole system may not have been shut down for all repairs as they found shut off and installed another)**

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	**Result** CR / SR /OK
Drinking Water System Facility Events			
F-1	Has there been recent operations or maintenance that could introduce bacteria into the system?	**Yes**	**CR**
	Notes: Many leaks in two sections of old mains and when completing repairs shut down whole system which results in pressure loss in system.		
F-2	Has system pressures dropped below 20psi recently?	**Yes**	**CR**
	Notes: Yes **pressure drops when system shut down for repairs, which reportedly is required monthly.**		
F-3	Has there been a recent fire fighting, hydrant flushing or other high-flow event?	**Yes**	**OK**
	Notes: No hydrants however they have a flushing device on end of main and have started to use it this summer.		
F-4	Is the disinfection system and surrounding area free of visible unsanitary conditions?	**Yes**	**OK**
	Notes:		
F-5	Has there been a indication from Department of Health and Community Services of a waterborne illness outbreak?	**NO**	**OK**
	Notes:		
F-6	Has the facility been subject to additional BWAs within the past 12 months? List reason codes.	**Yes**	**CR**
	Notes: **Reoccurring BWA. Most recent since July 2015**		
F-7	Were the last water samples results satisfactory? Explain below.	**Yes**	**OK**
	Notes: **Subsequent information from SNL indicates Oct 14,2015. However community requested to remain on BWA due to concerns with two sections of old water lines which continuously breaks.**		
F-8	Has the facility been subject to unauthorized access?	**No**	**OK**
	Notes: **No building and gate to pumphouse locked.**		
F-9	Have maintenance logs been reviewed to identify possible causes?	**Yes**	**CR**
	Notes:		
F-10	Has an increased color been noted in the source water?	**No**	**OK**
	Notes:		
F-11	Has there been an increase in turbidity in source water or tap water?	**No**	**OK**
	Notes:		
F-12	Has there been complaints of water taste from residents?	**Yes**	**OK**
	Notes: **Only when chlorine residual is high and they smell chlorine**		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	 **Result** CR / SR /OK
F-13	Has there been complaints of odor in tap water from residents?	**No**	**OK**
	Notes:		
Operational Change			
O-1	Has there been any additional or backup equipment added to system recently?	**No**	**OK**
	Notes:		
O-2	Has there been any significant changes in water demand (eg. additional large consumers such as fish plants)?	**No**	**OK**
	Notes:		
O-3	Have additional water sources been added recently?	**No**	**OK**
	Notes:		
Distribution System			
D-1	Do SCADA logs indicate a low pressure event (less than 20 PSI)?	**NA**	
	Notes:		
D-2	Are there any known cross-connections on the system?	**No**	**OK**
	Notes:		
D-3	Were any unsanitary conditions identified at pump station?	**No**	**OK**
	Notes:		
D-4	Has there been recent pump maintenance conducted?	**No**	**OK**
	Notes:		
D-5	Are distribution assets secured against unauthorized access?	**Yes**	**OK**
	Notes: **Disinfection building yes. Gate to intake area is locked.**		
D-6	Have recent water main repairs followed AWWA 651 disinfection protocol?	**NA**	
	Notes: **Unknown**		
D-7	Has there been a recent water main branch installation (street, subdivision, large consumer etc.)?	**No**	**OK**
	Notes:		
D-8	Has there been a recent water main break?	**Yes**	**CR**
	Notes: **Reportedly every month there is a leak on one of two old sections on branches waterlines off the main line.**		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	 **Result** CR / SR /OK
D-9	Is the system being regularly flushed (unidirectional, spot)?	**Yes**	**OK**
	Notes: **Just started this year flushing using device at end of water main.**		
D-10	Is there evidence of intentional contamination such as forced access?	**No**	**OK**
	Notes:		
D-11	Are there any components of the water distribution system near on-site septic systems?	**Yes**	**CR**
	Notes: **No. All residents on septic systems. Reportedly some sections of old service lines go through or near septic fields.**		
D-12	Are there any known leaks in municipal sewage system (if applicable)?	**Yes**	**SR**
	Notes: **When they occur they are being fixed. Monthly occurrence**		
D-13	Are there any high-volume users on system (ex. fish plant)?	**No**	**OK**
	Notes:		
D-14	List any known or suspected leaks within the distribution system	**Yes**	**SR**
	1. Two branch old branches lines keep breaking and minor reapirs are completed when required.		
	2		
	3		
Storage Tanks			
S-1	Are overflows and vents secured and screened?	**NA**	
	Notes:		
S-2	Is the facility secured against unauthorized access?	**NA**	
	Notes:		
S-3	Do openings, hatches and ports have gaskets as required?	**NA**	
	Notes:		
S-4	Is tank in suitable condition without cracks or excessive rust?	**NA**	
	Notes:		
S-5	Has prescribed maintenance and inspection been performed on storage tanks and pressure tanks?	**NA**	
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	**Result** CR / SR /OK
S-6	What maintenance has been conducted recently? Including painting or coating application.	**NA**	
	Notes:		
S-7	Is there a maintenance plan in place, and if so was it followed?	**NA**	
	Notes:		
S-8	Have leaks been observed from the tank or connections?	**NA**	
	Notes:		
S-9	Is there evidence of intentional contamination such as forced access?	**NA**	
	Notes:		
S-10	Are vents protected from debris and rainwater with a minimum 300 mm clearance between adjacent surfaces?	**NA**	
S-11	Have chlorine residuals been measured at tank intake and output?	**NA**	
	Notes:		
Treatment Processes (including disinfection)			
T-1	Does water treatment include an operational disinfection system? Describe system below.	**Yes**	**OK**
	Notes: Hypo chlorination system, using hypochlorite 12%, Mixing 20L @ 12% chlorine with 80L of water ====~3% chlorine solution		
T-2	Is there any water treatment processes beyond disinfection? Describe treatment processes below.	**No**	**OK**
	Notes:		
T-3	Are all treatment devices operational? List those out of service.	**Yes**	**OK**
	Notes:		
T-4	Is there adequate disinfectant chemicals in storage or have supplies been ordered?	**Yes**	**OK**
	Notes: Usually orders 20-30 20L hypochlorite 12% which lasts ~ 6 months.		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	**Result** CR / SR /OK
T-5	Is there a maintenance plan in place, and if so was it followed?	**Yes**	**OK**
	Notes: Clean stilling well at least annually.		
T-6	Have there been any recent equipment installations?	**No**	**OK**
	Notes: Distribution system upgraded in 2005.		
T-7	Have there been any treatment interruptions? List their date and duration.	**No**	**OK**
	Notes: None reported.		
T-8	Is free chlorine residual measured immediately downstream from the point of application?	**Yes**	**OK**
	Notes: Measured at first Seniors Home but not recorded.		
T-9	Are flow rates at or below the rated capacity of system?	**No**	**OK**
	Notes: Not normally however when old water lines break flows increase....		
T-10	Is the chlorine system flow-proportioning?	**Yes**	**OK**
	Yes.		
T-11	Have any changes in raw water quality been recently noted?	**No**	**OK**
	No.		
T-12	Have C x T requirements been met (free chlorine residual of at least 0.3 mg/l after 20 minutes or equivalent CT)?	**Yes**	**OK**
	Notes: Mostly except for few instances.		
Source - Well			
S-1.1	Is ground graded away from casing?	**NA**	
	Notes:		
S-1.2	What is the typical flow?	**NA**	
	Notes:		
S-1.3	Is the sanitary seal intact?	**NA**	
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* **Response** Yes/No/NA	**Result** CR / SR /OK
S-1.4	Are vents protected from debris and rainwater with a minimum 300 mm clearance between adjacent surfaces?	**NA**	
	Notes:		
S-1.5	Does casing extend 600mm above ground?	**NA**	
	Notes:		
S-1.6	Is there evidence of standing water at the wellhead?	**NA**	
	Notes:		
S-1.7	Is the casing sealed with a bentonite, grout or other approved seal?	**NA**	
	Notes:		
S-1.8	Is the wellhead secured to prevent unauthorized access?	**NA**	
	Notes:		
S-1.9	What is the distance to nearest known septic field?	**NA**	
	Notes:		
S-1.10	What is the distance to new excavations in area?	**NA**	
	Notes:		
S-1.11	Has there been a recent spill in the area (septic or other)?	**NA**	
	Notes:		
S-1.12	What is the distance to farms or livestock?	**NA**	
	Notes:		
S-1.13	What is the general condition of the well?	**NA**	
	Notes:		
Source - Surface Water			
S-2.1	Have there been any reports of beavers or muskrat in the water supply? Or concentration of wildlife or birds using the water supply?	**No**	**OK**
	Notes:		
S-2.2	Are there any on-site septic systems near the water source and intake?	**No**	**OK**
	Notes:		

