Evaluation of Existing Potable Water Dispensing Units and Recommendations for Design and Operational Guidelines

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Newfoundland Labrador

Department of Environment and Conservation

Prepared by:

CBCL LIMITED
Consulting Engineers

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Solving today's problems with tomorrow in mind

May 27th, 2010

Paula Dawe
Water Resources Management Division
Department of Environment and Conservation
PO Box 8700
4th Floor - Confederation Bldg - West Block
St. John's NL A1B 4J6

Dear Ms. Dawe:

RE: Evaluation of Existing Potable Water Dispensing Units and Recommendations for Design and Operations Guidelines

As requested in the original Terms of Reference for the study entitled 'Evaluation of Existing Potable Water Dispensing Units and Recommendations for Design and Operations Guidelines' we are pleased to submit the final report in fulfilment of the above-noted study. Enclosed you will find a data CD, containing:

- PDF copies of the final report and the six original technical memoranda;
- A Word 97-2003 compatible version of the final report;
- Excel 97-2003 compatible versions of relevant spreadsheets; and
- All graphic materials included in the report.

One (1) unbound and five (5) bound copies of the final report are also included.

Yours very truly,

CBCL Limited

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Project No. 093017.00

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CHAPTER 1 EXECUTIVE SUMMARY

As part of the Drinking Water Safety Initiative, the government of Newfoundland and Labrador is seeking to improve drinking water infrastructure in small rural communities throughout the province. Many of these communities have declining tax bases and ageing populations. Most draw their drinking water from surface water sources that have high and/or variable concentrations of colour, iron, manganese and other undesirable aesthetic parameters. Many lack the resources to treat the water consistently, resulting in frequent boil water advisories. One solution to the challenges faced by many of these communities may be the installation of potable water dispensing units (PWDUs).

PWDUs are small water treatment systems that are designed to provide high quality drinking water to the residents of small, rural communities. Their equipment is sized to produce enough water to fulfill the consumption needs of a community. The PWDU is generally located in a central location within the community and residents gather water in their own containers. Non-potable water continues to be provided to homes via a municipal water distribution system.

This report represents the culmination of a one year study that sought to critically assess the design, construction, operation and adoption of PWDUs in seven communities in the province of Newfoundland and Labrador. The information presented in this report was originally submitted to the Department of Environment and Conservation in the form of six technical memoranda. It will be of interest not only to the government employees working on the Drinking Water Safety initiative, but also to the residents, officials and water system operators of small, rural communities in Newfoundland and Labrador and throughout Canada.

Chapters 2 to 3 introduce the terminology used in the report and the overall rationale of the PWDU study.

Chapter 4 provides an overview of the treatment equipment used and the costs associated with the purchase and installation of each of the seven PWDUs. Three of the systems include ozonation for colour and metals removal and pressure filters for the removal of particulate. The remaining four are based around small-scale reverse osmosis treatment systems. All seven systems also incorporate disinfection, whether through UV light (6/7) chlorination (1/7) or both. The quality and cost of the systems varies from community to community.

Chapter 5 focuses on the dispensing areas where residents interact with the PWDU. The PWDU dispensing areas are the only portion of the system accessible to users, and as a result, their convenience, accessibility and cleanliness tend to have a strong influence on user perceptions of the

PWDU. Through communication with PWDU operators and users a number of best design and operation practices for the dispensing areas were identified by CBCL. These include accessibility, flexible operating hours, simple designs that encourage proper cleaning and maintenance and timed locks. Chapter 5 also includes a number of recommendations for improvements to the dispensing areas of the existing PWDUs and the dispensing areas of future systems.

Chapter 6 is an analysis of the costs associated with the operation and maintenance of the seven existing PWDU systems. Costs associated with energy use, labour and equipment replacement were calculated for each community and used to estimate the total annual cost of operating each of the existing PWDUs. Overall, it was estimated that each PWDU would cost between $9,000 and $11,500 to operate each year. The reverse osmosis systems were slightly less expensive to operate than the ozone and filtration systems because the reverse osmosis systems require less energy, less care and less expensive replacement parts. Reverse osmosis PWDUs located in communities using diesel generators for power, however, were found to be more expensive to operate than the ozone and filtration PWDUs because of the increased cost of power.

In Chapter 7, PWDU use drivers such as the accessibility of the community and the levels of education and employment among residents are identified. Barriers to PWDU usage are also identified, including inadequate operation and maintenance and lack of public support in larger, more accessible communities.

Samples of the feed and treated water from each PWDU were taken for 12 months and the results are discussed in detail in Chapter 8. The results of the testing are used to assess performance of the systems and to try to establish whether the quality of the treated water could be correlated to the per capita water usage in each community. During the study, all seven systems produced treated water free of health-based parameters such as arsenic, lead, and disinfection byproducts. Most of the systems also produced water that was aesthetically pleasing. The systems that were less capable of consistently providing aesthetically pleasing water were less likely to have been well adopted within their communities.

Chapter 9 is an assessment of the existing PWDU Guidelines as provided in the document ‘Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units’ published by the Department of Environment. Each of the seven existing PWDUs is compared to the recommendations provided this document. Deviations from the guidelines are noted and recommendations are made for improvements to the PWDUs and the PWDU Guidelines.

Chapter 10 presents an overview of three potential approaches to PWDU O&M management. Currently, each of the existing PWDUs is maintained by a local operator, who may be a trained, certified water supply operator, a local maintenance person or a volunteer operator. As more PWDUs are installed, multiple regional O&M networks or a province-wide O&M network may become feasible. Either of these options could reduce O&M costs for each community by allowing communities to share operators or by reducing local operator hours by transferring responsibility for certain O&M tasks to a central coordinator.

Finally, Chapter 11 includes two PWDU-related education packages. The first is made up of curricula for three one-day PWDU operator courses. The second is a public education package that can be used by the Government of Newfoundland and Labrador to promote PWDU use and PWDU safety in communities around the province.

CHAPTER 2 GLOSSARY

APS:	Atlantic Purification Systems
BDCM:	Bromodichloromethane
BWA:	Boil Water Advisory
CWQI:	Canadian Water Quality Index
DBP:	Disinfection Byproduct
ENVC:	Department of Environment and Conservation
GAC:	Granular Activated Carbon
GCDWQ:	Guidelines for Canadian Drinking Water Quality
HAA:	Haloacetic Acid
LSD:	Local Service District
Municipal Guidelines:	Guidelines for the Design, Construction and Operation of Water and Sewerage Systems
ORP:	Oxidation-Reduction Potential
PFD:	Process Flow Diagram
PWDU:	Potable Water Dispensing Unit
PWDU Guidelines:	Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units
PWQA:	Perceived Water Quality Assessment

RO:	Reverse Osmosis
TCU:	True Colour Units
TDS:	Total Dissolved Solids
THM:	Trihalomethane
WQRLA:	Water Quality Risk Level Assessment

CHAPTER 3 INTRODUCTION

3.1 Background

The government of Newfoundland and Labrador has adopted a Multi-Barrier Strategic Action Plan for drinking water safety, one level of which involves addressing the need for improved water infrastructure in the province. Although much progress has been made, a substantial number of small, rural communities continue to struggle to address concerns about drinking water quality. Seven of these communities have, with the assistance of the provincial government, installed small-scale drinking water treatment systems designed to supply potable water to the communities. These potable water dispensing units (PWDUs) are generally located in centralized locations where residents can easily come to collect their drinking water.

3.2 Project Organization

The PWDU study was originally broken into seven technical memoranda:

1. Treatment System Design.
2. Dispensing Areas.
3. Operations and Maintenance.
4. Local Capacity Analysis.
5. Water Quality Assessment.
6. Standard PWDU Treatment System Design.
7. Recommendations for the Design, Operation and Maintenance of PWDUs.

As the project progressed, technical memoranda 6 and 7 were combined and operator and public education modules were added to the project deliverables. This report represents the culmination of nearly a year of research and includes content from each of the seven memos as well as the education modules.

3.3 Objectives

The seven existing PWDUs evolved, for the most part, separately from one another. The main objective of this project was to assess the strengths and weaknesses inherent in the design, treatment, dispensing and operating strategies employed by each community in order to update the existing standards for new PWDUs to be constructed.

Objectives listed in the original proposal included:

- To conduct performance monitoring of existing PWDUs under a range of pre-treatment water quality conditions to ensure post-treatment water quality meets Guidelines for Canadian Drinking Water Quality (GCDWQ);
- To identify conditions that result in the existing PWDUs not being able to produce water that meets GCDWQ;
- To identify the problems and issues associated with the existing PWDUs;
- To make recommendations for the operation and maintenance of PWDUs;
- To identify criteria to use to evaluate local capacity to operate and maintain the PWDUs;
- To identify alternative O&M strategies for the existing PWDUs (ex. regionalization);
- To evaluate the design and operation of similar systems in other jurisdictions;
- To make recommendations for up to five standard PWDU designs based on the quality of source water; and
- To identify upgrades required for existing PWDUs to be in compliance with Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units.

CHAPTER 4 **TREATMENT EQUIPMENT**

Technical Memorandum #1, Treatment Equipment Summary, was submitted to the ENVC on June 1st, 2009. Comments were received on June 8th, 2009.

4.1 Community Summaries

4.1.1 Community A

The potable water dispensing unit in Community A serves a population of 201 people. It was installed in 2000 by FloTech Enterprises Ltd. The PWDU is located approximately 2 km from town and is easily accessible for most of the year. Many residents use All Terrain Vehicles (ATVs) or snowmobiles to access the site. The potable water system can produce up to 2,300 L of water each day, and the average usage is 950 L/day. Residents pay $0.12 per L of water dispensed.

The town has no other water treatment or distribution system, so two water streams are produced by the PWDU. The first is a non-potable water stream that can be used for various indoor and outdoor applications, and the other is a potable water stream for drinking and cooking.

The current process consists of pre-chlorination for oxidation followed by multimedia filtration for turbidity removal and granulated activated carbon (GAC) treatment for the removal of some colour and chlorine residual. A portion of the filtrate from the GAC filter, which is not considered potable water, is sent to a primary dispensing tap, where it is chlorinated before being provided to the user. The remainder of the filtrate from the GAC filter continues through a series of pre-filters and a reverse osmosis (RO) membrane filter, which removes any remaining dissolved contaminants. The membrane permeate is stored until it is required by a user. At that point, the water is then disinfected with UV light before finally being post chlorinated and dispensed to the community as potable water.

The system in Community A was significantly more expensive to construct compared to the other systems. It is also very expensive to operate and maintain, with annual O&M costs averaging approximately $25,000. This is partly because the community is far from a major service centre, and also because electricity for the community is generated onsite by diesel generator. In addition, the raw water in Community A is particularly challenging to treat because of its dark colour and periodically high iron and turbidity levels. This results in increased O&M costs as filters have to be changed more frequently to maintain high finished water quality.

To date, customer complaints have not been received about the water quality from the users of the Community A PWDU. However, the lack of funding, operator turnover, and long delays for the delivery of replacement parts have resulted in periodic PWDU shut-downs. These have led to some frustration among residents, who have become accustomed to having access to the high quality water provided by the PWDU.

The PWDU in Community A was taken offline in December of 2009 because the community was no longer able to afford the high operation and maintenance costs associated with the system. Their PWDU system was upgraded and serviced by the equipment supplier in early 2010, however, the community is still struggling to ensure that the system is properly operated and maintained. The system upgrades and servicing were paid for by the Department of Municipal Affairs and cost $20,000.

A schematic of the PWDU treatment process in Community A is provided in Appendix A.

4.1.2 Community B

Community B started using a PWDU in 2004. The PWDU is located adjacent to the main water storage standpipe in the west end of the town. The system was supplied by Durpro, and is capable of producing 4,000 L/day. The average use is 155 L/day, based on totalizer readings. A total of 761 people draw their drinking water from the PWDU. Users pay for the water through their municipal taxes.

The municipal water system in Community B includes filtration and disinfection with chlorine gas (ENVC, 2009). Water for the PWDU process is drawn directly from the main municipal distribution system. During the design process, the raw water was determined to be of high enough quality to be sent to the ozonation chamber without any pretreatment. The feed water is initially ozonated in a stainless steel contacting chamber and then sent to a 950 L holding tank. When water is required, the stored water is pumped from the holding tank through an activated carbon filter to remove colour, passes through a pH control cartridge filter, and is finally sent through a sediment filter to remove any remaining solids. The filtered water is disinfected with a UV light system and dispensed directly to the user.

A schematic of this process is provided in Appendix A.

4.1.3 Community C

Community C has been using dual PWDU units to provide potable water for its 703 residents since 2005. The systems were supplied by Atlantic Purification Systems, and were originally installed separately, one in the Town Hall and one at the chlorination building. The system at the chlorination building was subsequently moved to the Town Hall. Combined, the PWDUs can produce approximately 4,300 L/day of water, although on most days only approximately 3,000 L are dispensed.

The municipal water supply for Community C is Long Lake. Water is drawn directly from the lake and disinfected using chlorine gas. The pH is adjusted before the water is distributed to the community. The feed water to the PWDU is drawn from a tap on the municipal distribution system. The process consists of multimedia filtration for turbidity removal and GAC filtration for the removal of colour and chlorine residual in advance of the final filtration step, a reverse osmosis membrane. The filtered water is stored in two closed polyethylene water storage tanks and eventually passes through a UV light disinfection unit before being dispensed to the user. All of the aforementioned pieces of equipment were originally purchased in duplicate.

A schematic of the process described above can be found in Appendix A.

4.1.4 Community D

The PWDU system in Community D came online in the summer of 2009. It has a maximum capacity of 2,000 L/day and is designed to serve a population of approximately 200 people. The PWDU system was designed by Durpro based on the lessons learned during the construction and initial operation of the PWDUs in Community G and Community B.

At present, the municipal tap water in Community D is not filtered or chlorinated. The current 'Boil Water Advisory' lists Community D as being under a boil order due to a failed chlorinator. The PWDU process has been designed to accommodate a chlorinated feed stream. Therefore, when and if the chlorinator is replaced, it should not affect the quality of the finished PWDU water. The process begins with a 5 micron pre-filter followed by a granulated activated carbon filter. The water is then ozonated and sent to an ozone contact chamber to remove colour and other contaminants. After ozonation, the water is held in a 450 L storage tank. When water is required, the stored water is pumped through another GAC filter and finally sent through two post filters (5 micron and 1 micron), disinfected with UV light and dispensed to the user.

A schematic of the process as described by Durpro is provided Appendix A.

4.1.5 Community E

The PWDU process in Community E is similar to that found in Community C. It was installed in 2007 by Atlantic Purification Systems and can produce up to 4,000 L of potable per day. The average use is approximately 275 L/day. The service population is 285, including both permanent residents and cabin owners in the area.

The source of water for the PWDU system is the municipal water distribution system. Water provided to residents of Community E from the municipal water distribution system is disinfected with sodium hypochlorite; however, there is currently a boil water advisory for Community E because the chlorination system has not been working adequately. The feed water passes through a zeolite filter to remove turbidity and is then sent to an activated carbon filter to remove the remaining chlorine and some colour. The resulting chlorine-free stream is filtered through a reverse osmosis membrane unit and sent to a 1,000 L storage tank until it is needed. When water is dispensed from the storage tank, it is first pumped through a UV light disinfection system.

A schematic of the process can be found in Appendix A.

4.1.6 Community F

Community F has had a PWDU system since 2001, making it one of the first towns in Newfoundland and Labrador to install one. It serves a population of 618. The maximum flow rate from the system is 15,000 L/day and the average use is approximately 1,135 L/day. According to the operator, many residents have said that the water from the PWDU is superior to commercial bottled water.

Community F has a packaged water treatment plant to provide water for the municipal distribution system. The packaged treatment plant includes prescreening, pre-chlorination, coagulation/ flocculation, sedimentation, dual media filtration and post-chlorination. The PWDU process equipment was supplied by Atlantic Purification Systems. The packaged treatment plant is the source of the feed water for the PWDU. The treated water from the municipal treatment system initially passes through two pressure filters that are filled with a combination of GAC, Birm and sand. The water flows through two 5 micron RO membrane pretreatment filters, followed by an RO membrane. The membrane permeate is chlorinated and sent to a small, separate portion of the municipal clearwell until it is required by a user.

A schematic of the process can be found in Appendix A.

4.1.7 Community G

The PWDU system in the town of Community G was supplied by Durpro in 2007 and upgraded in 2009. According to the operator, the PWDU has approximately 100 daily users and the average use is 650 L/ day. The system was designed for an average flow rate of approximately 2,000 L/day and the maximum capacity is 3,800 L/day. The PWDU and the municipal water system serve a population of 1,349 inhabitants.

The PWDU is similar to that built three years previously in Community B and uses the chlorinated (chlorine gas) water from the municipal distribution system as its feed stream. The process consists of filtration through a GAC filter followed by a 5 micron hytrex filter and ozonation. The ozonated water is stored in a 950 L holding tank. When water is dispensed it is first pumped through another round of GAC filtration and a series of hytrex filters (5 micron and 1 micron) before being disinfected using UV light.

The system was upgraded in 2009 because the original design was based on feed water quality results that were not fully representative of the variation in raw water quality in the surface water source. Specifically, the system was designed based on a raw water colour of 20 – 40 TCU. Within a short time users began to notice colour in the water from the PWDU during periods following heavy precipitation. Additional monitoring indicated that on occasion, the colour of the raw water was above 150 TCU. This was particularly common when heavy rains occurred. The upgrades were designed to manage these occasional high colour events (up to 150 TCU). An Oxidation-Reduction Potential (ORP) feedback loop has been installed so that the system can automatically react to increases in ozone-consuming contaminants by increasing the dose of ozone provided.

A schematic of this process is provided in Appendix A.

Table 4.1 summarizes some of the important characteristics of the seven existing PWDUs.

4.2 Decision Making Criteria

4.2.1 Design Criteria

For the purposes of this study, the design criteria are defined as the parameters taken into account during the initial design and sizing of the PWDU equipment. The main concerns of the designers of the seven PWDU systems currently operating in Newfoundland and Labrador were:

- Raw water quality;
- Requirements for finished water quality (Guidelines for Canadian Drinking Water Quality, GCDWQ); and
- The maximum capacity of the required system.

Table 4.1 Summary of Seven PWDU Systems Operating in NL

	Community A	Community B	Community C	Community D	Community E	Community F	Community G
Population Served (Seasonal)	201	761	703	265	241 (285)	618	1349
Year Installed	2000	2004	2005	2009	2007	2001	2007
Maximum Capacity	2,300 L/day	3,800 L/day	4,300 L/day	2,000 L/day	4,000 L/day	15,000 L/day	3,800 L/day
Average Flow	950 L/day	450 L/day	3,000 L/day	Unknown	250 L/day	1,135 L/day	650 L/day
Supplier	FloTech	Durpro	APS	Durpro	APS	APS	Durpro
Consultant	Hatch	Kendall Engineering	Atlantic Engineering	Newplan	Kendall Engineering	Kavanaugh and Associates	Kendall Engineering
*Approved by ENVC	No	No	No	Yes	Yes	No	Yes

Some systems had other specific requirements that had to be addressed during the design. The design criteria used during the design of the PWDUs is summarized in Table 4.2.

Table 4.2 PWDU Design Criteria

	Raw Water Quality	Finished Water Quality	Capacity	Other
Community A	high colour, DOC, iron, high and variable turbidity (ENVC)	GCDWQ	2,300 L/day	
Community B	moderate colour, DOC, variable turbidity (ENVC)	GCDWQ	3,800 L/day	
Community C	moderate colour, DOC, variable turbidity (ENVC)	GCDWQ	4,300 L/day (19 L/min for 4 hours)	
Community D	high and variable colour and DOC, moderate turbidity (ENVC)	GCDWQ	2,000 L/day	colour above 150 TCU
Community E	moderate colour, turbidity, high DOC (ENVC)	GCDWQ	4,000 L/day (19 L/min for 3.5 hours)	boil water order
Community F	high and variable colour, DOC, moderate turbidity (ENVC)	GCDWQ	15,000 L/day	high, variable TDS
Community G	moderate and variable colour, DOC (ENVC)	GCDWQ	3,800 L/day (11.5 L/min for 5.5 hours)	upgrade completed in 2009 to account for high feed water colour

4.2.2 Selection Criteria

For the purposes of this study, selection criteria are defined as the parameters considered when the town, design engineer, or supplier is choosing between a variety of different systems, all of which could be used to meet the design criteria.

Through discussion with suppliers, design engineers, and representatives from the communities in question, it was established that the appropriateness of a given process for small, remote communities in Newfoundland and Labrador was the most important factor driving the choice of equipment used. In many cases, it appeared that the final definition of appropriateness was dependent on the subjective opinions of those in charge of the design, usually the supplier (*i.e.,* suppliers were pre-selected and performed the majority of the design). For example, all three systems designed and installed by Durpro are ozonation systems, and the processes were designed by Durpro based on criteria provided by the province via the engineering consultant. Durpro generally believes that ozone is more appropriate for rural NL than an RO membrane or another sort of more experimental treatment. They prefer not to use RO membrane filtration in these applications because it cannot be continuously monitored for integrity and the system does not actually inactivate pathogens, it only removes them by physical separation.

Other companies were less averse to RO filtration, which are generally safe and easy to operate. RO membranes, however, are sensitive to chlorine, and therefore the chlorine must be removed before the water reaches the RO elements. In the PWDUs, this has usually been accomplished using a GAC filter placed ahead of the RO membrane.

Many of the criteria used by the towns, engineering consultants and especially the suppliers to decide on a particular PWDU design are similar to those that have been formally documented in 'Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units' available from the ENVC.

4.3 Cost Analysis

Available data on estimated and actual costs for the existing PWDU systems were assembled and compared. Cost estimates varied depending on the source of the information.

In general, estimated equipment costs were provided by equipment suppliers and/or the consulting engineers, while total estimated costs were provided by the consulting engineer. Final construction costs, including equipment, building, and engineering costs, if applicable, were provided by the Department of Municipal Affairs (DMA).

Estimated and actual systems costs for the existing PWDU systems are provided in Table 4.3.

Funding in most cases was provided by the federal government, the provincial government and the town itself. For example, the funding of the systems in Community B, Community C, Community E and Community F were shared 35/35/30 between the federal government, the province and the town, respectively. The systems in Community A and Community D were funded entirely by the province. The cost for the original system in Community G was funded 65/35 by the province and the town, respectively, but the cost of the upgrade was funded 90/10, respectively.

Table 4.3 Comparison of Estimated and Final Project Costs for Existing PWDU Systems

Community	Estimated			As Constructed	
	Equipment Cost (By Supplier)	Equipment Cost (By Engineer)	Total Cost (Engineer)	Equipment Cost (MA)	Total Cost (MA)
Community A				$40,000	$140,000
Upgrade					$20,000
Community B	$33,000			$47,000	> $70,000
Community C	$22,650			$26,000	$26,000
Community D	$68,000	$81,500	$173,000		$250,000
Community E	$23,700			$27,000	< $30,000
Community F	$31,915	$31,915	$52,700		
Community G	$43,000			$46,575	$54,000
Upgrade	$15,000				

The cost of the system in Community D is thought to represent a reasonable estimate of the anticipated cost of the new, standardized PWDUs that are planned for other communities in the province. This is because the process employed in the Community D PWDU includes many of the same elements as the standardized PWDU and it is housed in an independent building that was built specifically for the application.

4.4 Summary

Seven PWDUs have been constructed in small or very small rural communities in Newfoundland and Labrador since 2000. The systems use either ozonation and filtration or RO membranes (usually coupled with GAC filtration) to treat the water and use UV light to disinfect the treated water before dispensing it to the user. The systems range in capacity from 2,000 L/day to 15,000 L/day. Only three of the PWDU systems have received construction approvals from the regulators.

The systems were mostly designed by equipment suppliers based on raw water quality data, the required capacity, and the need to conform to the Canadian Drinking Water Quality Guidelines. The type of system used was usually based on the expertise and equipment preferences of the supplier, and were designed to be appropriate for small, rural communities.

Capital costs were dependent on the location of the community, the type of system installed and the raw water quality. Equipment-only costs ranged from $26,000 to $47,000 as reported by MA. Total costs, which included engineering fees and the cost of a building to house the PWDU system, ranged from $26,000 to $140,000.

CHAPTER 5 DISPENSING AREAS

Technical memorandum #2 was submitted to the ENVC on July 7th, 2009. No comments were received on the content of the memorandum, which has since been split into two sections. The first, which describes the basic configuration of each of the dispensing areas and provides an assessment of users' perceptions of the dispensing areas, follows below. The second, which compares the seven dispensing areas to the existing PWDU standards, can be found in Chapter 9.

5.1 Introduction

Chapter 4 of this report discussed the treatment equipment and process designs of the seven existing PWDUs. Although the strengths and weaknesses of each system are of great interest to consultants, suppliers, and operators, users of the PWDUs are unlikely to come into contact with the treatment equipment. Instead, most users will be interacting with the PWDU exclusively via the water dispensing areas. The success or failure of the PWDU project in each community is therefore likely to depend in large part on the accessibility, usability and safety of the equipment and space used to dispense treated PWDU water.

The Department of Environment and Conservation has recently released a report entitled 'Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units' (ENVC, 2008). This document outlines some requirements and recommendations for consultants, suppliers and contractors to aid in the design and construction of new PWDU systems and PWDU dispensing areas in the province. Many design suggestions are provided to minimize contamination, ensure accessibility and encourage responsible use of the PWDU by residents.

All but one of the existing PWDUs and their associated dispensing areas were built before the PWDU Guidelines were released, and may therefore conform to all, some or none of the requirements and recommendations provided in that document.

The objectives of this chapter are as follows:

- Describe the potable water dispensing areas of the existing PWDUs;
- Assess the opinions of PWDU users with respect to the dispensing areas; and
- Create a list of best practices as observed in the existing PWDU dispensing areas.

5.2 Community Summaries

5.2.1 Community A

The Community A PWDU is located about 2 km outside of town. It is easy to access in the winter (snowmobile) but harder in the summer because of the lack of adequate roads. Many people drive up with ATVs. The potable water dispensing area is open from 8 am to 12 pm from Monday to Friday, during which time the operator is at the plant. At all other times the potable water dispensing area is locked. Customers use coins to pay $0.12/L for water.

There are two publicly accessible taps; one for general household water (non-potable) and the other for drinking water. The non-potable water access tap is located inside a newly constructed building next to the PWDU building. The non-potable water is discharged from the treatment system through tap that can be fitted with a hose. The second access tap, for potable water, is located inside the PWDU building and is made of PVC plastic. A pipe runs from the treatment area to the dispensing area. The discharge from the tap is manually controlled by the user. It is always pressurized, and the system is essentially automatic and controlled by the level of the storage tank. A stool is provided to hold customers' jugs at the proper height. The dispensing area (potable) is located in the same building as the treatment equipment, with the two areas being separated with a partition and a locked door.

No problems were reported with the system by the operator; besides the periodic need to shut down to wait for parts to arrive.

The water quality in Community A is challenging, and filters must be changed more often than might be expected. Because Community A is located far from a major service centre, it can take a while for replacement parts to arrive. There are also some health and safety concerns, according to the operator. There is no phone at the PWDU and in the case of an accident or illness at the site; a user or the operator would not be able to contact anyone in the town.

Overall, however, the community and the operator are very happy with the quality of the water produced by the PWDU.

5.2.2 Community B

In Community B, the PWDU dispensing area is located beside the municipal water distribution stand-pipe. A small public access room is heated and can be accessed by users 24 hours a day, 7 days a week. Vandalism has not been reported despite the fact that the PWDU dispensing area is always open. There is sufficient parking for at least two vehicles close to the entrance of the building. The building was not designed to be wheelchair accessible.

The dispensing system in Community B is controlled by the user through a system of buttons and taps. The user pushes one button to make the water flow from the storage tank through the UV disinfection unit and towards the taps. Another button is used to stop the water from flowing. If the stop button has not been pressed within five minutes, the water stops flowing automatically. The water eventually flows to two manual chrome-plated taps installed above a grated catch-basin to catch any potential spills or splashes. The taps were not designed to accommodate hose attachments.

Instructions on how to pressurize the system and use the taps are posted inside the PWDU dispensing area. Water quality records are available in the town office. According to the PWDU operator, users appear to be happy with the PWDU dispensing area although they would prefer that it be closer to the centre of town. Customers pay for dispensed water through their municipal taxes.

5.2.3 Community C

The PWDU in Community C is located adjacent to the Town Hall, making it convenient for most users. The dispensing area is heated using a portable heater and is open during office hours: Monday/Tuesday/Wednesday, 8:00 am to 5:00 pm, Thursday 8:00 am to 8:00 pm, and Friday 8:00 am to 2:30 pm.

The Town Hall is located in the centre of town, within 2 km of almost all of the residents. The parking area around the PWDU has enough room to accommodate at least two cars. It was recently determined that the dispensing area was not sufficiently accessible for disabled users, and renovation plans are scheduled for summer 2010.

The dispensing unit in the Community C PWDU consists of a manual water tap that enters the dispensing area from the treatment area. The tap is made of PVC and galvanized steel. The ends are threaded, making it easy to attach hoses. The tap is located approximately one metre from the floor and can accommodate a variety of collection containers. A wooden box can be used to hold smaller containers closer to the tap. A drain is located directly below the tap. Residents do not have access to the treatment area as it is locked at all times.

Since the dispensing unit consists only of a tap, instructions are not posted in the dispensing area. Water quality records are available in the Town Hall.

The PWDU operator considers the system to be a success and had no major complaints. Users pay for the PWDU water through their municipal taxes.

5.2.4 Community D

The Community D dispensing area was modeled on the one in Community G (discussed below). It is located in a heated building in the centre of town. Most users will access the PWDU by walking, as this is the main form of travel in the community.

The town has not decided how the PWDU water will be paid for. Options under consideration include as part of municipal taxes or by use of a coin operated system. The hours of access are also still being developed, but the current plan is to have the dispensing area open every day from 7:00 am until 9:00 pm. Outside of these hours, the dispensing area will be locked.

A filling station with three adjustable-height taps dispenses water from the PWDU for the user. The taps are manually controlled by the user and can accommodate a variety of collection containers. They are installed above a sink to ensure proper drainage of spilled or splashed water. The system is pressurized for dispensing by the user by pressing a button. After approximately one minute, the button will flash green and the user is able to draw water from the taps. Users are only able to access the dispensing system, as the treatment equipment is isolated behind a separating wall.

5.2.5 Community E

The Community E PWDU is located in a heated shed adjacent to the Town Office and is convenient for most users. There is enough parking to accommodate at least two cars. The PWDU is open to users from 8:00 am to 8:00 pm, seven days a week. There are a number of cabins in the area, and many of their owners use the PWDU water on the weekends. Access is controlled via a timed lock. The dispensing area is not accessible for disabled users. Residents are not able to access the treatment equipment, as it is separated from the dispensing area by a locked door.

The dispensing equipment is straightforward and no instructions are posted. Water from the PWDU is dispensed to users through a flexible hose connected to a squeeze nozzle. The tap is located above a large sink to provide drainage in the event of a spill. The flexible hose and large sink make it easy to fill a variety of jugs and containers from the tap. Water quality results are not posted in the PWDU dispensing area.

There have not been any complaints or major concerns with respect to the dispensing area. The operator cleans the dispensing area every week to minimize sanitation-related concerns. He reports that the time lock on the PWDU entrance and the squeeze nozzle are particularly effective.

5.2.6 Community F

The Community F PWDU is located in the centre of town (somewhat removed from the main roads) and is attached to the existing WTP. The PWDU acts as a polishing step for the municipal water supply, providing superior quality potable water for the residents. There is ample parking surrounding the WTP and the PWDU. Most people who live in town walk up with their plastic bottles, and some people have been known to show up with wheelbarrows.

The dispensing area consists of an outdoor tap that is accessible to users 24 hours a day, 7 days a week. It is accessible for disabled users. The system is started up when a user pushes the start button. A pump starts and will then operate for two minutes before automatically shutting itself off. The holding tank where the water is stored has a level-sensor that will automatically start the front of the process (RO) when the water level reduces to a set point. Residents do not have access to the treatment equipment, which is locked within a separate room within the building.

No instructions or emergency numbers are posted at the PWDU dispensing area. Water quality results are posted at the Town Hall. The entire system (holding tanks etc) is cleaned fully once a month and the taps are cleaned daily.

5.2.7 Community G

Community G has one of the more sophisticated dispensing areas of the seven PWDUs included in this study. The dispensing area is located at the centre of the town inside a heated building that is accessible 24 hours a day, 365 days of the year. The dispensing area is not locked, and vandalism has not been reported. The area around the PWDU has sufficient parking to accommodate more than two cars. The dispensing area is wheelchair accessible. Although the equipment and the dispensing area are in the same building, they are separated by a partition. The operator enters the treatment area from outside through a separate, locked door.

Users dispense water from a prefabricated filling station. Three taps located above a sink provide potable water to users. Their heights can be adjusted to accommodate different sizes of collection containers. The flow of water from the taps is manually controlled by the user. When people first arrive, they push a button to get the system pressurized. After about one minute, water can be dispensed. The pressure stays on for fifteen minutes and then shuts itself off automatically. The status of the water treatment system (water ready, water processing, water not ready) is displayed via a set of buttons near the dispensing unit.

When the system was first brought online, the dispensing unit became contaminated with bacteria. According to the operator, this caused by the direct contamination of the tap by a collection container or a human hand, although concerns have also been raised about the design of the sink. According to the PWDU operator, water is known to form stagnant pools in the sink because it does not drain properly.

Written instructions are provided for the operation of the dispensing unit. The dispensing area also includes a community information board. Water quality results are not available onsite, but are posted nearby at the Town Office.

5.3 Customer Satisfaction

The quality of the dispensing area of the PWDU, in many ways, governs the degree to which the system is adopted by the residents of the community. Therefore, an effort was made to collect information about the feelings of PWDU users with regards to the PWDU dispensing area.

5.3.1 User Survey

A user survey was sent out to the six communities who had active PWDUs as of April 2009, but unfortunately, a total of only 22 responses were received from three communities. Of those who did respond, 64% lived in Community F, 27% lived in Community C, and the remainder lived in Community E.

5.3.1.1 Community C

The PWDU is very popular with the population of Community C, the operator reports that residents of over 250 homes use it for drinking water on a regular basis. During a recent CBCL site visit six user surveys were retrieved which had been filled out by PWDU users during the month of May, 2009. All of the survey respondents described the water quality as being between 7 and 10 out of a possible 10. Users were divided about the quantity of water dispensed; some were satisfied while others felt there was room for improvement. The respondents were also divided about the accessibility and convenience of the PWDU, in some cases rating these as 4 to 5 out of a possible 10. Other users were more impressed, rating the accessibility and convenience as 8 or 10 out of a possible 10. Two out of the six respondents gathered water for people other than themselves. In both cases, the people they gathered water for lacked access to transportation to get to the PWDU. Some users washed their collection containers regularly, while others did not. Many of the respondents used the water they collected from the PWDU for cooking and tooth brushing in addition to drinking.

5.3.1.2 Community E

PWDU users in Community E have generally been very happy with the quality of the water provided by the system. Two user surveys were administered during a CBCL site visit and both users rated the water quality and quantity as 10 out of a possible 10. The users generally gathered 20 to 40 L of water during each PWDU visit and used the water for cooking, drinking and in one case tooth brushing. Both users collected water not only for themselves but for individuals who were elderly or physically incapable of gathering water on their own. One user reported washing their water bottles between each use, but the other user did not. This highlights the need for stringent disinfection of the PWDU dispensing areas and public education about water storage – some users will take a greater responsibility for the cleanliness of their drinking water and bottles than others.

5.3.1.3 Community F

Fourteen surveys were completed in Community F. About half of the respondents collected water not only for themselves, but also for others who lacked transportation or were physically unable. Almost all of those surveyed reported using 20L plastic jugs to collect PWDU water. The majority indicated that they clean their jugs between uses, usually with soap and warm water. About two thirds of the respondents reported storing their water in a cool location (refrigerator or water cooler). The water was used for drinking, cooking, ice-cubes and tooth-brushing. The users who responded to the survey were generally positive about the quantity and quality of water dispensed from the PWDU. They also considered the PWDU to be accessible and convenient.

5.3.2 Operator Interviews

In light of the low response rate to the user survey, it was necessary to contact the PWDU operators directly to gauge the feelings of the community towards the PWDU dispensing areas. The feelings of the operators with regards to the dispensing areas were also of particular interest since they are in a position to observe how users interact with the dispensing system.

Most of the operators interviewed were happy with the PWDU treatment systems and dispensing areas. They reported that the dispensing areas were well received by the community and that the quality of water was consistently high.

5.4 Summary and Recommendations

Based on discussions and findings, the following strategies (best practices) have proven effective with the existing PWDUs:

- Central, accessible location;
- Flexible access hours;
- Simple design that encourages proper maintenance;
- 'Free' water; and
- Timed locks at the entrance to the PWDU.

However, a couple of problems with the dispensing areas were raised during the interviews, including the following:

- Sanitation related problems;
    - Contaminated bottles in contact with taps;
    - Stagnant water in sinks;
    - Customers using their own personal hoses on public equipment;
- Inconvenient hours of operation;
- Inconsistent operation due to the need for replacement parts; and
    - More of a problem in areas further from service centres.

CHAPTER 6 OPERATION AND MAINTENANCE COSTS

Technical memorandum #3 was submitted to the ENVC on August 28th, 2009. Comments were received on September 1st, 2009.

6.1 Introduction

6.1.1 Objectives

The two major objectives of this chapter are as follows:

1. To compare the *reported* O&M costs to the *actual* and/or *calculated* costs of the seven existing PWDUs:
   a. Reported O&M costs were provided by operators of the seven PWDUs and may or may not include costs associated with energy use, labour, consumables and equipment replacement. These cannot be directly compared because different communities have included one, some or all of the aforementioned costs in their determination of the annual O&M costs associated with their PWDUs.
   b. Actual and/or calculated O&M costs have been determined by CBCL Limited based on current operation and maintenance schedules as provided by PWDU operators. The actual calculated costs include energy use, labour, consumables and equipment replacement costs. They can be compared across communities and systems to determine the effects of population size, location and system type on the O&M costs of a PWDU. Where information on a particular aspect of O&M was not available, estimates and assumptions were made based on conversations and data provided through various sources (described in individual sections).
2. To evaluate the difference between theoretical and actual O&M practices. This will provide insight into the adoption of standard water treatment practices by operators and PWDU users. It may also point out O&M discrepancies that could be resolved to provide more efficient and effective operation of the PWDUs.

6.1.2 Different Perspectives on Operation and Maintenance Costs

6.1.2.1 Reported O&M Costs and Practices – Operator Perspective

The operating and maintenance costs associated with the use of the seven existing PWDUs vary depending on the type of system being used, the local capacity to monitor and manage the system and the distance of the community from major service centres. Detailed information about the time and costs of operating and maintaining the PWDUs was obtained from a number of sources:

- Interviews with PWDU operators (phone and in person);
- Operator presentations from the annual NL water conference in Gander (2009); and
- ENVC reports and presentations.

In general, operation and maintenance (O&M) costs reported for the RO-based PWDUs ranged from $1,000 to $2,000 a year, while those reported for the ozonation/filtration systems ranged from $4,000 to $5,000 a year. One anomaly, however, is the O&M for the PWDU in Community A, located on an island off the coast of Labrador, which was reported to cost $25,000 per year.

6.1.2.2 Actual/Calculated O&M Costs and Practices – Engineering Perspective

In an effort to compare the systems more accurately, CBCL has separated the total cost of O&M for each system into four separate components:

- Energy requirements;
- Labour requirements;
- Consumables and equipment replacement; and
- Major equipment.

Different strategies were used to determine costs for each of the systems in each of the four categories as discussed in the following sections.

6.2 Energy Requirements

Electricity is required to operate the PWDU equipment and to provide heat and lights to the building in which it is housed. For the purposes of this project, when possible, only the energy costs associated with the PWDU treatment equipment were considered (*i.e.*, heating and lighting costs were not included due to the differences between building styles/sizes).

The energy required to operate each PWDU is dependent upon the type of treatment system used and the water production each day. For example, treating surface water with a reverse osmosis unit requires high pressure, and thus more energy. Ozonation also uses large amounts of energy because of the equipment required to generate the ozone from air. Some systems have higher daily flows because they serve larger populations or are particularly well used within the community. The total energy cost, in dollars, will also be affected by the local electricity rates. Two of the communities in this study use diesel generators as their only source of electricity.

With the exception of Community D, total annual energy costs were calculated for each community using the published power requirements of major equipment components, the daily flow through the system as determined through communication with PWDU operators, and the cost of energy ($/kWh) as assumed by CBCL for each community based on current NL Power electricity rates and/or the cost of diesel fuel. The resulting total daily cost was multiplied by 365 (days/year) to obtain the estimated total annual cost. The town clerk in Community D was able to provide CBCL with a power bill for their stand-alone PWDU building. This was used to calculate the estimated total annual energy cost for that community. Also included, for comparison purposes, was the cost of water production, in cents per L.

Table 6.1 indicates the calculated annual energy costs associated with the operation of the PWDU equipment in each of the seven communities participating in the study.

Table 6.1 Calculated Annual Energy Costs for Seven Existing PWDUs

Community	Type	Calculated Energy Cost ($/year)	¢/L
Community A	RO	$3,266.00	0.94
Community B	Ozone	$310.59	0.55
Community C	RO	$713.00	0.08
Community D	Ozone	$636.00	0.12
Community E	RO	$122.00	0.12
Community F	RO	$724.89	0.18
Community G	Ozone	$625.00	0.26

In general, the RO-based systems were found to be more energy efficient, as determined by the cost per litre treated, than the ozone/filtration systems. The exception was Community A, which has unique circumstances. The individual results and the assumptions used for each community during these calculations are summarized in the sub-sections that follow.

6.2.1 Community A

The annual energy cost of $3,265.74/year (0.94 ¢/L) for the system in Community A is by far the highest listed in Table 6.1 because of the unique circumstances encountered in this and many other remote northern communities in Labrador. There is no distribution system in the community, and the PWDU is the only source of treated water. As a result, the cost of operating an intake pump is included in the total energy cost of the PWDU, a cost which is not included for the remaining PWDUs.

Assumptions

- Diesel power costs approximately $0.30/kWh;
- System operated for 6.6 hours per day:
  - The design flow for the system is 2.4 L/minute; and
  - The daily volume of dispensed water is 950 L.

6.2.2 Community B

The annual energy cost to operate the ozonation and filtration PWDU in Community B was found to be relatively low at $310.59/year (0.55 ¢/L). The low total cost is likely because the system only dispenses approximately 155 L/day. The cost per litre, however, is higher than many of the other systems because it was assumed, based on information in the PWDU O&M manual, that the system operates in recirculation mode for 10 minutes out of each hour in addition to the time required to treat and dispense water to users.

Assumptions

- Average daily use is 155 L/day;
- Output during production is 8.7 L/min;
- The system operates for 10 minutes each hour irrespective of demand, therefore, the air compressor, oxygen concentrator and ozone generator operate for an additional 240 minutes each day; and
- The control panel and valves are energized 24 hours a day.

6.2.3 *Community C*

The energy costs for the PWDU equipment in Community C costs are approximately $713/year (0.08 c/L) The system runs regularly because it is well used by the community, with approximately 2,500 L of water produced daily. The cost per treated litre of water is 0.08 ¢/L, the lowest cost of all the PWDUs.

Assumptions

- Total flow has been estimated to be 2,500 L/day; and
- The RO has an output of 0.95 L/min.

6.2.4 *Community D*

The system in Community D has only just started operating and it is difficult to say what kind of average daily flow may eventually be drawn from the system. However, in order to provide some sense of comparison between the system in Community D and the other PWDUs, CBCL assumed the WHO minimum standard for water consumption: 5.5 L/person/day in order to calculate an average daily flow for the community. It should be noted that based on the other existing PWDUs, this number is actually quite high. If the Community D PWDU is adapted to a degree similar to those in other communities, the actual water consumption rate per person per day is likely to be closer to 1 to 3 L. Two calculations were then performed to estimate the total energy cost in Community D.

6.2.4.1 Power Required to Operate Treatment Equipment

The WHO rate of consumption was multiplied by the population of Community D to determine a theoretical treated water requirement for the population. This was carried through to the cost calculations, which were based on the power required to run the equipment known to be part of the Community D PWDU. This resulted in a total calculated annual cost of $636.00/year and a cost per litre of 0.12 ¢/L. Since the actual annual water consumption in the community is likely to be below this amount in during operation, it is expected that the total annual cost for energy will be less than $600 while the cost per litre of treated water will likely be above 0.20 ¢/L.

6.2.4.2 Monthly Power Bill

The operator was not able to provide CBCL Limited with an approximate daily flow, but the town clerk reported that the total cost of power for the month of January was $170. This included the cost of running the filters, the ozonation equipment, and heat and lights for the stand-alone PWDU building. Since only one monthly bill was available (the community records were undergoing an audit at the time of communication) the approximate annual energy cost was determined by multiplying the energy cost from January by 12. The result is a total annual energy cost of $2,040.00 and a per litre cost of 0.38 ¢/L. This calculation assumes that the majority of the energy costs in that month were associated with the treatment equipment and thus, would be expected to remain stable throughout the year. The calculated energy costs for similar systems in Community B and Community G, however, indicate that this assumption is not valid. Instead, it is likely that the energy required to heat the building made up a large portion of total energy used in January. The actual annual energy cost in Community D is expected to be less than the calculated amount as heating costs will be lower during the spring, summer and fall months.

Both of these scenarios rely on a host of assumptions that cannot presently be verified. The actual annual energy cost (including equipment, heating, and lights) in Community D is expected to be somewhere between $636.00/year and $2,040.00/year. The treatment equipment on its own will likely cost less than $600 to operate each year.

Assumptions:

- Daily water consumption of 5.5 L/person;
- Results in a total flow of 1,458 L/day;
- WHO Water Use:
  - System components similar to those in Community G and Community B; and
- Monthly Power Bill:
  - Monthly energy bill of $170 can be considered representative of monthly energy costs throughout the year.

6.2.5 Community E

The PWDU in Community E produces only a fraction of the water treated at some of the other PWDUs and consequently, has a much smaller energy cost than the other systems at $122.00/year. The cost per litre is 0.12 ¢/L.

Assumptions

- Daily water usage estimated to be 275 L/day based on totalizer readings;
- The RO has an output of 3.14 L/min; and
- The dispensing pump runs at 10 L/min.

6.2.6 Community F

Community F's PWDU has one of the highest annual flow of all the systems discussed in this study. This, along with the cost of diesel generated electricity, resulted in an annual energy cost of $724.89/year and a cost per litre of treated water of 0.18 ¢/L.

Assumptions

- Energy provided by diesel generating plant ($0.30/kWh);
- Daily water use reported by operator is 1,135 L/day;
- The RO produces 9.5 L/min:
  - 2 hours of operation each day;
- The dispensing pump runs at 19 L/min; and
- Chlorine pump runs whenever the RO is in operation.

6.2.7 Community G

Community G is the largest community in this study, but the town uses a similar amount of water as the other, smaller communities. The operation of the system results in an energy cost of $625.00/year and each litre of treated water costs approximately 0.26 ¢/L to produce. Thus, although the system serves a much larger population, its total annual energy cost is comparable to that of the other PWDUs. Its cost per treated litre of water is lower than that in the other fully operational ozonation/filtration system (Community B) because four times as much water is dispensed from the Community G PWDU.

Assumptions

- Daily use reported as 650 L;
- Feed flow is 3.8 L/min;
- Ozonated water recirculates in the system for 10 minutes each hour;
- Run time for treatment is 172 minutes; and
- Run time for recirculation is 240 minutes.

6.3 Labour Requirements

The PWDU equipment must be regularly maintained in order to ensure high drinking water quality. The actual amount of time required for maintenance at a given PWDU is expected to vary widely based upon a number of factors:

- The equipment included in the PWDU (*i.e.*, UV vs. chlorine for disinfection);
- Whether the PWDU shares components with an existing system (*i.e.*, Community F);
- The total amount of water dispensed per day;
- The raw water quality;
- The experience of the operator; and
- The overall commitment of the community to maintaining the system.

This portion of the technical memo is divided into four main sections. The first section provides a brief summary of the existing O&M practices at each PWDU, as provided by the operators themselves during conference presentations and communications with CBCL representatives. The second section provides a discussion of recommended O&M practices, as recommended by suppliers and CBCL. The third and fourth sections explain the methodology applied by CBCL to calculate the labour costs associated with the existing PWDUs and discuss how the various systems compare to one another.