Code	System Aspects	CR - *Critical Issue* SR - *Serious Issue* Response Yes/No/NA	Result CR / SR /OK
S-2.3	Are there any new excavations or development activity in the water supply area?	**No**	**OK**
	Notes:		
S-2.4	Are there any farms or livestock in or near the water supply?	**No**	**OK**
	Notes:		
S-2.5	Has there been a recent spill in the area (septic or other)?	**No**	**OK**
	Notes:		
S-2.6	Is the reservoir/watershed area clean and free from potential sources of contamination?	**Yes**	**OK**
	Notes:		
S-2.7	Is there any new human activity in the reservoir/source area?	**No**	**OK**
	Notes:		
S-2.8	Have algal blooms been observed?	**No**	**OK**
	Notes:		
Environmental Event			
E-1	Has there been a heavy rainfall recently?	**No**	**OK**
	Notes:		
E-2	Has there been a rapid snow melt recently?	**No**	**OK**
	Notes:		
E-3	Has there been overland flooding recently?	**No**	**OK**
	Notes:		
E-4	Has there been a significant drop in available source water?	**No**	**OK**
	Notes:		
E-5	Has there been recent interruptions to treatment/distribution power supply?	**No**	**OK**
	Notes:		
E-6	Has there been extreme heat or cold recently?	**No**	**OK**
	Notes:		