6.3.1 Labour as Reported by Operators

Reported labour practices and costs refer to information provided by operators during their presentations at the 2009 Clean and Safe Drinking Water Workshop held in Gander from March 24th to 26th or during subsequent communications with CBCL. Specific communications included:

- Phone interviews conducted with six operators during the summer of 2009;
- Site visits to three existing PWDUs during the summer of 2009; and
- A phone survey conducted in February of 2010 (five of seven operators participated).

6.3.1.1 Operator Interviews

Existing PWDU O&M labour practices vary widely. The following paragraphs summarize the reported O&M activities at each PWDU.

Community A

The community has a designated operator who manages the PWDU, which includes taps for both potable (for consumption) and non-potable water (for general household use). The operator spends four hours a day operating and maintaining the system and responding to the needs of users. Some regular maintenance duties include water quality testing, filter replacement, screen cleaning (every four months) and a semi-annual cleaning of the raw water reservoir.

Update: The operator in Community A was laid-off in December 2009. No replacement has been hired to date.

Community B

Two operators manage the O&M activities related to the PWDU. They generally spend a total of 3 to 4 hours a week on the system. Some regular activities include cleaning the water dispensing area, changing filters and UV lamps, cleaning the storage tank and changing the activated carbon media. The total reported costs associated with O&M are approximately $4,700/year. According to the operator, labour costs make up a large fraction of this.

Community C

The PWDU in Community C is maintained by one operator, who spends approximately an hour a week on the RO system. Duties include regular flushing of the RO membrane, changing the sediment pre-filter for the RO once every two weeks and various other tasks as required. The operator considers the PWDU to be the simplest part of his daily duties, and has not reported any major problems with the system.

Update: The operator in Community C stopped working for the town in the Fall of 2009. He has been replaced by a new operator who does not have extensive water treatment experience.

Community D

Data is not available as the PWDU operator position has been filled by at least two different people during the six months that the PWDU has been in operation. O&M practices and calculated labour costs for Community D, however, are anticipated to be similar to those at the Community G PWDU.

Community E

One part time volunteer operator is responsible for the RO-based PWDU in the community of Community E. The operator checks the system every day of the week to ensure there are no alarms or other issues. The UV lamp is cleaned every two weeks, and the RO pre-filter is changed once a month. The supplier, APS, has been a useful training resource for the operator.

Community F

The PWDU in Community F was built at the same time as the town's packaged water treatment plant. The same operator maintains both systems. The original operator was not specifically trained in water treatment but his previous experience as an electrician has left him familiar with automated systems and a site visit confirmed that the PWDU was kept in excellent operating condition.

The PWDU treatment equipment is located inside the water treatment plant building, and in some cases, is integrated into the facility. For example, after the PWDU water has been filtered through the RO, it is sent to a storage tank and chlorinated. This storage tank is actually a concrete basin built into the main clearwell. Exact operation and maintenance costs for the PWDU were unknown to the operator and difficult to determine because the system is so integrated with the main municipal water treatment system.

Update: The original operator passed away in 2009. He was replaced by another town employee, who appears to be comfortable with the operation, maintenance and monitoring of both the packaged WTP and the PWDU.

Community G

The PWDU in Community G is operated by two full-time operators who are also in charge of the existing town water supply and distribution system. They spend a total of 4 to 5 hours every week managing the PWDU. Weekly tasks include disinfecting the dispensing area, cleaning the facility, inspecting gauges and monitoring water quality. The ozone generator is inspected once a month and the ozone generator lamps are cleaned four times per year. The operators also conduct an annual inspection of the system to ensure that all aspects of the system are operating correctly.

6.3.2 Recommended Labour Practices

6.3.2.1 Reverse Osmosis Systems

The reverse osmosis units used in Communities A, C, E and F was all made by different manufacturers, but have similar O&M needs. In most cases, maintenance is based on system performance and cleaning is recommended whenever fouling causes the flow to drop below 80% of the baseline value or when the percent rejection of the membrane falls below 95%. The operator is also generally required to flush the system daily or multiple times during the week to minimize the build-up of contaminants on the membrane surface. If cleaning and flushing fail to re-establish adequate flow-rates, the RO membranes must be replaced immediately.

In some cases, the manufacturer has simplified operation by providing specific time frames within which O&M activities are to be performed or by avoiding them altogether. Three of the four membrane plants were built without the equipment required to properly clean the membranes. Sometimes maintenance activities were recommended based on both operation time and system performance. For example, the supplier recommended that the sediment pre-filter should be replaced monthly or when the pressure differential across it is greater than 7 psi. As well, the supplier recommended that the carbon pre-filter should be replaced at least once a year and/or whenever colour/chlorine is found to be passing through.

6.3.2.2 Ozone/Filtration Systems

All of the ozone/filtration systems were designed and supplied by the same company. According to the O&M manuals provided to the operators, it should take approximately 1.5 hours a week to maintain the systems. Communities with ozone/filtration PWDUs include:

- Community B;
- Community G; and
- Community D.

The supplier recommends that the ozone generator be checked once a week to ensure it is working correctly. In order to do this, the operator must shut off the system, open the ozone generator cabinet and check for water through the sight glass of the coalescer. If water is detected, the water trap should be drained. Cartridges in the sediment filters are generally designed to be replaced at a given interval. For example, in Community B, the supplier recommends that the sediment filter be replaced when the pressure differential across the filter reaches 15 psi. The supplier recommends that the media in the carbon filters be changed out approximately once a year. Over time, sediment can accumulate in the holding tank. Therefore, the supplier recommends that the tank be cleaned out and rinsed at least once a year, but ideally more frequently. They also suggest that the UV lamps should be replaced annually and that the UV lamps themselves should be cleaned once a month. The supplier recommends that access to the dispensing area should be restricted once a week so that the operator can disinfect the taps with javex. Finally, the finished water should be tested for colour once a week to ensure that the water is being treated adequately.

6.3.3 Determination of Labour Costs

To compare the labour O&M requirements for each system, the following practices were applied to calculate the ‘recommended’ labour O&M requirements for each community. Task frequencies and durations shown in Table 6.2 are based upon supplier recommendations (as summarized in the previous sections) and CBCL experience with similar systems in other municipalities.

Table 6.2 CBCL Labour Practices for the Existing PWDU Systems

LABOUR PRACTICES		
Task	**Frequency**	**Duration (hours)**
System Check	Daily	0.25
Clean Dispensing Area	Weekly	1
Inspect Gauges and WQ	Weekly	1
Flush Membrane	Weekly	1
Change Cartridge Filter	Monthly	1.5
Clean UV Lamp	Monthly	3
Inspection of Ozonator	Monthly	2
Sanitize Membranes	Bi-monthly	6
Clean Ozone Generator Lamps	Quarterly	3
Clean Storage Tank	Quarterly	4
Replace Ozone Generator Filter	Semi-Annually	6
Change MM Media	Annually	8
Change GAC Media	Annually	8
Replace UV Lamp	Annually	3
Detailed Inspection of Ozone System	Annually	2
Change Membranes	Every 3 Years	8
Cost of Labour:		***$20/hour****

*Based on labour cost as reported by operators in Community B

These standards are only valid for the recommended O&M calculations and do not reflect established O&M practices at any of the existing PWDUs. In particular, it should be noted that many of the operators who maintain the PWDUs do so in addition to their established duties as community maintenance workers. PWDU operators in some communities work on a volunteer basis and are not paid for their services.

The reported labour time was determined through communications with PWDU operators and, in all but one case, subsequent calculations based on an assumed rate of operator pay ($20/hour). The exception to this was Community B, which was able to provide an annual labour cost. The 'calculated' labour time was determined based on supplier recommendations and the labour standards in Table 6.1. The resulting annual number of hours of labour spent by an operator performing O&M duties related to the PWDU was multiplied by the aforementioned assumed rate of operator pay.

6.3.4 Summary of Labour Costs

Table 6.3 compares the reported and recommended levels of labour-related O&M for each existing PWDU system. It must be emphasized that exact labour rates for each system are not known, therefore these costs are only valid for comparison among systems.

Table 6.3 Reported and Calculated Labour-Related Costs for the Existing PWDU Systems

Community	Type	Time (hr/year)		Cost		Annual Water Production	Cost/L (¢/L)	
		Reported	Calculated	Reported	Calculated	L/year	Reported	Calculated
Community A	RO	1300	260.25	$26,000.00	$5,205.00	346,750	7.50	1.50
Community B	Ozone	156	326.25	$4,197.50*	$6,525.00	56,575	5.51	11.53
Community C	RO	78	328.25	$1,560.00	$6,565.00	912,500	0.17	0.72
Community D	Ozone	156	326.25	$3,120.00	$6,525.00	532,170	0.59	1.23
Community E	RO	156	328.25	$3,120.00	$6,565.00	100,375	3.11	6.54
Community F	RO	156	333.25	$3,120.00	$6,665.00	406,026	0.77	1.64
Community G	Ozone	156	326.25	$3,120.00	$6,525.00	237,250	1.32	2.75

*Actual reported labour cost, not calculated.

As indicated in Table 6.3, most of the operators reported spending between 1 and 5 hours per week operating and maintaining their PWDU. To obtain an annual number, this was averaged to 3 hours per week and multiplied by 52 to get 156 hours of O&M per year. The variation between these numbers and those reported for other communities can be explained by two reasons:

1. Operators varied in their willingness and ability to provide the recommended amount of O&M.
2. Some communities may not have reported the full extent of the operators' O&M activities.

Community A had a particularly high reported annual labour cost. This is because when the system was operational, the operator worked at the PWDU for 20 to 25 hours each week. The calculated (recommended) annual labour cost for Community A is much lower than the reported cost as it is assumed that a person is not specifically required to dispense the water and is comparable to labour costs in other communities.

The calculated labour costs do not vary to the same extent as the reported costs because they have been standardized based upon the type of system being operated. In almost all cases, the calculated labour costs were significantly higher than the reported labour O&M costs. These higher costs are not necessarily indicative of inadequate care of the PWDU systems by operators. Instead, they reflect the individual circumstances of each operator and the assumptions made in order to calculate labour O&M costs that could be compared to one another.

The most important conclusion that can be drawn from these calculations is that the cost of operating the RO-based systems (as recommended by suppliers) did not differ noticeably from that of operating the ozonation/filtration systems (as recommended by suppliers).

6.4 Consumables and Equipment Replacement

Each community must spend a certain amount of money each year on consumable items including UV lamps, membrane elements, chemicals, sediment filters and filter media in order to maintain the system in good working order. The total cost of consumables will be dependent on the individual costs of the various items and their frequency of replacement. The frequency of replacement is often determined by the raw water quality and the level of regular equipment maintenance conducted by the operator.

Complete information on the cost and frequency of replacement of the various consumables in each system was not available and a number of assumptions had to be made. These assumptions were based on information gathered from the following sources:

1. Reported costs from the system itself.
2. Reported costs from a similar system.
3. Discussions with suppliers.
4. Information from previous projects.

A spare parts allowance of $100/year was made for each system. Table 6.4 below shows the approximate cost of consumables for each community (total cost per year and cost per litre treated).

Table 6.4 Consumables-Related Costs for the Existing PWDUs

Community	Type	Total Cost ($/year)	Cost Per Litre (¢/L)
Community A	RO	$2,520.00	0.73
Community B	Ozone	$696.00	1.23
Community C	RO	$1,141.00	0.13
Community D	Ozone	$656.00	0.28
Community E	RO	$938.00	0.93
Community F	RO	$1,266.00	0.12
Community G	Ozone	$656.00	0.28

The highest consumables cost was found in Community A. This is as a result of their particularly challenging raw water quality; they replace their membrane elements up to four times a year because they become too fouled to operate properly. In general, the RO systems had higher costs associated with consumables because the RO membrane elements, which must be replaced periodically (usually every 2 to 3 years) are particularly expensive.

6.5 Major Equipment

Some major pieces of equipment in the PWDUs will have to be periodically replaced. Municipalities should try to put aside a certain amount of money each year to save up enough capital to purchase these larger pieces of equipment. The amount that should be put aside each year to save up for any given piece of equipment can be determined using a uniform series calculation (shown below) as long as the total cost (F), the interest rate (i) and the number of years (n) between replacements are known.

$$A = \frac{F}{\left(\frac{(1+i)^n - 1}{i}\right)}$$

The PWDUs that use RO technology will have to replace their RO pumps ($1,000/each) approximately every five years and those that use ozonation/filtration technology will have to replace their ozone generating systems ($10,000/each) every five to six years. All of the systems with dispensing pumps ($1,000/each) will have to replace them every five years or so.

Assuming an interest rate of 5% per year, the systems using RO technology will have to put aside approximately $360 per year in order to purchase suitable RO and dispensing pumps after the five year replacement period. The three systems using ozonation/filtration will have to put aside approximately $1,990 per year in order to purchase a new ozonation system and a new dispensing pump at the end of five years. These estimates may appear to unfairly emphasize the equipment replacement costs associated with the ozonation/filtration systems. This is because the RO membrane elements, which represent the largest equipment replacement costs for the RO-based systems, were treated as 'consumables' and included in the calculations for the previous section.

Table 6.5 summarizes the total amount of money that should be put aside in each community to cover the purchase of major equipment.

Table 6.5 Annual Contribution Required for the Purchase of Major Equipment

Community	RO Pump	Ozonation System	Distribution Pump	Total Cost	$ Saved Per Year	¢/L
Community A	1	0	1	$2,000	$362	0.10
Community B	0	1	1	$11,000	$1,991	3.52
Community C	2	0	0	$2,000	$362	0.04
Community D	0	1	1	$11,000	$1,991	0.37
Community E	1	0	1	$2,000	$362	0.36
Community F	1	0	1	$2,000	$362	0.09
Community G	0	1	1	$11,000	$1,991	0.84

6.6 Summary and Total Costs

The four main costs associated with the operation and maintenance of the PWDUs was added together for each of the seven communities with existing PWDUs. The resulting total costs and costs per litre of water treated for each community are shown in Figure 6.1.

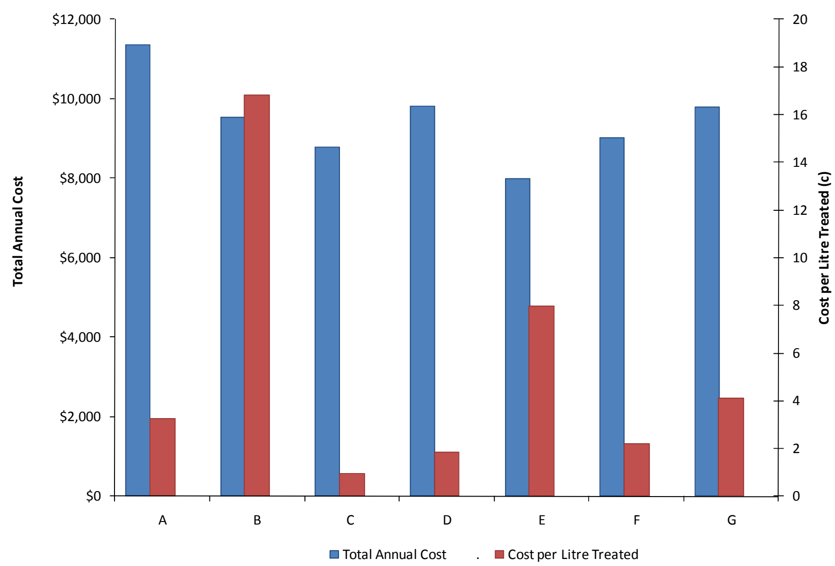


Figure 6.1 Total Annual Cost ($) and Total Cost Per Litre of Treated Water (¢/L) for the Existing PWDU Systems

6.6.1 Total Annual O&M Costs

Figure 6.1 shows that the seven existing PWDUs generally have comparable total O&M costs, with the ozonation/filtration systems costing approximately $10,000/year to operate and the RO-systems costing on average $9,000/year with the exception of Community A.

The bulk of the total cost for all of the systems was found to be made up of the recommended cost of labour, which was approximately $ 6,500 in each community. The communities were differentiated from one another by the cost of power ($/kWh), the amount of power required to run the various systems and the amount of money to be put aside each year to save for the replacement of large pieces of equipment.

It was determined that the ozonation/filtration systems cost slightly more to operate than the RO systems because the ozonation equipment, which is complex and expensive, must be replaced at a cost of $10,000 every five years. RO pumps, are less expensive at $1,000/year. The communities employing ozonation equipment must put aside a larger amount of money each year to cover equipment replacement costs.

The cost of operating the PWDU in Community A appears high because the cost of power in the town was assumed to be three times that of communities not using diesel generators and the cost of running an intake pump had to be included in the total O&M cost for the PWDU since the community does not have a distribution system.

The calculated total annual O&M costs discussed above do not include the cost of heating and lighting the PWDU treatment and dispensing areas. Heating and lighting costs will vary depending on the specific weather conditions in each community, the type and size of the building as well as the cost of electricity.

6.6.2 Cost per Litre of Treated Water

As described in previous sections, a convenient way to gain insight into the O&M costs associated with the PWDU systems is to compare the cost of treating one litre of water in each system. The main driver of the per litre cost was determined to be the frequency with which the residents use the PWDU system. The per litre cost is also affected by the size of system; the smaller systems are more expensive to operate relative to the larger systems because they require the same levels of labour and equipment replacement despite treating only a fraction of the flow. As mentioned previously, these costs should be considered theoretical, not actual. All of CBCL's calculations were performed with an objective of establishing a 'worst case scenario' and the cost of treating a litre of water in the existing PWDU systems is likely less than the 1 to 17 ¢/L determined through the calculations. Table 6.6 summarizes the contributions of energy, labour, consumables and major equipment costs to the total cost of each litre of water dispensed from the PWDUs.

Table 6.6 Contributions of Energy, Labour, Consumables and Major Equipment Costs (¢/L) to the Total Cost of Each Litre of Water Dispensed from the Seven Existing PWDUs (¢/L)

Community	Type	Water Use/Day	Energy	Labour	Consumables	Major Equipment	Total
Community A	RO	950 L	0.94	1.50	0.73	0.10	3.27
Community B	Ozone	155 L	0.55	11.53	1.23	3.52	16.83
Community C	RO	2,500 L	0.08	0.72	0.13	0.04	0.96
Community D	Ozone	1,458 L	0.12	1.23	0.12	0.37	1.84
Community E	RO	275 L	0.12	6.54	0.93	0.36	7.96
Community F	RO	1,135 L	0.18	1.64	0.31	0.09	2.22
Community G	Ozone	650 L	0.26	2.75	0.28	0.84	4.13

Communities that use more PWDU water each day have lower per litre costs. The type of system employed (RO or ozonation/filtration) did not have as strong of an effect on the total calculated cost of treating one litre as did usage rates. The cost of labour made up the largest fraction of the total per litre cost in all of the communities. The cost of power was less of a factor in the total cost per litre treated than it was when the total O&M cost was calculated. The relative contribution of these factors did differ significantly amongst the systems however, as demonstrated in Figures 6.2 and 6.3 shown below.

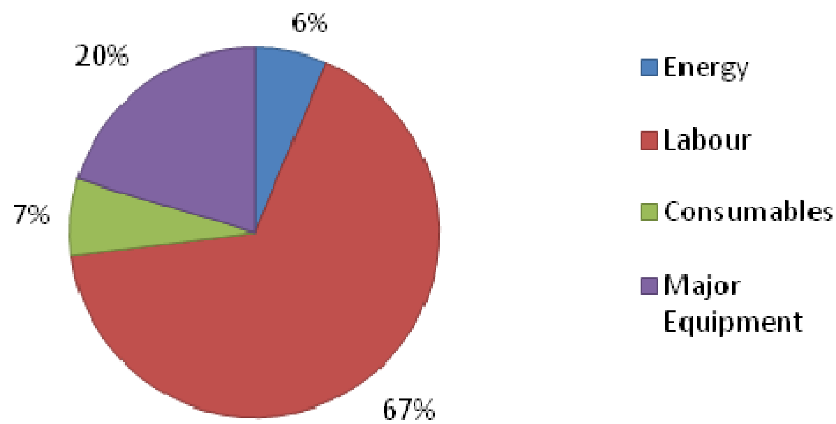


Figure 6.2 Breakdown of the cost of Treating One Litre of Water in Community G (Ozonation)

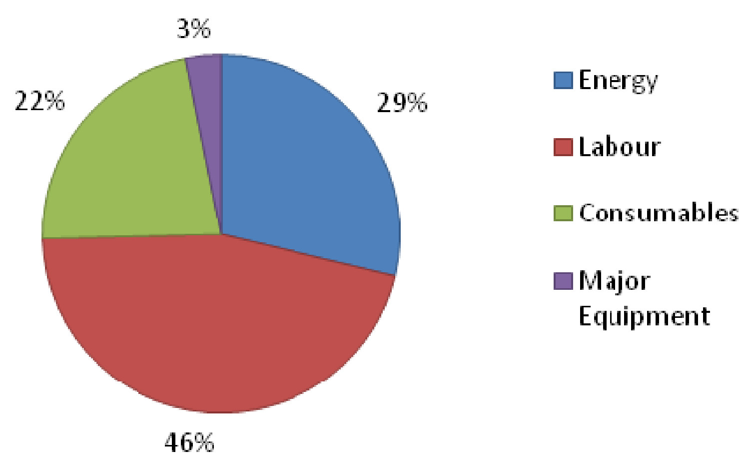


Figure 6.3 Breakdown of the cost of Treating One Litre of Water in Community A (RO)

The PWDUs in Community G and Community A have a similar cost per litre treated (4.13 ¢/L and 3.57 ¢/L respectively). The system in Community A costs more to operate each year, mainly as a result of the elevated cost of power in the community, however, the residents of Community A also use more PWDU water each year than their counterparts in Community G (350,000 L/year and 240,000 L/year respectively) which results in a lower cost per litre.

Despite the similar per litre treated cost, the relative contributions of power costs, labour-related costs, and the costs associated with the purchase of consumables and major equipment in the two communities are very different. Therefore, the two systems would be expected to react differently to variations in these costs. For example, calculated labour costs make up 67% of the cost to treat a litre of water in Community G but only 46% of the cost to treat a litre of water in Community A. Conversely, energy-related expenses make up 6% of the cost of treating a litre of water in Community G but 29% of the cost of a litre of water in Community A.

Under current (in many cases, assumed) conditions, it costs approximately the same amount of money to treat a litre of water in Community G as it does to treat one in Community A. However, if, the cost of labour were to increase, the cost of treating a litre of water would be expected to rise more sharply in Community G than in Community A. Increases in the cost of fuel would be expected to increase the cost of water treatment in Community A significantly, but would have a much lesser effect on the cost of water treatment in Community G.

The PWDU in Community C uses similar technology (RO) as the one in Community A, however, each litre treated in Community C costs only a fraction of one treated in Community A. This can mostly be explained by the much higher assumed usage rate in Community C (912,000 L/year based on flow rates). However, a comparison of the relative contributions of each cost factor, as shown in Figure 6.4 below, suggests that the cost of power also has an impact on the difference in the total cost of a treated litre of water from each of the two RO systems.

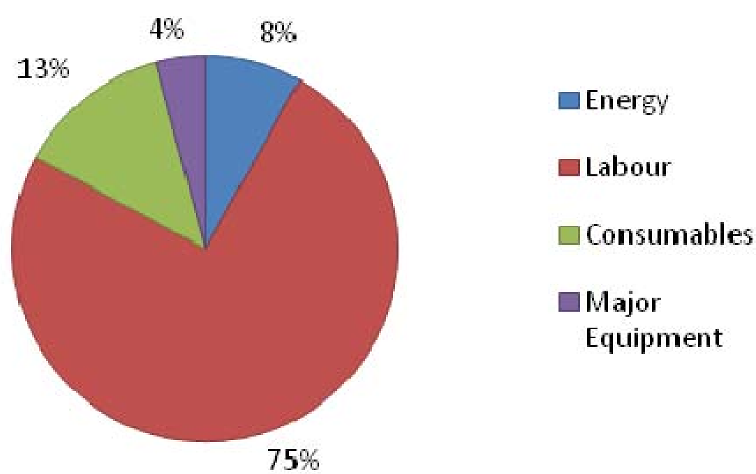


Figure 6.4 Breakdown of the cost of Treating One Litre of Water in Community C (RO)

A much larger proportion of the cost of treating a litre of water in Community C goes towards paying an operator to maintain the system (75%) than in Community A (46%). This suggests that minimizing operator duties will reduce costs (per litre) more in Community C than in Community A, where the cost of treating a litre of water is more closely tied to the cost of diesel fuel.

Consumable costs also formed a larger proportion of the total per litre cost in Community A than in Community C because the more challenging water quality in Community A results in the membrane elements being switched out up to four times a year instead of every two to three years like in Community C.

6.7 Conclusions

1. O&M costs reported by the seven communities with existing PWDU systems vary widely because:
   a. Not all costs are accounted for (*i.e.,* heat and lights).
   b. Some communities view PWDU O&M as an extension of the O&M of the main treatment system and have not budgeted funds and/or effort spent specifically operating and maintaining the PWDU.
   c. Different amounts of information were provided to CBCL by each community. In particular, little or no information was available from Community D.
2. O&M costs reported by the communities were often much lower than those determined through calculations performed by CBCL.
3. Systems cost more to operate if they are served by diesel generators because of higher electricity costs.
4. Challenging water quality results in increased spending on consumables.
5. The systems cost a similar amount to operate each year, regardless of the amount of water dispensed or the population of the community. Ozonation/filtration systems generally cost slightly more to operate than RO systems.
6. Systems that were used more cost less on a per litre treated basis.
7. Labour costs made up the largest fraction of the total and per litre cost for each system.

CHAPTER 7 PWDU ADOPTION BY COMMUNITIES

Technical Memorandum #4 was submitted to the ENVC on January 21st, 2010. Comments were received on January 25th, 2010.

7.1 Introduction

Providing clean, safe drinking water in small, rural communities in Newfoundland and Labrador has proven to be challenging due to the unique history and geography of the province (Sabau and Haghiri, 2008). Each of the seven communities who currently own and operate potable water dispensing units opted to build the small systems, as opposed to full-scale water treatment plants, for similar reasons. Many have ageing infrastructure and challenging raw water quality or existing treatment that does not fulfil the needs of residents. However, a number of other, mainly socioeconomic factors have also led to the adoption of PWDUs as the method of choice for providing clean drinking water to residents. All of these communities are made up of small, declining populations living in relatively remote parts of the province. Many rely on seasonal industries such as fishing and consequently, high percentages of their populations are employed for only a portion of the year. Per capita income is generally low and tax revenues are minimal. All of these factors have affected not only the initial choice of drinking water treatment technology but also the ability (or capacity) of each community to adequately operate and maintain their PWDU over the long term.

Despite these many similarities per capita PWDU usage rates vary from community to community. The reasons for this may include the quality of the water dispensed at the PWDU, the quality of the water available at residential taps, the distance that users must travel to access the PWDU, the hours of operation of the PWDU as well as the socioeconomic status and cultural norms of the community itself.

This chapter is intended to provide a more detailed analysis of the local capacity of the seven communities who have chosen to install water dispensing units in order to establish the factors that drive PWDU usage rates. Information was collected from a variety of sources including socioeconomic data from Statistics Canada and community reactions collected during interviews with operators, leaders and residents. The results of this analysis will be used to determine the most effective strategies that can be employed by the provincial government and individual communities to ensure that PWDUs are well maintained and adopted by the community.

7.2 Defining Local Capacity

In 2008 the ENVC released a report entitled 'Sustainable Options for the Management of Drinking Water Quality in Small Systems' that sought to establish the abilities of Newfoundland and Labrador communities to implement positive changes in their drinking water infrastructure. In the report, local capacity was defined as the ability of a given community to implement corrective measures independently of outside sources. In this definition, local capacity took into account financial, technical and human resources. However, in the report, the population of a given community was used as the main indicator of its local capacity.

The link between population size and local capacity is intuitive. The most obvious reasons why larger communities are generally more capable of implementing important projects include their access to larger tax bases and a larger pool of qualified applicants for operator positions (ENVC 2006). Other reasons include access to higher levels of education, lessened reliance on seasonal industries and increased per capita income.

However, the relationship between population size and local capacity may not hold in every circumstance. Other factors that will likely influence the local capacity of the communities in the PWDU study include the education and employment profile of the community, the effectiveness of the local governing body and the overall accessibility of the community (distance from major service centres). For example, a number of very small communities in Newfoundland and Labrador are built around major year-round industries such as mining or oil refining and their residents tend to have higher income and educational levels.

Figure 7.1 shows the relationships that exist between population, the level of unemployment (May 2006) and the percentage of residents who receive employment insurance (EI) at some point during the year in the seven communities discussed in this report.

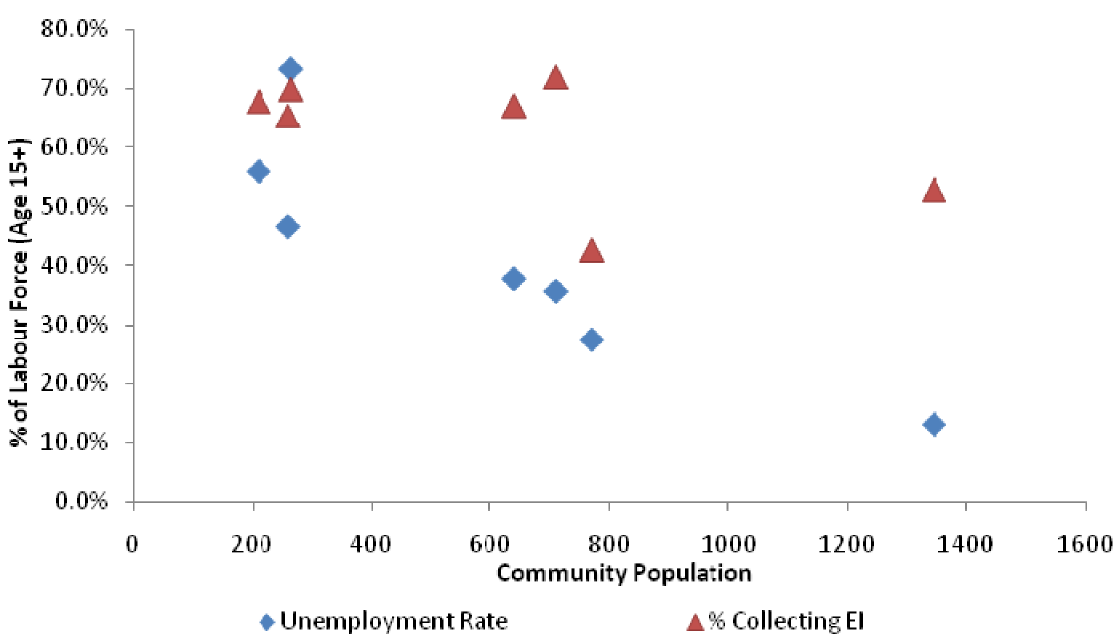


Figure 7.1 **Unemployment Rate (May 2006) and Percentage of Population Collecting Employment Insurance (2005) as a Function of Population (2006)**

The trends in Figure 7.1 suggest that communities with higher populations had less unemployment in May 2006 than communities with lower populations. Similarly, the percentage of people receiving EI, appears to increase slightly as population decreases, suggesting that many people living in the smaller communities work in seasonal industries such as fishing, forestry or construction.

Figure 7.2 shows that higher populations were often, but not always, associated with higher per capita income.

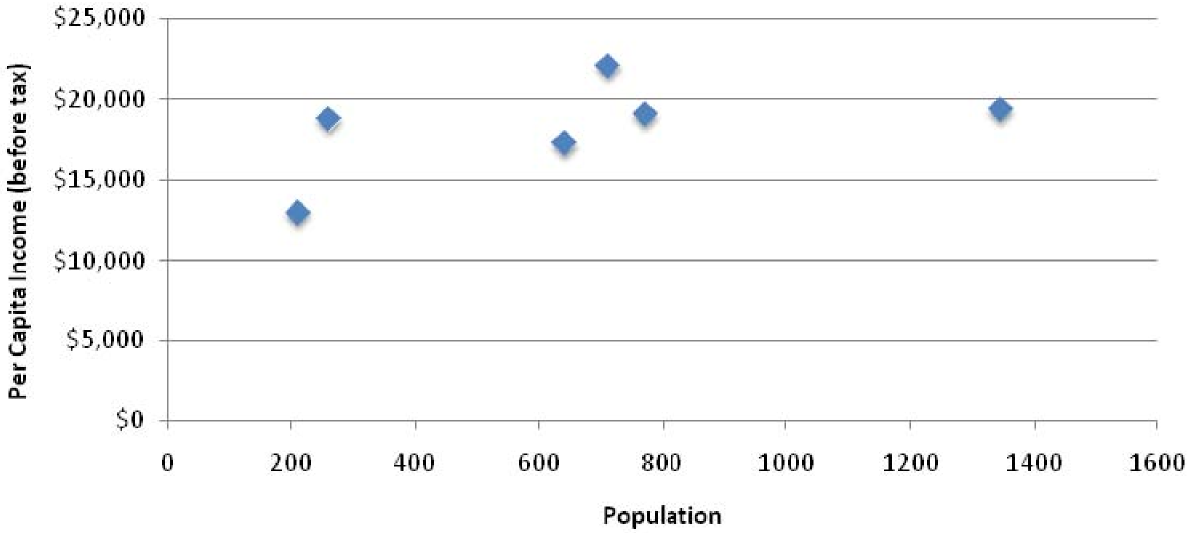


Figure 7.2 Per Capita Income Before Taxes (2006) as a Function of Population (2006)

The relationships between population and employment/income followed the expected trends, but did not apply perfectly in each case. For example, the residents of some small communities have access to higher paying jobs (permanent or seasonal) in local industries, whereas others make do with fewer options.

In large-scale studies, such as the one summarized in the Sustainable Options report (500+ communities), it is not feasible to compare the relationships between several interconnected variables in each community. In such cases, only the most relevant and easily collected data can be used with exceptions noted as necessary. However, in a small study like this one, a more nuanced view of local capacity is possible and will lead to more individualized solutions for the communities under investigation. It will also permit an analysis of the factors that impact the 'local PWDU capacity'.

7.3 Evaluation Criteria

What sets the communities where the PWDUs are well-adopted apart from those where they are less well-adopted? Many factors may influence adoption in all or only some of the communities. These factors can generally be grouped under 'local PWDU capacity' and 'PWDU use drivers'. Simply put, there are some factors that can be controlled and improved by the residents and/or local government in a given community, and others that are largely outside of their direct control. Those factors that are within the control of the community can be referred to as local PWDU capacity factors whereas those that are not can be considered PWDU use drivers. Some examples of local PWDU capacity and PWDU use drivers are summarized in Table 7.1.

Table 7.1 Local PWDU Capacity Factors and PWDU Use Drivers

Local PWDU Capacity	PWDU Use Drivers
PWDU Treated Water Quality*	Accessibility of Community
PWDU Convenience	Population
PWDU O&M	Employment and Education Levels
% Budget Devoted to Drinking Water	Cultural Norms
Governance	Community History

*Assuming that system design/upgrades are under the control of the community.

In order to establish the effects of these various factors, there must be a measurable indicator of the level of adoption within the community. Two known indicators are the average amount of water dispensed per day per person for each PWDU as well as the amount of time the operators report spending on the PWDU each week.

7.3.1 PWDU Use

The per capita daily volume dispensed from the PWDU is the most direct indicator of the degree of public support enjoyed by the PWDU in a given community. Increased PWDU use represents greater return on the original investment of money into the equipment and the ongoing investment of money into its operation and maintenance. Also, PWDU adoption by the community will ideally lead to greater health and productivity among residents while saving money on the cost of purchasing bottled water. The approximate daily average per capita PWDU water usage for each community is presented in Figure 7.3. One community, Community D, was not included in the analysis because the operator was not able to provide an estimate of the daily PWDU usage.

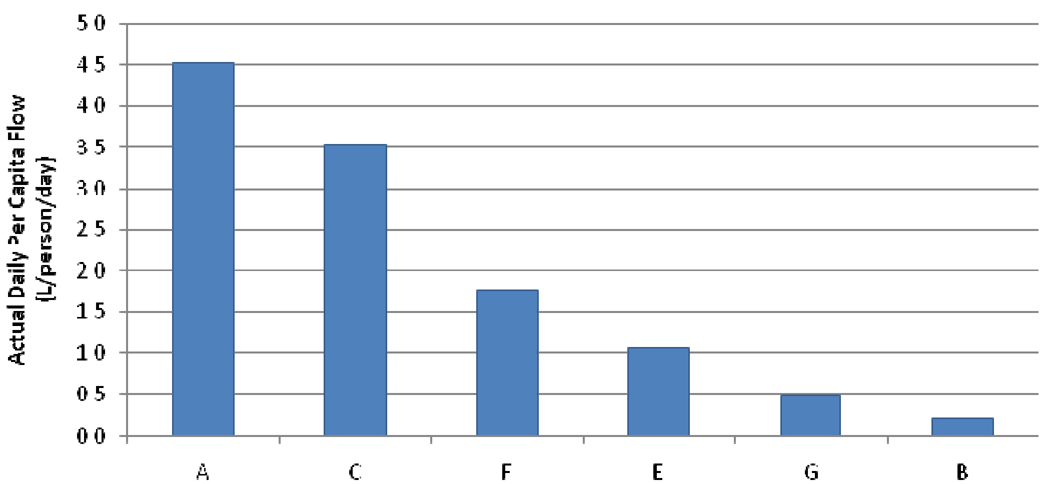


Figure 7.3 Actual Daily Per Capital Water Usage from PWDUs

The highest per capita water use was in Community A at 4.5 L/person/day, followed by Community C at 3.5 L/person/day. Community B had the lowest per capita water use at 0.2 L/person/day. Community A does not have a municipal water system. The relatively high level of adoption in that community likely reflects this – the residents do not have the option to use water from their taps and may use the PWDU water for non-consumptive uses such as brushing teeth/cleaning as well.

It should be noted that although Community A has the highest per capita usage rates of the six systems for which water usage information is available, community officials report that only 40% of residents use the PWDU to obtain drinking water.

7.3.2 Reported O&M Time

Daily per capita water usage gives some indication of how well the PWDU has been adopted by the community but it does not indicate how well the treatment equipment is taken care of. During phone and in person interviews conducted in 2009 and a survey conducted in February of 2010, the PWDU operators reported the average number of hours they spent operating and maintaining the PWDUs each week. These numbers can be used as an indirect indicator of the level of service provided, although they are also likely to be influenced by the type of system (ozone system operators reported more hours than RO operators) and whether or not the operator is paid for the time he/she spends on the system. Figure 7.4 below shows the amount of time each operator reported working on their PWDU each year (weekly reported value x 365 days).

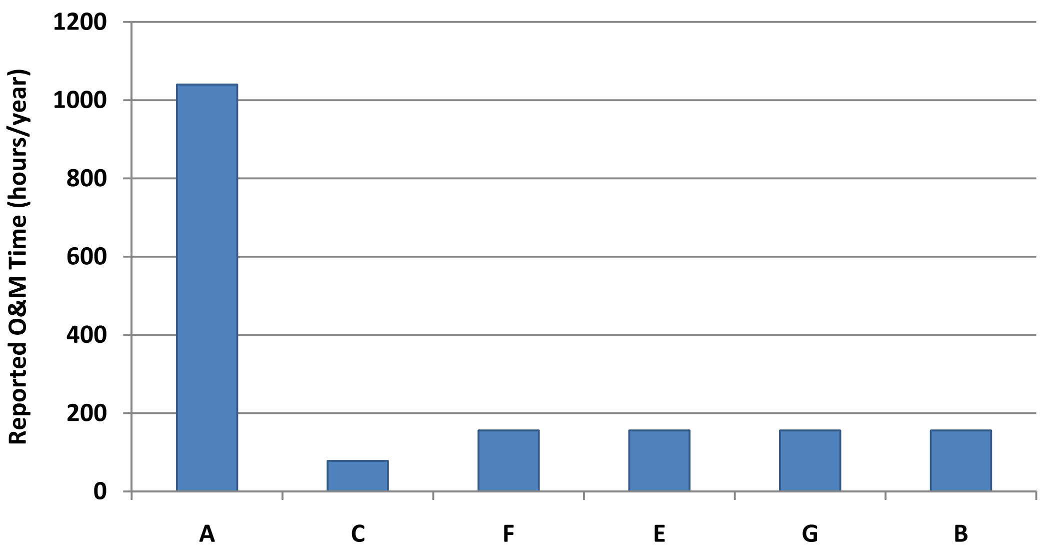


Figure 7.4 Amount of Time Spent Operating and Maintaining PWDUs, as Reported by Operators

Figure 7.4 demonstrates why reported O&M time is not an ideal indicator of the quality of O&M provided at each system. Specifically, unlike the operators at the other PWDUs, the operator in Community A is paid to be at the PWDU for four hours each day. This results in him spending a total of 1,040 hours at the PWDU over the course of each year. During this time the operator helps residents dispense water from the two water treatment systems on site: one for potable water and one for non-potable water. He also performs any maintenance duties that come up on either system. The potable water treatment system is a part of the non-potable water treatment system, so any O&M duties performed on the non-potable water treatment system have a direct impact on the functioning of the potable water treatment system as well. The remaining communities are unwilling or unable to pay an operator to be on site for four hours a day. In most cases, their PWDUs are looked after by the town maintenance person as one of many daily duties.

The location of the PWDU with respect to the municipal water supply/treatment equipment likely also plays a part in the amount of O&M time reported by each operator. For example, the PWDU treatment equipment for Community F is located within the same building as the municipal treatment equipment.

This may have resulted in him over- or underestimating the time spent specifically on the PWDU equipment.

Thus, it is proposed that for the purposes of this report the amount of O&M time reported by operators be considered a local PWDU capacity factor as opposed to an indicator of how well the PWDU is cared for. That is, a relatively controllable factor that may impact the adoption of the PWDU within the community.

7.3.3 Quality of O&M

As discussed in Chapter 6, not all of the PWDU operators were found to be equally effective at operating and maintaining their PWDUs. Some were more likely to keep daily records or clean the dispensing area than others. Undoubtedly, the quality of the O&M provided to each PWDU was be influenced by various socioeconomic factors, but it is particularly difficult to assess the relationships between them for three important reasons:

1. **Design**
   The treatment systems and dispensing areas differ significantly in design, making it difficult to establish evaluation criteria that will adequately capture the circumstances of all seven communities. As a result, time spent on O&M, water quality and PWDU water usage could not be linked to the competence of the operator. Examples include:
   a. The dispensing area in Community F consists of a small tap located on the outside wall of the water treatment plant, while those in communities D and G are located within heated building and include sophisticated water dispensing taps. Cleaning the first may require five minutes, while cleaning the others may take up to half an hour.
   b. The ozonation and filtration systems require more complex O&M than the reverse osmosis systems.
   c. Communities B and G have both experienced water quality issues as a result of the design of their treatment systems. The operators of these two systems complete more recommended tasks, keep better records and are better trained than many of their peers in other communities, but appear less competent if compared based on water quality or PWDU usage rates within the community.
2. **Individual Operator Circumstances and Experience**
   Operator training and education are only effective if the operator is open to learning new tasks and puts their new knowledge and prior experience into practice. Some of the most capable operators (as determined through phone interviews and site visits) lacked formal training and/or certification but possessed extensive technical knowledge related to their systems. Although population, education levels and employment may predict the likelihood of finding an effective operator within a community, they cannot account for individual circumstances such as older, experienced technical people moving back to the community after retirement. If more communities were involved in the study, these individuals would be outliers, but with a sample of seven operators (only five of whom were available to take the operator survey in February 2010), individual circumstances became more relevant.
3. **Consistency of Operation**
   PWDU operation and PWDU operators have not remained constant throughout the study.

Taking these three caveats into account, over the course of the study it was often noted that operators who completed recommended tasks, kept records, were easy to contact and seemed knowledgeable about their systems came from communities that:

- Had larger populations;
- Were less dependent on outside revenue sources;
- Invested in operator training;
- Did not have a history of long-term boil water advisories; and
- Had minimal operator turnover.

It follows that communities with similar characteristics will be more likely to be able to find, train and retain a competent PWDU operator in the future.

7.4 Local PWDU Capacity

7.4.1 Perceived Water Quality

The perceived water quality is essentially the degree to which quality of the water leaving the PWDU conforms to the health and aesthetic guidelines for drinking water provided by Health Canada (2008). All of the PWDUs on average treat water to within the guidelines. For many of the PWDUs, the finished water regularly has levels of common aesthetic concerns such as iron, manganese and colour that are below detection limits. In contrast, the water from the Community B PWDU has an average colour of 14 TCU, which is just below the guideline value of 15 TCU and well above the level at which most people can detect colour in the water (5 TCU). The colour in the water in these communities is not harmful, however, it may help to explain why the PWDU in that community is the least adopted of those under investigation. The second least adopted PWDU is the one in Community G, which experienced high colour levels during rain events during its first year of operation. Perceived water quality is unlikely to be the sole explanation for the low levels of adoption seen in these communities however, it probably played a significant part. Chapter 8 will contain a more in-depth investigation of the water quality in the feed and product streams of the PWDUs and its possible effect on PWDU adoption within communities.

7.4.2 PWDU Convenience

The convenience and upkeep of PWDU dispensing areas was discussed at length in Chapter 5. Surprisingly, the location and hours of operation of the PWDU within the community do not appear to have major influences on the level of adoption. The PWDU in Community G is one of the least adopted systems (0.48 L/person/day) despite being located in the centre of town and being open 24 hours a day. In contrast, the Community A PWDU is well used despite being located 2 km from the centre of town and open only during the hours when the operator is at work (8:00 am to 12:00 pm). During phone interviews a number of the operators suggested that their PWDU might be better adopted if it were located closer to the centre of town This suggests that the previous two examples may not be indicative of an actual trend and that factors other than convenience have stronger effects on adoption in some communities.

7.4.3 Governance

Governance, or the way that a community is run, can have a strong effect upon the success of infrastructure projects such as the PWDUs but is innately difficult to quantify. It may include such things as the priority placed on various services in the municipal budget, the inclusion of long-term economic planning and relationships between local officials with constituents and higher levels of government.

The Global Water Partnership defines 'Water Governance' as 'the range of political, social, economic and administrative systems that are in place to regulate the development and management of water resources and the provision of water services at different levels of society' (Rogers and Hall, 2002). For the communities in Newfoundland and Labrador who currently own and operate PWDUs this translates to the following questions:

- How supportive are local officials of the PWDU concept?
- Is the local government open to working with provincial government officials?
- Does the community invest in training for PWDU operators?
- Does the local governing body invest in PWDU operations and maintenance?
- Has the local governing body set aside sufficient money to purchase larger, more expensive pieces of equipment?
- How open is the local governing body to collaboration with other communities to improve PWDU O&M practices?

Two indicators of good water governance that were determined for each community are the presence of a trained and/or certified operator (indicating that the community has invested in operator training) and the completion of an integrated community sustainability plan (ICSP). Table 7.2 summarizes these indicators of good governance for the six communities for whom PWDU usage rates are known.

Table 7.2 Indicators of Good Water Governance in Communities with PWDUs

Community	Trained Operator	Certified Operator	ICSP	Per Capita PWDU Usage (L/person/day)
Community A	No	No	Not Required	4.5
Community C	No	No	In Progress	3.5
Community E	Yes	No	Complete	1.1
Community F	Yes	No	In Progress	1.8
Community G	Yes	Yes	In Progress	0.5
Community B	Yes	No	Unknown	0.2

There did not appear to be any connection between the completion of an integrated community sustainability plan and the per capita PWDU water usage reported for each community. The presence of a trained and/or certified operator appeared to decrease the per capita usage of PWDU water, possibly because the communities able to afford operator training and certification are wealthier, and less likely to have numerous PWDU use drivers, which are discussed in the following section.

7.5 PWDU Use Drivers

Throughout the remainder of this chapter, data will be presented in graphs to show the effects of various local PWDU capacity factors and PWDU use drivers on PWDU water usage rates. When bar graphs are used the data will be organized from left to right in descending order based on the usage rate of each community (*i.e.*, Community A to Community B).

7.5.1 Population

The Sustainable Options report used population as the main indicator of local capacity in the over 500 communities investigated throughout the province. As described previously, in many ways, population is strongly correlated to local capacity factors such as unemployment and participation rate. However, as shown in Figure 7.5 below, PWDU use is not strongly correlated to population.