Code	System Aspects	Response Yes/No/NA	Result CR / SR /OK
		CR - Critical Issue *SR - Serious Issue*	
Sampling Location			
	☐ SAMPLING COMPLETED BY QUALIFIED THIRD PARTY (EHO etc.) **SKIP L-1 to L-8 and P-1 to P-6**		
L-1	Is the tap from which sample collected clean, free of rust, have good flow?	**NA**	
	Notes:		
L-2	Are there any potential nearby sources which could result in contamination of the sampling tap?	**NA**	
	Notes:		
L-3	Is the tap used regularly?	**NA**	
	Notes:		
L-4	Has there been repairs to components in area/system since last sampling?	**NA**	
	Notes:		
L-5	Are any private treatment devices present? Sample taken: ☐ Upstream ☐ Downstream of treatment	**NA**	
	Notes:		
L-6	Are backflow preventers installed and if so has the required maintenance been conducted?	**NA**	
	Notes:		
L-7	Has there been a recent installation/repair of components within sampling building?	**NA**	
	Notes:		
L-8	Has there been any documented/known low pressure events since last testing (main break etc.)?	**NA**	
	Notes:		
Sampling Protocol			
P-1	Has the sampling protocol outlined in the Drinking Water Manual - Health and Community Services been followed?	**NA**	
	Notes:		
P-2	Were aerators, swivels and/or remote hoses removed prior to sampling?	**NA**	
	Notes:		

Code	System Aspects	*CR - Critical Issue* *SR - Serious Issue* Response Yes/No/NA	Result CR / SR /OK
P-3	Were sterile sampling bottles used and adequate storage available at the prescribed temperatures?	**NA**	
	Notes:		
P-4	Were clean gloves used to handle sample bottles and conduct sampling?	**NA**	
	Notes:		
P-5	Was tap flushed 5 minutes before beginning to collect samples?	**NA**	
	Notes:		
P-6	Was sampling completed by a person other than the normal collector?	**NA**	
	Notes:		

GENERAL NOTES

Volunteer operator indicated they are concern with the liability issues of operating the system.

BWA System Assessment Summary

Review results of the assessment worksheets to identify likely root cause(s) of the boil water advisory (Critical Issues) and areas of concern which may result in re-occuring BWA (Serious Issues).
Attach additional sheets as required.

Description of Deficiency   Some service lines on two old branch lines go through areas suspected to be contaminated from septic fields. The source of faecal contamination should be investigated and corrected.

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational Issue	☐	Environmental Issue
☒	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☒
Serious Issue	☐

Description of Deficiency   Two branch lines that are old, have very frequent breaks and need repairs. It was noted that the whole system was shut down when repairs were being completed and this may result in pressure drop in water main and potential for intrusion of untreated water into the distribution system.

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational Issue	☐	Environmental Issue
☒	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☒
Serious Issue	☐

Description of Deficiency   Long distribution line (~2200m) requires that chlorine residuals at disinfection system needs to be around 2 mg/l so adequate residual is in the line in Harris Point. This may be addressed by booster chlorination. Appears that chlorine residual was very low near disinfection system during start of the BWA.

Assessed Risk			
☐	System Facility Issue	☐	Source Issue
☐	Operational - Issue	☐	Environmental Issue
☒	Distribution Issue	☐	Sampling Location Issue
☐	Storage Issue	☐	Sampling Protocol Issue
☐	Treatment Issue	☐	Not Identified

Critical Issue	☒
Serious Issue	☐

SEE STANDARD OPERATING PROCEDURES TO ADDRESS THE AREAS OF CONCERN NOTED ABOVE