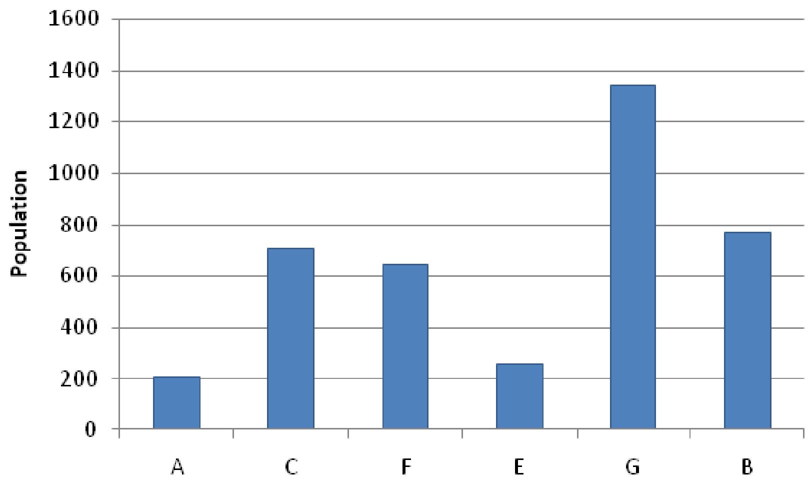


Figure 7.5 Effects of Population on Per Capita PWDU Water Usage

For example, Community A and Community E have similar populations but different average daily per capita PWDU uses (4.5 L/person/day and 1.1 L/person/day respectively). Community F, Community C and Community B all have between 600 and 800 residents but those residents use 4.3, 3.5 and 0.2 L/day/person respectively. There does appear to be a weak relationship whereby PWDU usage decreases as population increases. Population is likely one of many less important factors that can have an impact on PWDU use. The actual correlation between population and average daily per capita water usage was found to be -0.53.

The correlation between population and the amount of O&M time reported was also relatively weak at -0.53 suggesting that communities with larger populations are slightly less likely to put significant amounts of time into caring for their system. This correlation is probably slightly skewed by the high number of hours reported by the Community A operator, who is paid an hourly wage to be at the PWDU for four hours each day. If Community A is ignored, it becomes clear that similar amounts of time are being spent servicing PWDUs in both larger and smaller communities.

7.5.2 Accessibility

Communities located closer to larger population centres have certain advantages over those that are further away. The most important among these, with regards to the PWDUs, is access to a greater variety of services and material conveniences. This increased access is expected to have a positive effect on the amount and quality of O&M that can be performed on the equipment. However, increased access to larger, fully serviced communities may also reduce the willingness of residents to use a PWDU as their main source of drinking water. Figure 7.6 shows the approximate travel time to each community from the closest sizeable town/city with 5000 residents or more as determined through online mapping services, ferry schedules and flight schedules.

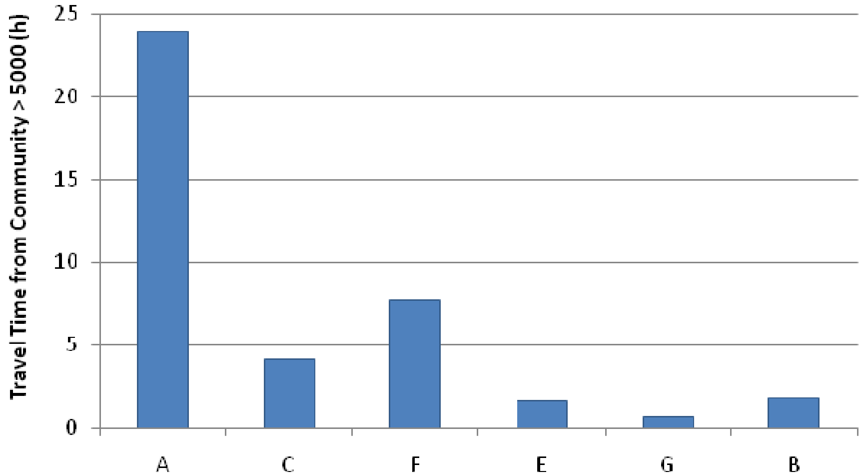


Figure 7.6 Travel Time from a Community of More than 5,000 Residents

A fairly strong correlation exists between the inaccessibility of a given community and its adoption of a PWDU system. The correlation between them was determined to be +0.81. The communities that are most difficult to get to are more likely to make frequent use of the PWDU. This result, though hardly unexpected, may prove to be one of the strongest predictors of PWDU use amongst the communities.

In order to compare the accessibility of the seven communities categories of 'accessibility' were created and are summarized in Table 7.3.

Table 7.3 Accessibility Categories for Community Evaluations

Travel Time to Community > 5000 Inhabitants	Category
0 to 2 hours	Easy to Access
2 to 5 hours	Somewhat Accessible
> 5 hours	Difficult to Access

7.5.3 Employment and Education Profile

The level of employment in a community may give some indication of the ability and willingness of residents to and take time to gather their own water. Figure 7.7 shows the percent unemployment (May 2006), percent participation in the work force (2005) and the percentage of residents lacking a high school diploma in each community.

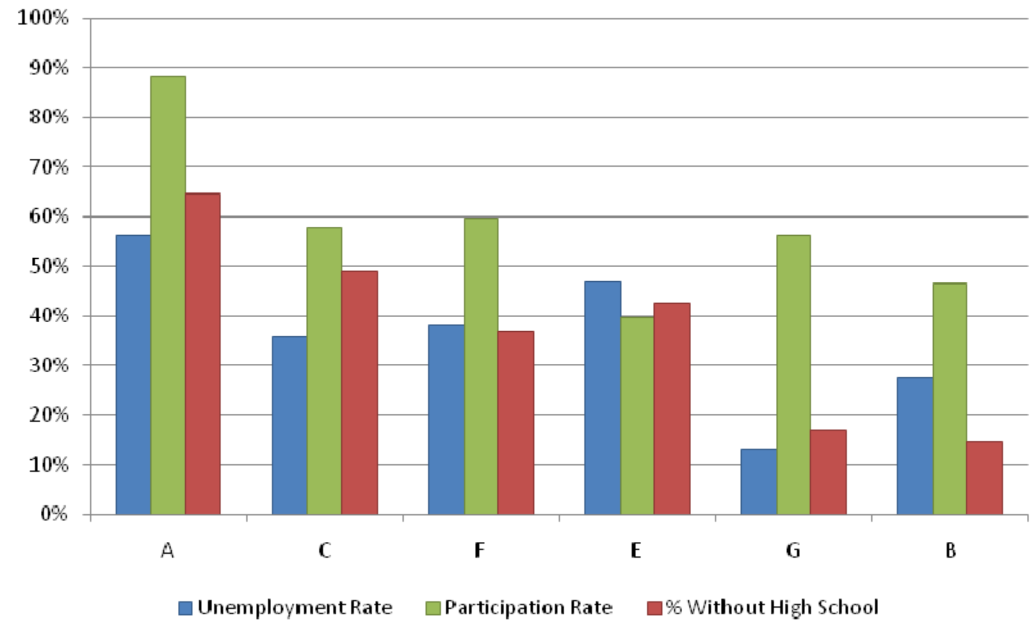


Figure 7.7 **Unemployment Rate (2006), Participation Rate (2005) and Percentage of the Population Lacking a High School Diploma (2006)**

Communities with higher levels of unemployment appear to have adopted the PWDUs more readily than those with lower levels. It could be that residents in these communities are more available during the hours when the PWDUs are operating. It might also be that communities that are otherwise well suited to PWDUs (small population, more remote) are also more likely to experience high levels of unemployment. There is a statistical correlation of +0.69 between unemployment and the average number of litres dispensed per person from a community's PWDU. Communities where high unemployment is paired with a high participation rate generally have seasonal industries that employ a large percentage of the population. The existence of a seasonal industry also appears to be associated with increased PWDU usage.

Similarly, the PWDUs are more likely to be adopted in communities where a sizeable proportion of the residents lack a high school diploma. This may be as a result of the correlation between lack of high school education and unemployment and indicative of the fact that many people who lack a high school diploma are unable to leave communities that have a large number of PWDU use factors (small population, more remote). The correlation between the percentage of people without high school diplomas and the average daily per capita PWDU use in the participating communities is +0.92.

7.5.4 Wealth

The per capita income in each community gives some indication of the wealth enjoyed by residents as well as the amount of money available to the municipal government in the form of taxes.

Figure 7.8 shows the per capita income in each of the six communities investigated in this chapter.

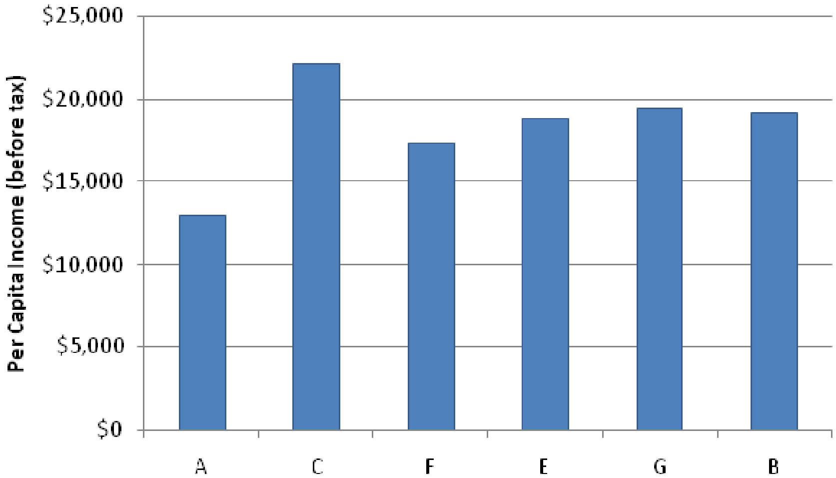


Figure 7.8 Per capita Income Before Tax in Six Communities Who Have Chosen to Install PWDUs

The relationship that per capita PWDU usage has with per capita income is similar to that which it has with unemployment levels. As residents become more wealthy PWDU usage begins to drop off. The exception to this is Community C, where residents enjoy a relatively high per capita income but also make good use of their PWDU. The correlation between per capita income and average daily per capita PWDU use is weakly negative at -0.42.

The economic well-being of the community as a whole can be established based on how dependent it is on outside sources of revenue to provide basic services. Figure 7.9 presents the percentage of the total revenue claimed by each of the six communities under investigation that came from local sources in 2006.

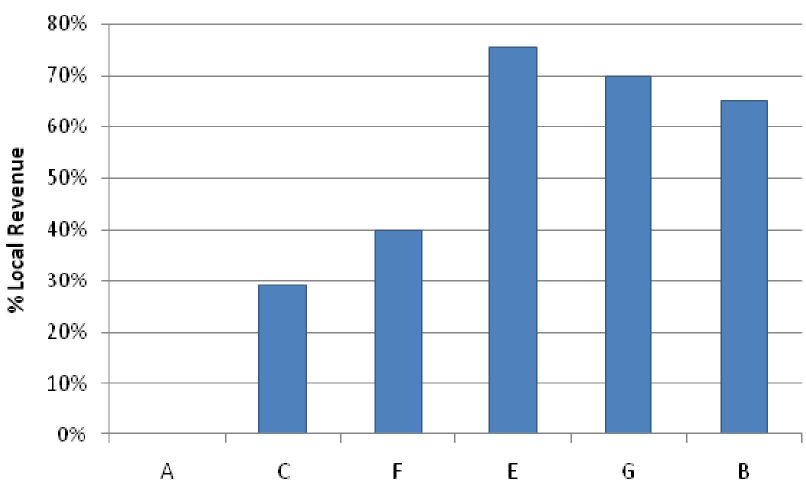


Figure 7.9 Percentage of Total Community Revenue Gathered from Local Sources

The communities who were more dependent on outside sources of revenue were, in general, more likely to use their PWDU frequently. The correlation between usage and percent local revenue was -0.94, one of the highest in the study.

7.6 Evaluation of Each Community

Each community has an individual mix of local PWDU capacity factors and PWDU use drivers that determines how well the PWDU concept is adopted among residents. The tables below summarize the main findings of the graphs above for each community in an attempt to explain the mix of factors at play.

7.6.1 Community A (4.5 L/person/day)

As discussed in previous sections, Community A is unique among the communities participating in the PWDU study for a number of reasons. It is located on an island off the coast of Labrador and is only accessible by boat or, more commonly, by plane. Electricity is provided by generators and the PWDU is the only source of treated non-potable and potable water available to residents. The lack of a water distribution system is a PWDU use driver that almost certainly skews the PWDU usage rate higher than the other communities in the study. This fact makes it difficult to compare the PWDU drivers and local PWDU capacity in Community A to those in the other participating communities. Also, until recently, the PWDU operator was on-site whenever the PWDU is open to the public – approximately 20 hours a week. This is well above the 1 to 4 hours of O&M time reported by operators in other communities and may not be indicative of higher quality O&M.

Other local PWDU capacity factors and PWDU use drivers in Community A are listed in Table 7.4.

Table 7.4 Local PWDU Capacity Factors and PWDU Use Drivers in Community A

Local PWDU Capacity	PWDU Use Drivers
High Treated Water Quality	Difficult to Access
Inconvenient Location	Small Population
1,030 Hours of O&M/Year	Seasonal Employment
0.12 Cents/L Dispensed	Local Revenue = 0%
Limited Operating Hours	65% Lack High School Diploma

Recent communication with local officials in Community A has indicated that although the community has a high PWDU usage rate compared to the other communities, the system is still considered to be under-used. Only 40% of residents report using the PWDU to obtain drinking water; the remainder rely on untreated water sources. This is of particular concern because the community funds the PWDU by collecting user fees for each litre of water dispensed.

7.6.2 Community C (3.5 L/person/day)

According to the operator, the PWDU in Community C is well-used by full and part-time residents of the community. On questionnaires returned to CBCL from Community C some residents listed concerns about low flow rates from the PWDU.

Other local PWDU capacity factors and PWDU use drivers in Community C are listed in Table 7.5.

Table 7.5 Local PWDU Capacity Factors and PWDU Use Drivers in Community C

Local PWDU Capacity	PWDU Use Drivers
High Treated Water Quality	Somewhat Accessible
Convenient Location	Population > 500
78 Hours of O&M/Year	Local Revenue = 29%
Limited Operating Hours	49 % Lack High School Diploma

7.6.3 *Community F (1.8 L/person/day)*

Community F is also somewhat of an outlier because unlike the other communities discussed in this report, the town has a full-scale water treatment plant that provides residents with relatively high quality water from their taps at home. However, a small reverse osmosis system was purchased to supplement the water treatment system in order to deal with high TDS levels and colour spikes in the municipal treated water. Much like Community A, Community F is located on an island (in this case off the southern coast of the island of Newfoundland) and uses generators to provide electricity for residents.

Other local PWDU capacity factors and PWDU use drivers in Community F are listed in Table 7.6.

Table 7.6 Local PWDU Capacity Factors and PWDU Use Drivers in Community F

Local PWDU Capacity	PWDU Use Drivers
High Treated Water Quality	Difficult to Access
Convenient Location	Population > 500
156 Hours of O&M/Year	Local Revenue = 40%
Available 24 Hours/Day	37% Lack High School Diploma

7.6.4 *Community E (1.1 L/person/day)*

Local PWDU capacity factors and PWDU use drivers in Community E are listed in Table 7.7.

Table 7.7 Local PWDU Capacity Factors and PWDU Use Drivers in Community E

Local PWDU Capacity	PWDU Use Drivers
High Treated Water Quality	Easy to Access
Convenient Location	Population < 500
156 Hours of O&M/Year	Local Revenue = 76%
Open 12 Hours/Day	42 % Lack High School Diploma

7.6.5 *Community G (0.5 L/person/day)*

The Community G system was originally designed to be similar to that in Community B and at first, it had many of the same problems. However, the treatment equipment was upgraded and the water quality has gone up noticeably. Despite this, per capita PWDU usage rates remain low. This could due to the pre-existing concerns about water quality or due to less tangible historical and cultural biases against collecting water from outside the home.

Other local PWDU capacity factors and PWDU use drivers in Community G are listed in Table 7.8.

Table 7.8 Local PWDU Capacity Factors and PWDU Use Drivers in Community G

Local PWDU Capacity	PWDU Use Drivers
High Treated Water Quality	Easy to Access
Convenient Location	Population > 1000
156 Hours O&M/Year	Local Revenue = 70%
Open 24 Hours/Day	17% Lack High School Diploma

7.6.6 Community B (0.2 L/person/day)

The very low per capita usage rates of the Community B PWDU can be explained in a number of ways. The quality of the water dispensed from the PWDU is not as high as that in other participating communities due to some flaws in the system design. The PWDU dispensing area is located at the town's standpipe, which is a short distance from the centre of town, making it less convenient than the PWDUs in many other communities. Finally, Community B used to be a much larger and more prosperous town that has experienced many setbacks in recent years. Cultural biases against collecting water from outside the home may be influencing the adoption of the PWDU among residents.

Other local PWDU capacity factors and PWDU use drivers in Community B are listed in Table 7.9.

Table 7.9 Local PWDU Capacity Factors and PWDU Use Drivers in Community B

Local PWDU Capacity	PWDU Use Drivers
Low treated Water Quality	Easy to Access
Inconvenient PWDU Location	Population > 500
156 Hours of O&M/Year	Local Revenue = 65%
Open 24 Hours/Day	15% Lack High School Diploma

7.6.7 Community D (Usage Unknown)

The operator in Community D was not able to provide CBCL with an estimate of PWDU water usage, however, he indicated that it was well-used by residents. This is not surprising given the PWDU use drivers that exist in the community, which are summarized in Table 7.10.

Table 7.10 Local PWDU Capacity Factors and PWDU Use Drivers in Community D

Local PWDU Capacity	PWDU Use Drivers
High Treated Water Quality	Difficult to Access
Convenient Location	Population < 500
156 Hours of O&M/Year	Local Revenue = 29%
Convenient Operating Hours	37% Lack High School Diploma

7.6.8 Summary of PWDU Use Drivers

The results presented in the tables above suggest that PWDU usage is influenced more by drivers that are not under the control of residents or local government such as population, location (accessibility) and the employment and educational profile of the community. Of these PWDU use drivers, the accessibility of the community and the degree to which it is dependent on outside funding appear to have the strongest effects upon usage rates.

When two communities have similar PWDU use drivers, the difference in their per capita usage rates can generally be explained through local PWDU capacity differences. For example, Community G and Community B both have low usage rates and few PWDU use drivers. The PWDU in Community G is likely better used than the one in Community B because it has better water quality as a result of an upgraded system design.

7.7 Strategies to Overcome Barriers to PWDU Use

The lack of easily quantifiable local PWDU capacity indicators correlated to increased PWDU usage rates suggests that the factors that have the strongest impact are the PWDU use drivers, which are not under the direct, observable control of community members and leaders. However, two communities with similar PWDU use drivers will tend to be differentiated by their respective local PWDU capacities. In light of this, it is expected that improving local PWDU capacity will have a positive effect on PWDU usage, although in some cases this increase may be modest as a result of being overwhelmed by the PWDU use drivers.

7.7.1 Community Education

Public buy-in to water treatment and quality projects has been noted as a limiting factor in international rural development projects such as that assessed by Garande and Dagg in Chile (Garande and Dagg, 2005) and likely has an effect on PWDU adoption in communities in Newfoundland and Labrador as well. By conducting effective public consultation, providing public education about the health and monetary benefits of PWDUs and increasing communication between users and operators, the province and the leadership of individual communities may be able to increase the adoption of PWDUs.

7.7.1.1 Increased Public Consultation

As part of the existing PWDU study being conducted by CBCL Limited, questionnaires were distributed to each community in an attempt to gauge the feelings of residents towards the existing PWDUs. Three of the seven participating communities returned between 2 and 14 questionnaires. Most of the questionnaires collected indicated that people were happy with the quality of the water dispensed by the PWDUs. The members of one community were concerned about the costs involved in building and operating the PWDU and by the fact that non-residents were using the water.

A more intensive method of assessing public reaction to the PWDU concept is warranted to obtain a more nuanced view of the factors driving PWDU usage in the participating communities. The existing questionnaires were distributed at the PWDU dispensing areas and thus were limited to PWDU users. Future public consultation should be aimed at all residents of the communities and should perhaps be presented in a different format.

7.7.1.2 Community Public Education Campaign

Following public consultation, a community public education campaign should be undertaken to inform residents of the participating communities about the advantages of the PWDU concept and the health benefits associated with high quality drinking water. Appendix H contains a public education package designed by CBCL Limited to be used by the ENVC.

Communication

Communication between water treatment operators and the community can be improved through signage and the posting of water quality monitoring results. It may also be helpful to provide a journal or log where users can leave messages for operators.

7.7.2 Improved Technology

7.7.2.1 System Design

Although most of the PWDU systems provide water of excellent quality, some notable exceptions exist. The treatment facility in Community B regularly fails to remove sufficient colour, iron and manganese from the influent water before it is dispensed to users. This is likely because the system was not designed to have enough flexibility to handle large increases in influent concentrations of these contaminants. Initially, this was also a problem at the Community G PWDU but a number of improvements were implemented to improve the flexibility of the system. Similar modifications, including an ORP monitor in the ozone contact chamber, a larger ozone generator and more effective air treatment ahead of the ozone generator could improve the quality of the water dispensed from the Community B PWDU significantly. The RO-based systems in Community E and Community F have experienced isolated incidents where the integrity of the membrane and/or treatment system may have been compromised. These were indicated by one time (according to available data) increases in turbidity and colour respectively. Increased monitoring of the processes using online instruments (ex. turbidimeters) may provide more timely information to operators about the status of the membranes and allow them to replace the membranes as soon as a major break is detected.

7.7.2.2 Dispensing Areas

In most cases it is impossible to change the established PWDU location. However, access hours could be extended in some cases to permit a larger percentage of the population to access the PWDU. Many of the dispensing areas can also be improved through the addition of more appropriate dispensing taps, dispensing counters with drains, backflow prevention devices and a cleaning area for water collection containers.

7.7.3 Operation and Maintenance

Increased or improved O&M may result in higher quality water in some of the underused PWDUs. It might also result in increased use of the PWDUs that are already relatively well-adopted.

Tasks that are generally being performed at all of the existing PWDUs include:

- Daily equipment checks;
- Basic maintenance (cleaning tanks, replacing cartridge filters); and
- Ordering and installing replacement parts.

Tasks that might improve the effectiveness of the PWDUs include:

- Daily record-keeping (flow, turbidity, colour);
- Establishment of a Preventative Maintenance Plan;
- Preparation of Standard Operating Procedures (SOPs) for PWDU processes; and
- Preparation of Contingency Plans for PWDUs.

7.7.3.1 Operation Strategies

There are a number of other ways that operations and maintenance activities could be regionalized, particularly once additional PWDUs are built. For example, neighbouring communities with full treatment or with simple well systems could be included in the regional plan or PWDU communities could join up with existing regional water treatment operation networks. A centralized PWDU equipment store-house could be developed and overseen by a government employee. This would minimize ordering and shipping times for equipment. A 'PWDU Coordinator' position could be created so that PWDU operators have a person to contact in case of maintenance difficulties. The PWDU Coordinator may be responsible for collecting daily/weekly flow and water quality information from the individual operators by phone, fax or online. Water quality and usage trends could be tabulated and analyzed to ensure that systems are operating optimally and to detect any anomalies that might indicate the need for equipment replacement or increased public education.

These options are considered in detail in Chapter 10.

7.7.3.2 Operator Training

Operator training has been noted as an important goal for many provinces in Canada in the wake of the Walkerton tragedy. Although some of the communities have operators trained by the province, many more do not. Further training and eventual certification for all operators may help to improve the level of O&M being provided to the existing PWDUs. A specialized PWDU operation course could be designed and provided to operator candidates by the Department of Environment and Conservation. This course could be modeled on the existing 'Very Small Systems' course currently being provided by the ENVC. Ideally, the course would be provided within or close to the communities where PWDUs are currently installed.

PWDU operator education is addressed in detail in Chapter 10.

7.7.4 Improved Governance

Improved community governance may increase community participation with respect to the use, operation and maintenance of the PWDU. One example of better governance would be the completion and adoption of an integrated community sustainability plan. Other, more PWDU-specific examples are discussed below.

7.7.4.1 Paying to Dispense PWDU Water

Most of the participating communities do not charge their residents to use the water dispensed from the PWDUs. Instead, the residents of some communities have had slight increases applied to their annual water bills. However, once the money is collected, there is no assurance that it will be used for the upkeep of the PWDU treatment equipment or dispensing area except in the event of a major malfunction. One way to ensure that sufficient money is available to keep the PWDU running optimally and the dispensing area sanitary would be to set up a PWDU-specific fund. Either a portion of each water bill could be dedicated to the fund or a PWDU user-fee could be established. The first option, if properly communicated to the public, may encourage greater usage by the population. The second option would ensure that only those residents who chose to use the PWDU were responsible for its continued operation and maintenance. Of the 22 PWDU users who filled in questionnaires, 21 indicated that they preferred paying for the PWDU through municipal taxes and one indicated that he/she would prefer to pay a user fee based on water usage. A larger survey including both PWDU users and non-users in each community may show different results.

7.7.4.2 Encouraging PWDU Use

PWDU usage could also be encouraged by increasing the perceived convenience of the system for residents. One way to accomplish this may be to extend PWDU hours, to provide appropriately sized collection containers to each household, to provide collection container cleaning facilities at the dispensing areas or to locate other services (mailbox etc) close to the PWDU.

7.8 Summary and Recommendations

Despite many similarities among the communities who currently own and operate PWDUs, important differences between them have led to differing levels of adoption of the PWDU concept. The factors influencing PWDU adoption have been divided into 'Local PWDU Capacity' and 'Local PWDU Use Drivers'. Local PWDU Capacity includes:

- Quality of PWDU design and equipment;

- Engaged operator;
- PWDU convenience;
- Perceived cleanliness/O&M;
- Good governance; and
- Public participation.

For example, the lowest levels of adoption (as measured by daily per capita PWDU water use) were found in communities where the system design was (or continues to be) inadequately rigorous to treat the influent tap water to within acceptable water quality. A number of other 'local PWDU use drivers' also appear to influence the level of adoption:

- Community located far from major population centres;
- Small population;
- Seasonal industry;
- Resource-based economy;
- High levels of unemployment; and
- High percentage of the population has not completed high school.

Communities with many local PWDU use drivers were more likely to use the PWDU for potable water. Unfortunately, many of the socioeconomic factors that make these communities such excellent candidates for a PWDU also present challenges to their successful long-term operation. For example, if few people have finished high school, it may make it difficult to hire and train a new PWDU operator should the first operator retire or leave the community. Low per capita income and small populations result in tight municipal budgets with little leeway for major repairs to the PWDU treatment system. One solution to this challenge may be the creation of regional networks of communities who have chosen to install PWDUs. Twenty-nine additional communities across the province have recently committed to building a PWDU in 2010 and more are likely to follow if the new systems are well-adopted. A regional network would allow the communities to share a number of the costs involved in operating and maintaining a PWDU system over the long-term. Also, a regional network would permit communities to purchase larger quantities of common components to minimize shipping times and costs. The development of a regional network would require buy-in from the participating communities in addition to centralized support from the provincial government.

The provincial government, as the main provider of funding for water quality improvements in many of these small communities, has a vested interest in maximizing the adoption of the PWDUs by communities and ensuring that they are well taken care of. Specific actions that could be taken by the provincial government include the development of new training courses to target PWDU operators and community leaders, community education initiatives and support for upgrades to PWDU equipment and dispensing areas.

On an individual level, there are a number of actions that can be taken by the communities themselves to improve PWDU adoption and PWDU O&M. Communities may choose to invest in improvements to their existing PWDU equipment and dispensing areas or to encourage PWDU usage through more effective education and/or water governance.

CHAPTER 8 WATER QUALITY

Technical Memorandum # 5, Water Quality, was submitted to the ENVC on March 8th, 2010. Comments were received on March 16th, 2010.

8.1 Introduction

The primary objective of this chapter is to assess the operation of the seven existing PWDUs by evaluating the results of water quality testing conducted on the treated water from each system over a period of twelve months.

The secondary objective is to establish whether there is a correlation between the raw, PWDU feed and treated water quality and the different PWDU usage rates observed in each community. Intuitively, one would expect higher PWDU usage rates in communities where the existing tap water quality is poor and the PWDU treated water quality is high. One of the major questions that this chapter will attempt to answer is 'How does relative, or perceived, water quality affect usage?'

8.1.1 Theory and Background

The definition of good water quality is more dynamic than it might initially appear. A recent article in the research journal Ground Water discussed the trials of a community water utility wrestling with poor perceived water quality among its residents. The water, which was drawn from a recently constructed well, was deemed unacceptable by users based not on its chemical quality (which was excellent), but rather because the water was arriving at their homes at a higher temperature than they were used to. The well was located above a naturally occurring source of hydrothermal waters that heated the well water to 28oC. As the water was not subsequently cooled, this naturally occurring feature of the well resulted in warm water being delivered to homes. As a result of user complaints, the well was eventually taken offline. This example serves as a reminder that one must take into account the subjective expectations of users as well as the objective results of analytical testing when determining perceived water quality (Chappelle *et al*., 2009).

Health Canada, the United States Environmental Protection Agency and the International Water Association have established health-based water quality guidelines and aesthetic limits in an effort to provide an objective definition of good water quality. The Canadian health-based guidelines are calculated using an average body mass and the expected human-health effects of a given concentration of a water quality parameter. Aesthetic objectives are based on the anticipated colour, odour and taste effects of a given parameter. In both cases, guideline values must be measurable using existing analytical methods and achievable using available, affordable water treatment technology.

This objective measure of water quality fails to take into account the subjective expectations of users. Most parameters that are regulated by health-based guidelines are not easily detected by users in their tap water. As a result, residents tend to place what might appear to be an inordinate amount of importance on those parameters that result in noticeable colour, taste and odours in the water.

8.1.1.1 Health Related Parameters

Health related parameters are biological or chemical characteristics of water that have the potential to affect human health. They can be naturally occurring or anthropogenic ('man-made'). Regular monitoring of water being sent to users helps to ensure that these parameters are not present at levels above those deemed safe.

Commonly monitored health related parameters include:

- Total coliforms;
- Fecal coliforms;
- Trihalomethanes (THMs);
- Haloacetic acids (HAAs);
- Arsenic;
- Lead; and
- Turbidity.*

*Turbidity is regulated as a health-based parameter in tap water in Newfoundland and Labrador. Health Canada sets a health-based guideline of 0.1 NTU for treated water before the distribution system but has not (as of March 2010) established a guideline value for turbidity for tap water.

While potentially dangerous at levels above the guideline values, none of these parameters (except turbidity) are observable in tap water. It is not expected that their presence above guideline values will have a strong effect upon the perceived quality of the tap and/or PWDU water or the adoption of the PWDU amongst residents of the participating communities. The only exception may be in cases where exceedances of the health-related guidelines are widely publicized, such as when boil water advisories are declared.

8.1.1.2 Aesthetic Parameters

Physical and chemical characteristics of drinking water, which have not been shown to affect human health directly, have been designated as aesthetic parameters. Some aesthetic parameters commonly observed in water in Newfoundland and Labrador includes colour, iron, manganese, TDS and low pH. Although these parameters are unlikely to affect human health at concentrations normally found in surface and drinking water, their presence often deters users from consuming their tap water.

A recent study by Statistics Canada found that rural residents in Canada use larger volumes of water per capita that urban residents. The study also found that rural residents were less likely to treat their tap water with a point-of-use (POU) or point-of-entry (POE) device before consumption (Hardie and Alasia, 2009). From this, the authors concluded that the rural residents covered in their study had different (lower) expectations for water quality than did the urban residents. Based on these results, it would be easy to assume that PWDUs have to provide only the bare minimum in water quality to satisfy users, however, the aforementioned study failed to account for sources other than tap water. The residents of many rural communities in Newfoundland and Labrador, including those involved in the PWDU project, are already accustomed to buying bottled water or collecting spring water for consumption. As a result, the water from the PWDUs competes not only with the tap water, but also with water from other sources.

8.1.2 Potable Water Dispensing Units

In most cases, potable water dispensing units have been developed to reduce the concentrations of aesthetic parameters in the potable water provided to residents in addition to removing pathogens. The existing water supply, disinfection and distribution system, if properly operated, are capable of removing or inactivating pathogens but not of removing colour, iron, manganese and TDS, which are the parameters most likely to result in customer complaints and/or non-adoption of the tap water for potable water uses.

It should be noted that Community A does not have a water distribution system installed. The lack of distribution system is partly as a result of the local history and geography of the area. Located on an island off the coast of Labrador, the local service district can be difficult to access at certain times of the year and is made up of two distinct communities located a few kilometres apart. The residents of Community A are able to dispense both potable and non-potable water from their PWDU.

8.2 Water Quality Assessment Methods

Various Canadian government agencies have attempted to establish reliable assessment tools that can be used to evaluate and compare the safety and perceived quality of raw water supplies and treated drinking water. The goal of these assessment tools is to provide non-specialists with a straightforward, yet accurate, picture of water quality. One example is the CCME Canadian Water Quality Index (CWQI), which has been adapted specifically for use in Newfoundland and Labrador (Khan *et al*., 2004).

8.2.1 Canadian Water Quality Index (CWQI)

The CWQI (adapted for Newfoundland and Labrador) is calculated based on a variety of common water quality parameters, which are summarized in Table 8.1.

Table 8.1 Parameters included in the Canadian Water Quality Index (CWQI).

Health-Based Parameters	Aesthetic Parameters	Not Regulated by GCDWQ
Turbidity, Fluoride, Nitrate, As, Ba, Cd, Cr, Hg, Pb, Se	Conductivity, Colour, pH, Na, Sulphate, Chloride, Cu, Fe, Mn, Zn	Dissolved Oxygen, Alkalinity, Ca, Mg, K, DOC, P, N, Si, Al*, Be, Co, Li, Mo, Ni, Sr, V

*Except for coagulation-based treatment processes

Water sources are assessed based on the levels of these parameters and assigned both a numerical score and a classification as shown below

- Excellent (95 – 100);
- Very Good (89 -94);
- Good (80 – 88);
- Fair (65 – 79);
- Marginal (45 – 64); and
- Poor (0 – 44).

The strength of the CWQI lies in its ability to take into account the number of parameters exceeding guidelines, the frequency at which those guidelines are exceeded as well as the amount by which each guideline is exceeded. Its main weakness is the exclusion of a number of important health-based parameters such as pathogens, THMs and HAAs. Currently, communities with running DBP averages above the limits set out in GCDWQ are excluded from CWQI analysis, as are communities under boil water advisories due to pathogen detection.

More in-depth explanations of the CWQI as adapted for the province of Newfoundland and Labrador are available online (ENVC, 2010). The adapted CWQI calculator program was used during the preparation of this report.

8.2.2 Water Quality Risk Level Assessment (WQRLA)

In the report, Sustainable Options for the Management of Drinking Water Quality in Small Water Systems (2008), the ENVC presented a method to assess health risks based on water quality. In this report, this method will be referred to as the Water Quality Risk Level Assessment (WQRLA) to differentiate it from the other water quality assessment tools employed to evaluate the effectiveness of the PWDUs. The three classifications used in the report are shown in Table 8.2.

Table 8.2 Criteria for the ENVC Water Quality Risk Level Assessment (WQRLA)

High Risk	Moderate Risk	Low Risk
Arsenic	Turbidity	TDS
Lead	Colour	Iron
Fluoride	pH	Manganese
Barium	Chlorate and chlorite	Copper
Trihalomethanes (THMs)	Haloacetic Acids (HAAs)	Chloride
Bromodichloromethane (BDCM)	Short-term Boil Water Advisory (BWA)	Other*
Long-term Boil Water Advisory (BWA)		
Radiological parameters		
Other*		

*Other was not defined

In the report, this risk assessment method was used to establish which of the 500 or so small communities in Newfoundland and Labrador were most in need of drinking water quality improvement. The assessment method did not take into account the frequency at which parameters were detected in the drinking water or the severity of the exceedance. Communities who were determined to be in need of assistance were later assessed in greater detail.

8.2.3 Perceived Water Quality Assessment (PWQA)

The existing PWDUs were developed to provide water that was not only safe (free of health-based water quality parameters), but also appealing to users. To better take into account the aesthetic parameters affecting perceived water quality and the frequency of detection of health-related parameters, updated classifications as follows are suggested by CBCL Limited:

Low Risk:

Acceptable: Health-related and aesthetic parameters within the GCDWQ.

Unacceptable: Health-related parameters within GCDWQ, aesthetic parameters present above GCDWQ (turbidity, colour, iron, manganese).

Moderate Risk: Health-related parameters sporadically above GCDWQ (THMs, HAAs, short-term boil water advisory).
High Risk: Health-related parameters consistently above GCDWQ (THMs, HAAs, long-term boil water advisory).

The two most important changes made to the existing ENVC classifications were the expansion of the 'low risk' category to include classifications of 'acceptable' and 'unacceptable' and the exclusive use of the GCDWQ to establish the relative importance of each parameter (ex. turbidity after the treatment plant was considered to be an aesthetic parameter).

8.3 Historic Record of Raw and Tap Water Quality

The required and/or recommended limits (GCDWQ and/or ENVC) for health and aesthetic parameters are indicated on each of the graphs in this section as dashed black lines (where applicable).

8.3.1 Health Related Parameters of Concern

8.3.1.1 PATHOGENS

Pathogenic organisms, which include certain types of bacteria and viruses as well as protozoans such as Giardia and Cryptosporidium are the water quality parameters most likely to pose an acute threat to human health and their removal is the primary goal of all water treatment systems. They are generally monitored by measuring the presence/level of indicator organisms such as total and fecal coliforms present in the treated water. If the indicator coliforms are detected in the treated water, a boil water advisory (BWA) is declared. BWAs are also declared when conditions within the water system are conducive to bacterial contamination of drinking water (ex. disinfection system is not working properly or the distribution system is undergoing repair). Table 8.3 summarizes the history of BWAs in the seven communities involved in the study.

Table 8.3 Boil Water Advisories in Participating Communities

Community	Current BWA?	Date Most Recent BWA Declared	Reason
Community A	Yes	January 2010	Chlorination system off
Community B	No	None Known	
Community C	Yes	June 2003	No free chlorine residual detected
Community D	Yes	October 2001	Chlorinator failure
Community E	Yes	November 2002	Unsatisfactory residuals, bacteria
Community F	No	None Known	
Community G	No	May 1999	No continuous chlorination

Four of the seven communities who currently use PWDUs had boil water advisories declared for their tap water as of February 2010. Community G had a boil water advisory in 1999 while Communities B and F do not have any reported boil water advisories (ENVC, 2008). Boil water advisories are widely publicized among water system users and are likely to have a strong effect on their perception of the quality of their tap water. In communities where boil water advisories are frequent or continuous residents may:

- Use a PWDU more often;
- Gather their water from a spring or purchase bottled water; or
- Accept the quality of the tap water as is.

8.3.1.2 Arsenic and Lead

Elevated levels of arsenic and lead may have inspired the original installation of a PWDU. However, in contrast to the prescribed method of communicating the discovery of pathogens in drinking water through boil water advisories, lead and arsenic results are less likely to be communicated to residents in a direct way. As a result, elevated concentrations of these parameters are unlikely to impact PWDU usage rates. Table A-1 in Appendix C shows that arsenic levels in the raw and tap water in the seven participating communities were below the guideline value of 10 µg/L. Lead levels, shown in Table A-2, are similarly low, although Communities G and D have been known to have lead levels above the guideline value of 10 µg/L in their tap water on occasion. These elevated tap water lead levels may be as a result of leaching from household fixtures or lead solder.

8.3.1.3 Disinfection By-Products

Total THM and HAA results obtained by CBCL from the ENVC are summarized in Tables A-3 and A-4 in Appendix C. According to these results, between 2002 and 2008 Communities A, E and F had average THM levels above the guideline value of 100 µg/L. Communities D and G also had elevated levels of THMs during some sampling events. Residents cannot see THMs and HAAs in the water and are unlikely to experience acute health effects that can be linked directly to the consumption of water containing these parameters. However, in recent years the health concerns linked to THMs and HAAs have been covered extensively in the media. Their presence in tap water may therefore inspire some users to switch to a PWDU, spring water or bottled water.

8.3.1.4 Turbidity

According to the Guidelines for Canadian Drinking Water Quality, turbidity is considered to be a health-related parameter when measured within a water treatment plant because it can be an indicator of the presence of other parameters of concern. Elevated levels of turbidity can also interfere with the proper operation of treatment and disinfection processes. However, once the treated water is sent to the distribution system, its level of turbidity is no longer regulated. The guidelines do, however, state that turbidity levels above 5 NTU are apparent to the naked eye and may affect public perception of the tap water quality. In Newfoundland and Labrador, where many communities do not filter their water, turbidity is considered a health-related parameter. The ENVC has set a distribution system target for turbidity of 1 NTU. Therefore, turbidity levels in raw and tap water are monitored by the ENVC during their regular sampling events. Figure 8.1 below shows average and maximum turbidity levels measured in the tap water of the seven participating communities.

Average turbidity levels remained at or below 1 NTU in the tap water of all of the communities except Community A, as shown in Figure 8.1. However, the maximum values show that all but one of the communities occasionally exceeded the guideline. Turbidity was above the limit of visibility (5 NTU) in at least one instance in both Community A and Community C.

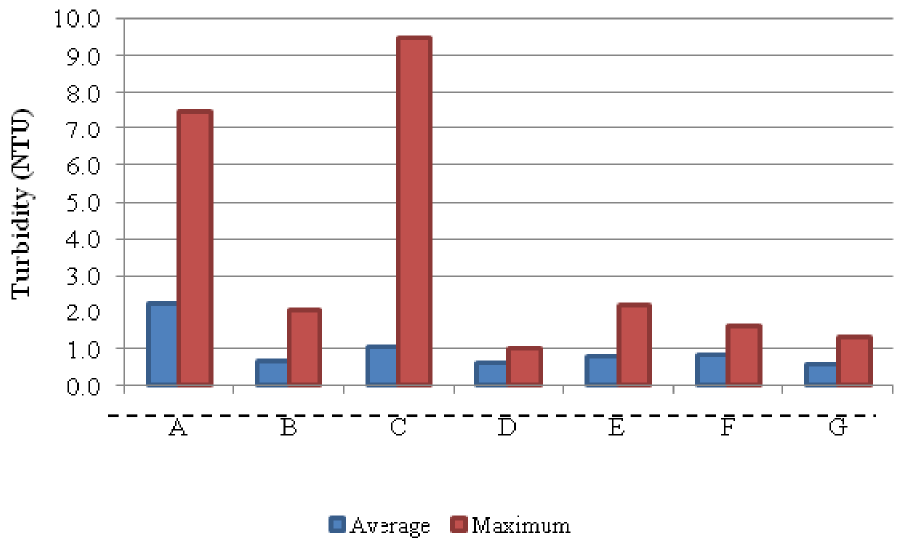


Figure 8.1 Turbidity in the Tap Waters of Participating Communities

8.3.2 Aesthetic Parameters of Concern

As discussed previously, aesthetic parameters such as colour, odour and taste are unlikely to have health effects but do tend to affect the users' perceptions of the quality of the water.

All of the participating communities draw highly coloured water from surface water sources nearby to supply their residents with drinking water. The average, maximum and minimum colour readings for each community are listed in Table A-5 in Appendix C. Only Community F provides full scale treatment of the water that is sent to users via the distribution system. As a result, the tap water from Community F is the only one that is regularly below the aesthetic objective for colour – 15 TCU. The remaining communities supply their residents with water that has noticeably high concentrations of colour-causing compounds.

Tables A-6 and A-7 in Appendix C show the average, maximum and minimum levels of iron and manganese recorded in the raw and tap water used in each community. All of the communities have experienced iron levels above the guideline value of 0.3 mg/L at some point since sampling began. Community A, Community D and Community G have experienced particularly challenging iron levels. Only one community, Community B, has measured manganese concentrations above the aesthetic objective of 0.05 mg/L in the tap water.

An aesthetic objective range of 6.5 to 8.5 has been established for pH in the GCDWQ. The Health Canada fact sheet on pH notes that although no specific human health effects have been linked to pH levels outside the recommended range, a number of indirect health effects may be encountered because pH influences many chemical reactions common in drinking water treatment and distribution/dispensing systems (metal speciation, corrosion, disinfection efficiency etc.). Most of the concerns related to the pH of treated water, however, are directly linked to pH-dependent reactions that occur in distribution systems such as corrosion.

The water produced by the PWDUs will not be sent through community distribution systems, therefore, the pH is unlikely to affect the aesthetic quality of the water being provided to users. For the purposes of this study, pH will not be used to assess the quality of the water produced by the PWDUs.

Average, maximum and minimum TDS levels measured in the raw and tap water in each community are provided in Table A-9 of Appendix C. Community F is the only community that has experienced levels of TDS above the aesthetic objective of 500 mg/L during the sampling period. These high concentrations of TDS led to the construction of a packaged full-scale water treatment system as well as the development of a reverse-osmosis-based PWDU for the community.

ENVC sampling, which occurs only twice a year, is unable to capture the full extent of tap water quality variations in each community. ENVC records from Community F indicate that iron levels in the tap water have been, on average, below the guideline value of 300 µg/L. Higher concentrations have occasionally been measured in recent years and red stains on sinks, appliances and laundry are common occurrences in Community F, as shown in Figure 8.2 below.

Figure 8.2 Iron Staining From Tap Water in Community F (Photos Taken in February 2010)

The deteriorating water distribution system is widely blamed for the poor water quality in Community F and as a result, many residents have adopted the PWDU. Similar situations might exist in other communities that might help to explain why some are more likely to adopt their PWDU than others.

8.3.3 Summary

The water quality parameters of concern in each community and an assessment of the perceived quality and safety risk associated with the tap water are summarized in Table 8.4 below.

Table 8.4 Summary of Water Quality Concerns in Participating Communities

Community	Most Recent Boil Water Advisory	Health-Related Parameters	Aesthetic Parameters
Community A	Current (2010)	Bacteria, THMs, HAAs, Turbidity	Colour, Iron, pH
Community B	None Listed	THMs, HAAs, Turbidity	Colour, Iron, Manganese, pH
Community C	Current (2003)	Bacteria, HAAs, Turbidity	Colour, Iron, pH
Community D	Current (2001)	Bacteria, Lead, THMs, HAAs	Colour, Iron, pH
Community E	Current (2002)	Bacteria, THMs, HAAs, Turbidity	Colour, Iron, pH
Community F	None Listed	THMs, HAAs, Turbidity	TDS, Iron, pH
Community G	1999	Lead, THMs, HAAs, Turbidity	Colour, Iron, pH

All seven communities have legitimate health and aesthetic water quality concerns with regards to their tap water. Undoubtedly these concerns precipitated the installation of the existing PWDUs. Given the infrequency of sampling, some communities may have other water quality concerns that are not apparent from the ENVC water records but which may, nonetheless, have an effect on the perceived water quality.

8.4 PWDU Sampling Schedule

The original proposal called for sampling of the PWDU feed and product water streams (RCAp – MS) to be conducted once a month for 12 months. Implementation of this plan proved to be complicated and led to samples not being collected as often as anticipated. The operators in these communities, for the most part, have numerous duties in addition to operating the PWDUs. Over the sampling period, urgent problems in their communities, such as sewer line breaks, arose that required their attention and prevented sample collection. Additional challenges, particular to the sampling program, also arose due to weather and shipping of bottles and samples. Table 8.5 is a record of the actual sample schedule correct as of March 1st, 2010.

Table 8.5 Record of Complete Sampling Events (Correct as of April 1, 2010)

Sampling Date	Community A		Community B		Community C		Community D		Community E		Community F		Community G	
	Source	PWDU	Source	PWDU	Source	PWDU	Source	PWDU	Source	PWDU	Source	PWDU	Source	PWDU
April	1	1	1	1	1	1	OFFLINE		1	1	1	1	1	1
May			1	1	1	1	1	1	1	1	1	1		
June	1	2	1	1	1	1	OFFLINE		1	1	1	1	2	2
July	1	1					OFFLINE				1	1		
August	1	1	1	2	1	2			1	2			1	1
September					1	1	1	1			1	1		
October	1	1							1	1			1	1
November			1	1	1	1					1	1	1	1
December	OFFLINE		1	1	1	1			2	2	1	1	1	1
January	OFFLINE		1	2					1	1	2	2	1	1
February	OFFLINE		1	1	1	1	2	2	2	2	1	1	2	2
March	OFFLINE		1	1			1	1	1	1	1	1	1	1
Total	5	6	9	11	8	9	5	5	11	12	11	11	11	11

Sampling challenges over the twelve month study period included:

- Significant operator turnover (Communities F, C, D, and A);
- Treatment systems periodically offline (Community A and Community D);
- Weather-related challenges (All systems); and
- Sample shipping limitations (Community A).

The majority of the gaps in the data can be accounted for by these four main factors. An additional source of confusion was the sharing of sampling administration duties between CBCL and the ENVC. In numerous instances, operators were not adequately informed about this arrangement and were confused by the provision of two sets of bottles. Consequently, two sets of samples would be sent off in one month while none would be sent the following month.

8.5 PWDU Water Quality

If the water from the PWDU is of noticeably higher quality than that available from the municipal water supply system, residents may be more willing to leave their homes to gather water. It should be noted that the residents of Community A do not have the option to receive municipal water at their homes. Thus, the feed water represents the actual raw water drawn from the source.

8.5.1 Health Related Parameters

Maximum and average values for all measured water quality parameters can be found in Appendix C.

Arsenic levels in the feed and treated PWDU streams were consistently below the detection limit (2 µg/L) throughout the sampling period in the PWDU treated water streams in all of the communities.

Lead levels in the feed water to the PWDUs varied considerably from community to community during the study, as shown in Appendix C. Lead concentrations in the treated water from the PWDUs were below the GCDWQ guideline value in all of the participating communities during the sample period as shown in Figure 8.3.

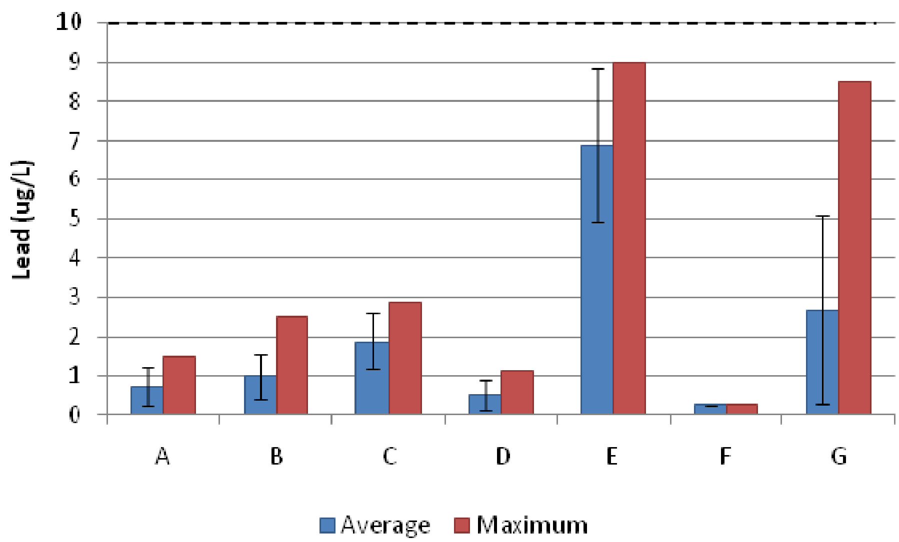


Figure 8.3 Average and Maximum Concentrations of Lead in PWDU Treated Water Streams (April 2009 to March 2010)

Lead concentrations in Community E came very close to exceeding the guideline (average = 7.7 µg/L, maximum = 9.0 µg/L) and should be monitored consistently in the future. Also of concern, the water from the Community G PWDU had a lead concentration of 8.5 µg/L in October of 2009. The concentration of lead in the PWDU feed water in both communities was often above the GCDWQ, suggesting that the lead in the PWDU treated water originated from the PWDU feed water, likely as a result of corrosion in the town's distribution system, as opposed to as a result of the corrosion of some part of the PWDU treatment equipment or piping. In the future, if exceptionally high lead concentrations are found in the PWDU feed water, the treatment equipment in both communities may not be adequate to remove it.

CBCL Limited was not required to monitor THMs and HAAs during the study. In some communities, however, both were measured in the PWDU feed and treated water streams during ENVC sampling events. The number of DBP readings varies from community to community. DBP sampling was not conducted in Community D because the municipal tap water is not chlorinated. The average readings from the ENVC sampling in other communities are shown in Figures 8.4 and 8.5 (an average of 0 implies that no sampling took place).

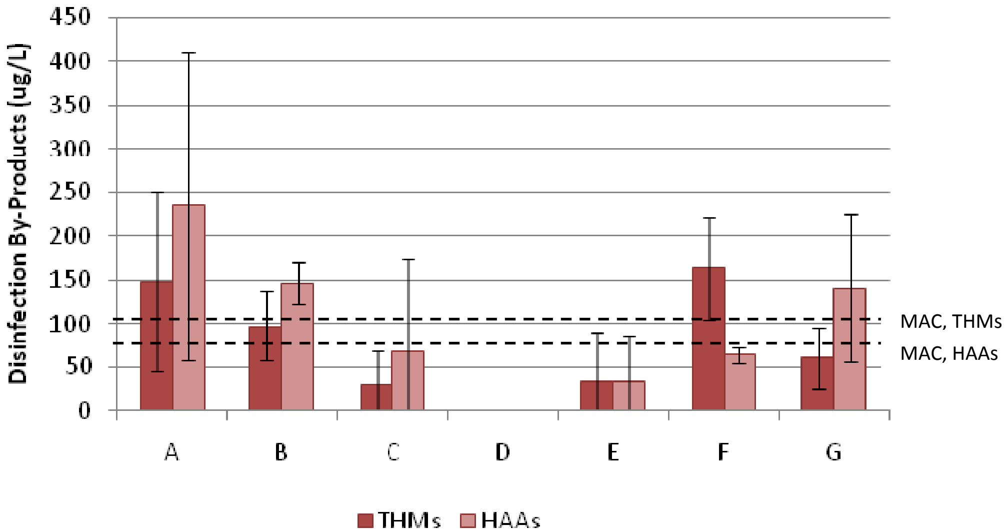


Figure 8.4 **Average THMs and HAAs in PWDU Feed Water Streams (ENVC Sampling Events)**

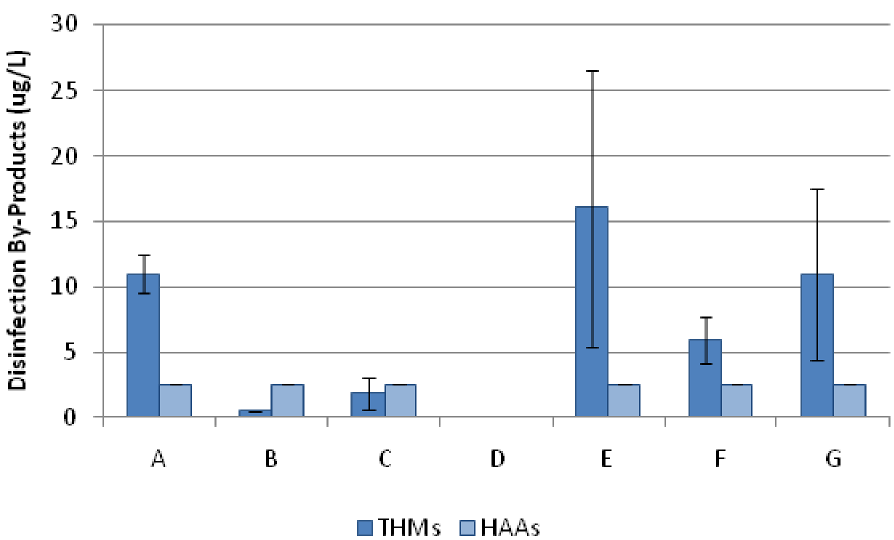


Figure 8.5 **Average THMs and HAAs in PWDU Treated Water Streams (ENVC Sampling Events)**

The average THM and HAA levels in the PWDU feed water streams were variable and, in some cases, counter-intuitive in light of other results discussed in subsequent sections. For example, the PWDU in Community B is fed with unchlorinated raw water that has not traveled through the distribution system. Yet, the 'PWDU feed water' samples had concentrations of THMs and HAAs above the GCDWQ limits. Obviously, these results do not represent the actual feed water to the PWDU, but rather, a tap water sample. As a result, in some communities, it was not possible to assess whether or not the PWDU treatment equipment was able to remove pre-formed DBPs as the feed water did not contain any. It was, however, possible to compare the relative safety of the tap water and the treated PWDU water. The variability observed between samples and within each community was likely as a result of differences in raw water quality and chlorine dosing strategies.

None of the treated water streams from the sampled PWDUs had THM or HAA levels above the guideline values of 100 µg/L and 80 µg/L, respectively, during the sample period. In some cases (B, E), this was because the municipal tap water and/or the PWDU feed water streams themselves were not chlorinated. As a result, there were no pre-formed THMs or HAAs in the PWDU feed water to be removed. In other cases (A, C, F, G), the treatment processes were able to remove most of the pre-formed THMs and HAAs from the PWDU feed streams.

Instead of monitoring for THMs and HAAs, the CBCL sampling program monitored the concentration of organic carbon as a DBP indicator. It has been shown that TOC (or DOC) can be used as a surrogate parameter to measure the concentration of disinfection THMs and HAAs, although the relationship is not exact (Najm *et al*., 1994). DOC is inexpensive to measure and thus, it was possible to monitor it more frequently than would have been possible for THMs and HAAs. This allowed monitoring to take place throughout the year to establish the full extent of variability in organic carbon concentrations in the PWDU feed and treated water streams in each community. THMs and HAAs are formed when organic carbon molecules react with chlorine. Figure 8.6 shows average concentrations of DOC measured in the feed and treated water from the seven PWDUs.

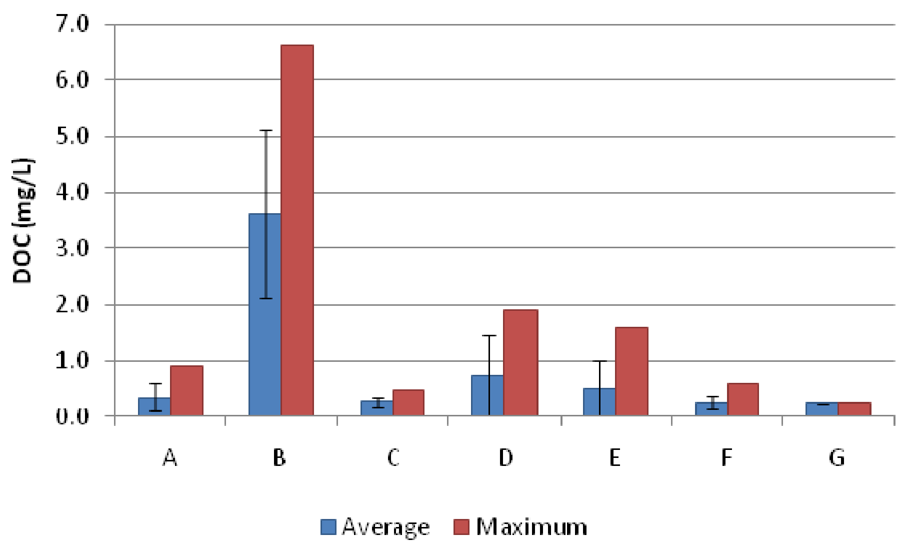


Figure 8.6 Average and Maximum Concentrations of DOC in PWDU Treated Water Streams (April 2009 to March 2010)

All of the communities except Community B had average DOC concentrations of less than 1 mg/L in the treated water from the PWDU. The average concentration of DOC in the treated water from the Community B PWDU was found to be 3.8 mg/L with a maximum of 6.6 mg/L. The feed water (tap water) in Community B was found to have an average DOC concentration of 6.0 mg/L (maximum = 8.0 mg/L). The relatively small difference between the average and maximum values found in the treated water vs. the feed water suggests that the high level of DOC remaining in the treated water was as a result of inadequate treatment rather than exceptionally high concentrations of DOC in the feed water. The feed water to the Community B PWDU is not chlorinated, but high levels of DOC in the treated water suggest that high concentrations of THMs and HAAs would be present if chlorination were practiced.

Turbidity levels in the water dispensed from the PWDUs have, on average, been below the guideline of 1 NTU in all of the participating communities as shown in Figure 8.7.

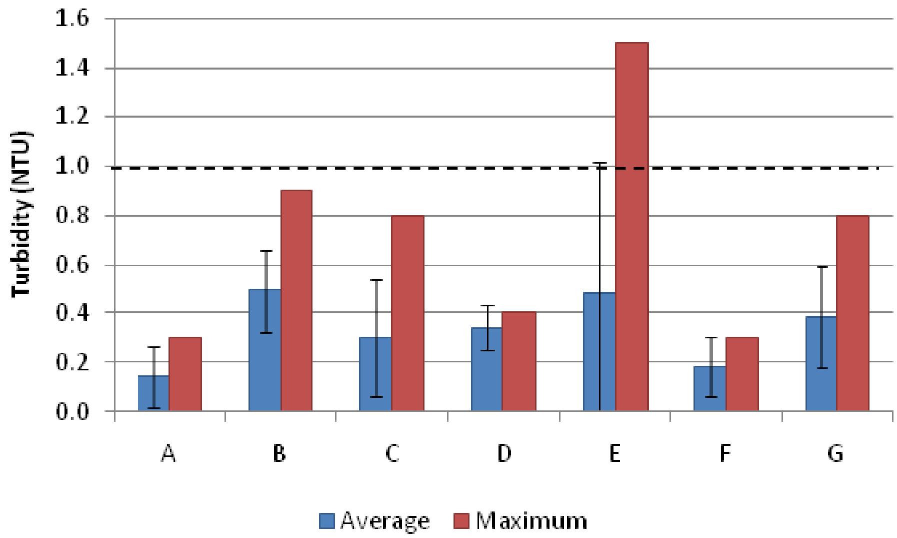


Figure 8.7 Average and Maximum Turbidity Levels in PWDU Treated Water Streams (April 2009 to March 2010)

The only high turbidity readings occurred in Community E, where readings of 1.3 and 1.5 NTU were found in August and October of 2010. These high readings may have been as a result of improper sampling technique, a malfunctioning RO membrane or build up of solids in the storage tank, piping or PWDU taps. Turbidity above 1 NTU was not detected in subsequent samples, suggesting that the issue was eventually resolved.

Overall, health-related parameters have not been detected at levels above the existing guidelines in the water being dispensed from the PWDUs.

8.5.2 Aesthetic Parameters

As discussed previously, the aesthetic quality of water has a major impact on its perceived quality. Consequently, many of the PWDUs were originally installed to remove aethestic parameters such as colour, iron, manganese and TDS from the disinfected tap water provided to residents. Figure 8.8 shows the average and maximum colour measured in treated waters from the seven PWDUs.

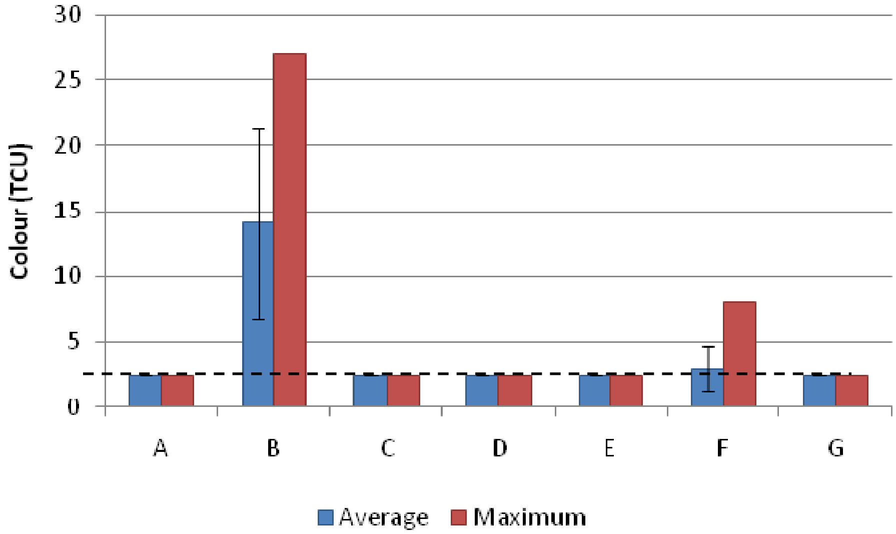


Figure 8.8 **Average and Maximum Colour Measured in PWDU Treated Water Streams (April 2009 to March 2010)**

Only Community B consistently had levels of colour above the guideline value of 15 TCU in the treated water from their PWDU during the sample period. However, it should be noted that although the aesthetic objective for colour is 15 TCU, in practice this value is significantly higher than the visual threshold for colour in water. Many people can detect as little as 5 TCU of colour in a water sample. In the competition for PWDU users, a colour reading above this value would put the PWDU at a definite disadvantage compared to bottled water.

Iron levels in the treated PWDU streams were all below the aesthetic guideline value of 300 µg/L as shown in Figure 8.9.

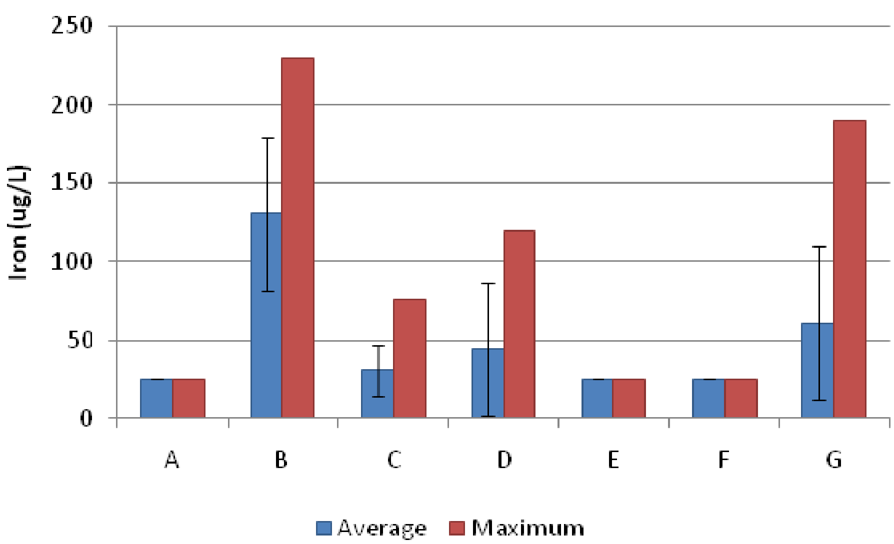


Figure 8.9 **Average and Maximum Concentrations of Iron in PWDU Treated Water Streams (April 2009 to March 2010)**

Manganese levels in the treated PWDU streams were, on average, below the aesthetic guideline of 50 µg/L as shown in Figure 8.10.

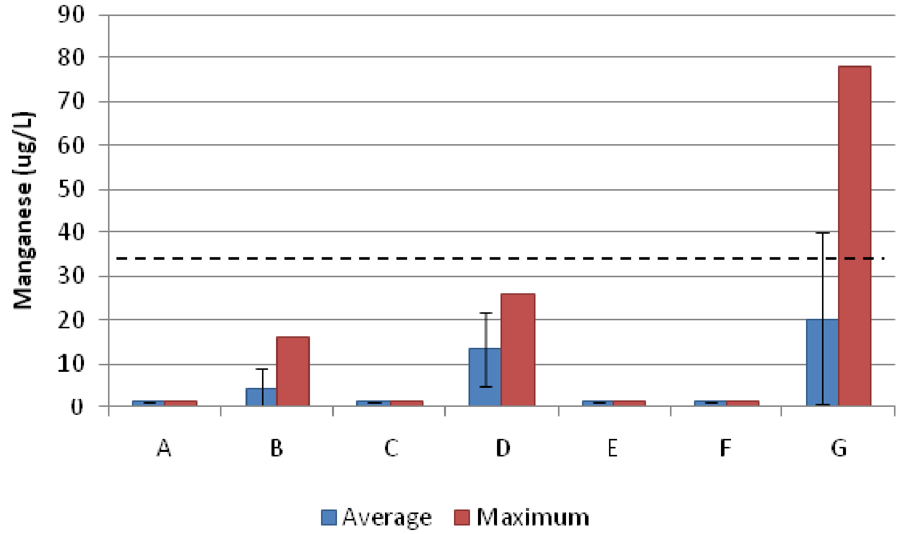


Figure 8.10 **Average and Maximum Concentrations of Manganese in PWDU Treated Water Streams (April 2009 to March 2010)**

In August of 2009, the treated water in Community G was found to have 78 µg/L of manganese (MAC = 50 µg/L). This may indicate that ozone dose on that sampling day was too low, or, given that the system is regulated based on ORP, too high. Some studies have shown that when ozone is over-dosed in water containing manganese there is a chance that the manganese will resolubilize to permanganate and as a result not be removed during subsequent filtration steps.

The concentration of TDS has been well within the acceptable limit (500 mg/L) in the treated water from all seven of the existing PWDUs as shown in Figure 8.11.

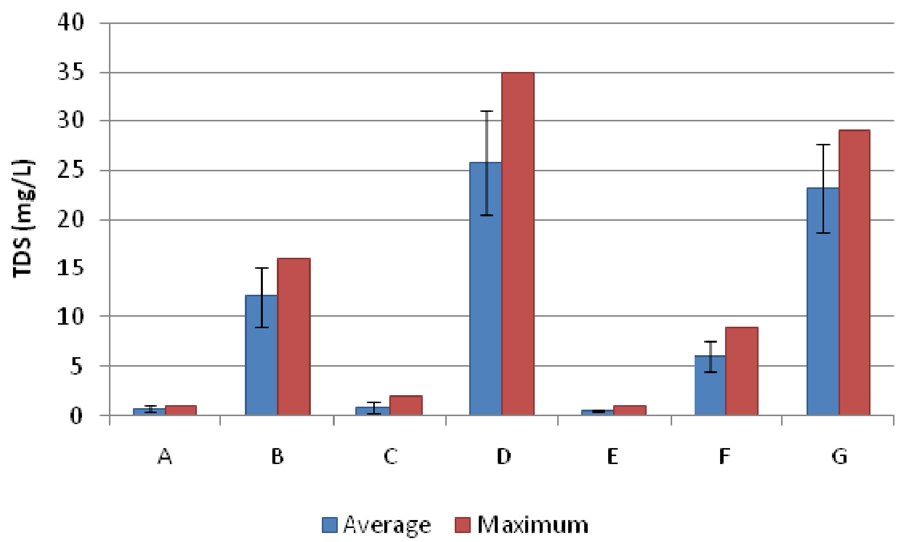


Figure 8.11 **Average and Maximum Concentrations of TDS in PWDU Treated Water Streams (April 2009 to March 2010)**

8.5.3 System Performance Assessment

Based on the water quality parameters assessed in previous sections, all of the PWDUs are removing adequate amounts of the following parameters:

- Arsenic;
- Lead;
- THMs;
- HAAs;
- Turbidity;
- Iron; and
- TDS.

The Community B PWDU is not removing colour or DOC adequately and the Community G PWDU has occasionally allowed manganese to pass through to the dispensed water.

8.6 Assessment of PWDU Water Quality

8.6.1 Canadian Water Quality Index

The Canadian Water Quality Index program was run using historical tap water data (ENVC), PWDU feed water data (CBCL and ENVC, 2009-2010) and PWDU treated water data (CBCL and ENVC, 2009-2010). The results are displayed in Table 8.6. Please note that the daily per capita PWDU flow from Community F has been revised 4.3 L/person/day to 1.8 L/person/day based on information obtained during a recent CBCL Limited site visit to the community.

Table 8.6 Canadian Water Quality Index Results for the Seven Participating Communities

Community	WQI			Categorization			Daily Per Capita Flow
	Hist. Tap	Feed	Treated	Hist. Tap	Feed	Treated	(L)
Community A	80	60	95	Good	Marginal	Excellent	4.5 L
Community B	80	87	93	Good	Good	Very Good	0.2 L
Community C	83	81	95	Good	Good	Excellent	3.5 L
Community D	70	69	96	Fair	Fair	Excellent	Unknown
Community E	82	81	93	Good	Good	Very Good	1.1 L
Community F	90	93	96	Very Good	Very Good	Excellent	1.8 L
Community G	79	78	93	Fair	Fair	Very Good	0.5 L

The results of the CWQI assessment indicate that all seven PWDUs are producing water with a CWQI score above 93, indicating that the aesthetic quality of the PWDU treated water has been ‘very good’ or ‘excellent’ throughout the sampling period. Communities with ‘excellent’ water quality (WQI score > 95) had higher per capita usage rates than those with ‘very good’ water quality (WQI score 89 – 94). The highest usage rates were often associated with large differences in WQI scores between the tap water and the PWDU treated water.

Other ENVC studies have pointed out the weakness of the CWQI with regards to health-related parameters such as THMs, HAAs and pathogens. The CWQI scores for the historical tap water results and the PWDU feed water are artificially inflated by the exclusion of DBPs and biological parameters from the WQI. For example, the community of Community C has been on a long term boil water advisory since 2003, but its raw water is still classified as ‘good’ by the CWQI.

8.6.2 Water Quality Risk Level Assessment

Each of the seven existing PWDUs was assessed for performance based on the water quality measured during sampling conducted from April 2009 to February 2010. Each system was designated as low, moderate or high risk based on the criteria presented in the ENVC report, Sustainable Options for the Management of DWQ in Small Water Systems (2008). The results are presented in Table 8.7.

Table 8.7 Results of WQRLA for the Seven Participating Communities

Community	Health Related Parameters	Aesthetic Parameters	Water Quality Risk Assessment	Daily Per Capita Flow
Community A	None	pH	Moderate	4.5 L
Community B	None	pH, Colour	Moderate	0.2 L
Community C	None	pH	Moderate	3.5 L
Community D	None	None	No Exceedances	Unknown
Community E	Turbidity*	pH	Moderate	1.1 L
Community F	None	pH	Moderate	1.8 L
Community G	None	pH, Manganese	Moderate	0.5 L

*Average turbidity for the Community E PWDU is below 1 NTU.

It should be noted that the tap water in all seven communities is rated as high risk. For the purposes of assessing the performance of each treatment process, the ENVC risk level assessment does show that the PWDUs are effectively reducing the occurrence of high risk parameters such as THMs and pathogens. The results from the analysis also establish that the PWDU water in all seven communities is associated with a lower level of risk than the corresponding tap water.

However, the WQRLA fails to differentiate between health-based parameters such as HAAs and turbidity and aesthetic parameters such as colour and pH. Thus, all of the PWDUs except that in Community D are listed as providing water of 'moderate' risk despite the differences in the quality of their treated water. For example, Community C and Community E have identical risk levels despite the fact that the former has only one aesthetic exceedance (low pH) and the latter was found to have turbidity levels above the health-based guideline of 1 NTU. The water quality risk assessment method also fails to account for the different per capita water usage rates reported for each community.

8.6.3 Perceived Water Quality Assessment

The measured water quality is compared to the PWQA and water usage rates reported for each community as shown in Table 8.8.

Table 8.8 Results of PWQA for the Seven Participating Communities

Community	Health Related Parameters	Aesthetic Parameters	Perceived Water Quality Assessment	Per Capita Daily Flow
Community A	None	None	Low Risk - Acceptable	4.5 L
Community B	None	Colour	Low Risk -Unacceptable	0.2 L
Community C	None	None	Low Risk - Acceptable	3.5 L
Community D	None	None	Low Risk - Acceptable	Unknown
Community E	Turbidity	None	Moderate	1.1 L
Community F	None	None	Low Risk - Acceptable	1.8 L
Community G	None	Manganese	Low Risk -Unacceptable	0.5 L

The PWQA provides a more sensitive analysis of the performance of the various treatment systems that can be used to set priorities for system repairs and operator training. It can also help to evaluate which system designs are most effective for the application.

The PWQA corresponds closely to the daily usage rates reported for each community. Under the PWQA, the presence of easily detectable aesthetic parameters such as colour results in a designation of 'unacceptable'. Communities with unacceptable water quality would be expected to have only very limited adoption within the community. For the existing PWDUs, this appears to be the case.

The socioeconomic profile of each community (PWDU use drivers, local capacity, etc.) is also likely to have an impact the level of adoption of the PWDU within the community, as described in Chapter 7.

8.7 Influence of System Design

Inevitably, the quality of the water leaving the PWDU is directly affected by the design of the system as well as the level at which it is operated and maintained. The water quality may also be impacted by the design of the dispensing system. For example, improper piping and taps may result in contamination of the treated water by pathogens and/or chemical parameters. Contamination may also occur if the dispensing area is not cleaned adequately or if the treatment equipment is improperly maintained.

In general, the PWDUs with reverse-osmosis-based treatment systems were better adopted than those with ozonation. This may be due to a flaw in the design of the ozonation systems that has since been remedied in the Community G system. The initial design did not take into account the full variation in feed water quality experienced over the course of the year, resulting in colour breakthrough during heavy rain events. To avoid this, an ORP monitoring system was installed on the treatment system in Community G to ensure that sufficient ozone is added to the system to control whatever amount of colour enters in the feed water. No ORP monitoring system was installed at the Community B PWDU, where colour breakthrough persists. Community D, which also relies on ozonation, was designed to be capable of treating a very high concentration of colour in the raw water.

With the exception of Community D (for which only three sets of results were provided), none of the existing PWDUs were continuously in compliance with the aesthetic objectives laid out in the GCDWQ. In most cases, small improvements to the treatment equipment would allow the PWDUs to achieve higher treated water quality. For example, the Buchan's PWDU could be brought into compliance if colour removal were improved through the addition of an ORP sensor or larger, more efficient ozone production equipment.

As for health-related parameters, the only exceedances noted were in Community E, which had occasional high turbidity levels. These may be as a result of sampling errors, dirty dispensing equipment or a broken membrane. These possibilities should be investigated and remedied if necessary.

8.8 Summary and Conclusions

The main conclusions of this chapter are as follows:

1. During the sample period, all of the PWDUs provided water within water quality guidelines for health-related parameters.

2. The treated water from the PWDUs was of much higher quality than the tap water available in the participating communities.
3. Three of the PWDUs have had exceedances of aesthetic parameters in their treated water, resulting in low perceived water quality.
4. These three PWDUs have the lowest per capita usage rates.
5. Per capita usage rates may increase if the perceived quality of the water from the PWDUs improves.
6. Existing water quality assessment tools such as the CWQI and WQRLA do not accurately predict perceived water quality – a new method (such as the PWQA proposed in this chapter) should be employed to evaluate the PWDUs.

The treated water from the PWDUs should continue to be regularly monitored for all health-based parameters. More frequent monitoring of aesthetic parameters may result in increased per capita usage rates in all of the communities.

CHAPTER 9 PWDU GUIDELINE DOCUMENTS AND SYSTEM CONFORMANCE

Technical Memorandum #6 was submitted to ENVC on March 19th, 2010. Comments were received on March 26th, 2010.

9.1 Introduction

This was the final technical memorandum to be submitted to the Department of Environment and Conservation (ENVC) as part of the Potable Water Dispensing Unit (PWDU) Study. The CBCL proposal for this project included a seventh technical memorandum focused on the development of a standardized PWDU design. This work has been submitted to the Department of Municipal Affairs as part of another project, Design and Construction of Potable Water Dispensing Units (093046) and thus, will not be repeated as part of the PWDU Study. The standardized design developed as part of the Design and Construction project will be referenced throughout Chapter 9. A schematic of the proposed treatment equipment can be found in Appendix B. The details of the proposed system are available in the design brief and engineering drawings from that project.

9.1.1 Background

The Department of Environment and Conservation published 'Guidelines for the Design, Construction and Operation of Water and Sewerage Systems' (referred to as the 'Municipal Guidelines' within this document) in 2005 and 'Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units' in 2008. Together, the two documents serve as guides for engineers and manufacturers designing, supplying and building PWDUs as well as for the communities and operators who use them. The Municipal Guidelines apply mainly to large municipal systems. As such, the components and design requirements they contain may not always be appropriate for systems as small as the PWDUs. CBCL Limited will draw from the findings of previous sections of the PWDU Study to assess how well the seven existing PWDUs conform to the guidelines contained in these two documents.

The PWDU guidelines were released in 2008, after the first PWDUs were installed and operating in Communities F, A and B. Applying the guidelines retroactively to the existing systems will result in a number of areas of non-compliance. Recommendations will be made, therefore, as to how the existing systems can be improved and brought into compliance with the PWDU Guidelines. It is recognized that owners, operators and suppliers were not provided with a framework for the design, construction or operation of these systems until very recently.

9.1.2 Objectives

The objectives of this chapter are as follows:

1. To review existing PWDU guidelines.
2. To assess whether the existing PWDUs are meeting the guidelines.
3. To recommend improvements to the guideline document based on the results of the assessment and other findings of the PWDU study.
4. To recommend improvements to the design and operation of existing PWDUs.
5. To compare a standardized PWDU design, developed by CBCL, to the existing and proposed PWDU guidelines.

9.2 System Capacity

To establish a reasonable capacity for a PWDU treatment system, the existing PWDU guidelines suggest multiplying the World Health Organization water usage allowance of 5-5.5 L of drinking water, per person, per day (L/p/d) by the population of the community. Table 9.1 compares the WHO recommended daily water allowance for each community to the actual designed capacity of the seven existing systems.

Table 9.1 WHO Recommended Allowance vs. Designed System Capacity

Community	Population	Per Capita Usage		System Capacity	
		Recommended Allowance (WHO)	Expected Usage Based on Design	Recommended (WHO)	Design
		(L/day/person)	(L/day/person)	(L/day)	(L/day)
Community A	210	5.5	11.0	1,155	2,300
Community B	770	5.5	4.9	4,235	3,800
Community C	710	5.5	6.1	3,905	4,300
Community D	265	5.5	7.5	1,458	2,000
Community E	260	5.5	15.4	1,430	4,000
Community F	640	5.5	24.3	3,520	15,000
Community G	1,345	5.5	2.8	7,398	3,800

Five of the seven were designed to provide more than the WHO recommended allowance of 5.5 L/person/day while two were designed to provide less. This is not surprising because the flexibility of the design of both ozone and reverse osmosis systems is limited by the availability of appropriately sized equipment. For example, the reverse osmosis unit installed in Community A is the smallest available from that manufacturer. As a result, the system can provide twice the WHO recommended water allowance.

As discussed in previous chapters, the existing PWDUs are located in communities that, in many cases, have few similarities besides their small populations. Thus, it is not surprising that the systems have been adopted to different degrees by each community. Table 9.2 compares the actual daily usage (as reported by operators) from each PWDU to the daily per person allowance recommended by the WHO.

The results in Table 9.2 represent average reported values and do not account for day to day variations in the total amount of water dispensed from each system. They indicate that none of the communities have reported a per capita water usage equal to or greater than the WHO allowance of 5.5 L/person/day.

Table 9.2 WHO Recommended Allowance vs. Reported Usage

	Population	Per Capita Usage		System Capacity	
		Recommended Allowance (WHO)	Reported Usage	Recommended	Based on Reported Usage
		L/day/person	L/day/person	L/day	L/day
Community A	210	5.5	4.5	1,155	950
Community B	770	5.5	0.2	4,235	155
Community C	710	5.5	3.5	3,905	2,500
Community D	265	5.5	0.0	1,458	n/a
Community E	260	5.5	1.1	1,430	275
Community F	640	5.5	1.8	3,520	1,135
Community G	1345	5.5	0.5	7,398	650

The existing PWDU Guidelines recommend designing the treatment system to treat the amount of water required by the community. The large variation in PWDU adoption rates between the seven communities suggests that PWDU usage is determined by many different variables and that population is but one of these.

Since usage is difficult to quantify beforehand, the capacities of the existing systems were constrained by one major design parameter - equipment availability. The communities participating in the study have equipment designed to work within municipal treatment systems. As a result, the individual parts are generally oversized for the application and consequently, the PWDU treatment systems do not operate continuously. Rather, the main treatment equipment is switched on or off based on the level of water in the storage tank. This approach results in the PWDUs operating only as required by demand, despite their oversized treatment equipment.

The standardized PWDU developed by CBCL as part of the PWDU Design and Construction project is designed to treat 4,000 L/day. In a community of 500 people, this flow would provide each resident with 8 L/day. This is more water than many smaller communities will need, however, the communities will have the option of running the system only as required by user demand. The savings accrued through the use of a standardized design are expected to offset the cost of the increased capacity. Storage space has also been provided for 1,000 L of water.

9.3 Source Water

PWDUs should be designed to be able to provide water that meets or exceeds all limits provided in the Guidelines for Canadian Drinking Water Quality (GCDWQ). The equipment required to achieve this will depend upon the quality of the feed water. PWDUs may be supplied by raw surface water, groundwater or through an existing water distribution system, which may or may not carry chlorinated water. If chlorinated water is used as the feed, the PWDU equipment should be resistant to chlorine and capable of reducing the concentration of pre-formed DBPs.

Table 9.3 shows the sources of the water treated by the seven PWDUs. It also indicates whether the feed water is treated and/or chlorinated.

Table 9.3 PWDU Feed Water Source and Characteristics

	Direct Source	Chlorinated
Community A	Filtered Water from Non-Potable System	Yes
Community B	Raw Surface Water	No
Community C	Tap Water (Unfiltered)	Yes
Community D	Tap Water (Unfiltered)	No
Community E	Tap Water (Unfiltered)	Periodically
Community F	Filtered Water from Packaged WTP	Yes
Community G	Tap Water (Unfiltered)	Yes

All of the communities that chlorinate were found to have high levels of DBPs such as trihalomethanes (THMs) and haloacetic acids (HAAs) in their tap water. Results presented in Chapter 8 indicated that all of the PWDUs have been, on average, reducing health-related parameters to within guidelines, including THMs and HAAs. None of the seven communities have recorded THM or HAA levels above the current GCDWQ guidelines in water dispensed from the PWDUs since ENVC sampling began.

9.4 Treatment Equipment, Controls and Automation

The treatment systems installed in the seven existing PWDUs can be classified as either ozonation followed by filtration or reverse osmosis. The systems that employ reverse osmosis are either set up to treat water from the municipal distribution system or as an add-on to a packaged water treatment plant.

Table 9.4 shows the seven participating communities classified according to the type of treatment system installed in their PWDU.

Table 9.4 PWDU Treatment Systems in Participating Communities

Ozonation and Filtration	Reverse Osmosis
Community B	Community A
Community D	Community C
Community G	Community E
	Community F

9.4.1 Ozonation and Filtration Systems

The ozonation and filtration PWDU treatment systems were all designed by Durpro; a water treatment equipment manufacturer based in Quebec. All three systems are efficient at removing pathogens and many other parameters of interest from the municipal tap water. Despite this, however, PWDU water quality concerns have persisted in Community B and Community G. Previous chapters have established that these concerns have had an impact on PWDU adoption in both communities. In both cases, the ozonation systems were not flexible enough to accommodate seasonal and/or weather-related changes in raw water quality that were not initially taken into account in the design. Essentially, the systems were not appropriate for the existing circumstances.

Table 9.5 provides a summary of the treatment system recommendations provided in the existing PWDU Guidelines and indicates whether each of the ozonation and filtration systems complies with the recommendations.

Table 9.5 Compliance of Ozonation-Filtration Systems with Existing PWDU Guidelines

	Community B	Community D	Community G	Recommendation
NSF Certification for All Components	No	No	No	Recommended
First Flush/Bypass Mechanism	No	No	No	Recommended
Backwash Disposal Location	Sewer	Sewer	Sewer	Sewer, Retention Pond or Dry Pit
Redundancy	No	No	No	Redundancy Recommended
Pre-treatment Sample Port	Unknown	Unknown	Unknown	Recommended
Post-treatment Sample Port	Unknown	Unknown	Unknown	Recommended
pH Adjustment	Yes	Yes	No	As required
Permit to Construct	No	Yes	Yes	Recommended
Process Pipe Labeling	No	Yes	Yes	Recommended
Surge Protection	Yes	Yes	Yes	Recommended
Disinfection Type	UV	UV	UV	UV or Chlorination
Disinfection Location	After Storage	After Storage	After Storage	After Storage
Automation				
Central Control Panel	Yes	Yes	Yes	Suggested
Automatic Operation Capability	Yes	Yes	Yes	Suggested
Instrumentation				
UV Transmittance	Yes	Yes	Yes	Suggested
UV Intensity	Yes	Yes	Yes	Suggested
Water Pressure	Yes	Yes	Yes	Suggested
Colour	No	No	No	Suggested
Turbidity	No	No	No	Suggested
Flow Meter	Yes	Yes	Yes	Suggested
Other	Tank Level	Tank Level	Tank Level, ORP	

In general, the three ozonation and filtration systems comply with the existing PWDU Guidelines. The PWDU document also recommends following the ozone-specific guidelines presented in the Municipal Guidelines published by the Government of Newfoundland and Labrador.

Table 9.6 summarizes the main recommendations for the design and operation of ozonation systems provided in the Municipal Guidelines and indicates how well each of the ozonation and filtration PWDU treatment systems complies with them.

Table 9.6 Compliance of Ozonation-Filtration Systems with Recommendations in the Existing Municipal Guidelines

	Community B	Community D	Community G	Recommendation
Air Preparation				
Compressor Type[1]	Oil-less	Oil-less	Oil-less	Oil-less, rotary lobe or liquid-ring
Compressor Fan	Yes	Yes	Yes	Recommended
Compressor Capacity	3.8 LPM	10 LPM	7 LPM	
Water Vapour Reduction	Unknown	Coalescing Filter	Coalescing Filter	Recommended
Compressor Redundancy	No	No	No	Redundancy Recommended
Dried Oxygen Dewpoint	-73°C	-51°C	-51°C	< -60°C
Dryer Type	Heat Exchanger	Heat Exchanger	Heat Exchanger, Refridgerated Air Dryer	
Dryer Redundancy	No	Yes[2]	Yes[2]	Redundancy Recommended
Air Filters	Yes	Yes	Yes	
Air Filter Pore Size	Unknown	Unknown	Unknown	
Generator				
Feed Gas	Oxygen	Oxygen	Oxygen	
Cooling Method	Air	Air	Air	
Generator Capacity	10 g/h	30 g/h	30 g/h	
Ozone Concentration	5%	5%	5%	> 1%
Redundancy	No	No	No	Redundancy Recommended
Contactor				
Contactor Type	Tubular	Cylindrical	Cylindrical	Not Specified
Contact Time (within contactor)	< 3 minutes	3 minutes	3 minutes	10 minutes
Materials Used				
Piping	304 SS	304 SS	304 SS	304L SS or 316L SS
Generator Shell	PVC	PVC	PVC	316L SS
Contact Chamber	304 SS	Stainless Steel	Stainless Steel	304L SS or 316L SS
Storage Tank	HDPE	HDPE	HDPE	Not Specified in Guidelines[3]
Joints etc.	Welded, flared, threaded SS	Welded, flared, threaded SS	Welded, flared, threaded SS	Welded; Teflon or Hypalon
Ozone Destruct Unit				
Type	Thermal Catalytic	Thermal Catalytic	Thermal Catalytic	Thermal and Thermal Catalytic
Redundancy	No	No	No	Redundancy Recommended
Instrumentation				
Pressure Gauges	Yes	Yes	Yes	

Table 9.6 Compliance of Ozonation-Filtration Systems with Recommendations in the Existing Municipal Guidelines (Continued)

	Community B	Community D	Community G	Recommendation
Electric Power Meters	Yes	Yes	Yes	
Dew Point Monitors	No	No	No	Suggested
Airflow Meters	Yes	Yes	Yes	Suggested
Temperature Gauges	Yes	Yes	Yes	Suggested
Water Flow Meters	Yes	Yes	Yes	Suggested
Treatment System Ozone Monitors	No	No	Yes	Suggested
Ambient Ozone Monitors	Yes	Yes	Yes	Recommended
Sensitivity of Ambient Ozone Monitors	300 ppb (fan + shut-down after 60 minutes)	300 ppb (fan + shut-down after 60 minutes)	300 ppb (fan + shut-down after 60 minutes)	Alarm at 100 ppb, system shut-down at 300 ppb
Alarms and Shut-downs				
Dew Point	No	No	No	Suggested
Inlet Feed Gas	Pressure	Pressure	Pressure	Suggested
Ambient Ozone Concentration	Shut-Down	Shut-Down	Shut-Down	Recommended
Ozone Destruct Temperature	No	No	No	Suggested
Other	O_2 flow	O_2 flow	O_2 flow	

[1]Rotary lobe and liquid ring not applicable at this size
[2]In that there are two (different) dryers
[3]It should be specified that ozone must be removed before the storage tank or that the storage tank should be constructed of 304L SS or 316L SS

The information presented in Table 9.6 indicates that the existing PWDUs that employ ozonation and filtration do not comply entirely with the ozone-specific portions of the Municipal Guidelines as currently written. There are two main areas of non-compliance: materials of construction and treatment equipment types. The existing PWDUs that employ ozone could be modified (where appropriate) to conform to the materials of construction requirements in the existing municipal ozone-specific guidelines. As discussed previously, there are difficulties associated with applying the guidelines developed for full scale systems to very small-scale PWDU treatment equipment. To avoid a discrepancy between guidelines and what is feasible in small-scale treatment systems, the existing ozonation guidelines could be adapted for the PWDU guidance document such that they are appropriate to the equipment used in PWDUs.

The PWDU guidelines emphasize that the treatment system chosen should be appropriate for the quality of the feed water being treated. The following short sections describe how appropriate each system is for the particular circumstances found in each community.

9.4.1.1 Community B

The treatment process in Community B, which consists of ozonation and filtration followed by UV disinfection, is technically appropriate for the feed water being supplied to the PWDU. However, the ozonation equipment was sized based on limited data and is, in fact, not consistently capable of removing the elevated colour and DOC that are periodically present in the feed water. More effective air/oxygen treatment, a larger generator or improvements to the ozone contact system might improve the quality of the finished water. The feed water is not chlorinated, therefore, there is no need to provide for THM or HAA removal within the treatment process.

9.4.1.2 Community D

The ozonation-filtration process employed in the Community D PWDU has been sized to treat the high concentration of colour present in the feed water. Municipal chlorination equipment is provided but the water is not currently chlorinated. The combination of GAC filters and ozonation is expected to remove both the chlorine and any pre-formed DBPs if the chlorinator should be brought back online. Based on the limited water quality available for the Community D PWDU, it would appear that the process employed is appropriate for the application.

9.4.1.3 Community G

Community G was the second PWDU installation in Newfoundland and Labrador by Durpro. The treatment process was adapted from that in Community B, with some minor modifications to account for different raw water quality. During the first year of operation, the system did not perform as intended due to the occurrence of unexpectedly high colour and turbidity levels in the feed water to the PWDU during heavy rain events. The treatment system was subsequently upgraded to include a larger ozone generator, more effective air and ozone treatment and an oxidation reduction potential (ORP) monitor. These upgrades have improved the quality of the finished water noticeably. The ORP monitor, in particular, has improved the flexibility of the system, making it more appropriate for the variable feed water quality.

9.4.2 Reverse Osmosis

Four of the communities participating in this study chose to install PWDU treatment systems that include reverse osmosis (RO) membrane filtration as the main treatment process. RO membranes are expensive to operate at a municipal level because of their large energy demands but are appropriate for smaller applications where very high finished water quality is required.

The RO systems in two of the communities treat water drawn from a municipal water distribution system. As a result, both systems include relatively extensive membrane pretreatment equipment, as detailed in Chapter 4. The remaining two RO systems are added directly on to packaged municipal water treatment processes. The feed water for these two processes comes directly from the municipal treatment systems without passing through the municipal distribution system.

The four RO systems are compared to the recommendations in the existing PWDU and Municipal Guidelines in Tables 9.7 and 9.8.

The Municipal Guidelines contain a discussion of the applications and general characteristics of reverse osmosis membrane systems but do not make any specific recommendations other than to ensure that the ENVC is kept informed about the design, construction and operation of the system. Table 6.9 lists some of the characteristics of the reverse osmosis treatment systems installed in the existing PWDUs.

It should be noted that during site visits, CBCL employees noted a number of issues with the systems in Community E and Community C. For example, in Community C, much of the piping is inappropriate for the application (*i.e.*, not designed for potable water).

Table 9.7 Compliance of Reverse Osmosis Systems Connected to Existing Water Distribution Systems with the Recommendations in the Existing PWDU Guidelines

	Community A	Community C	Community E	Community F	Recommendation
NSF Certification for All Components	No	No	No	No	Yes
First Flush/Bypass Mechanism	Unknown	Unknown	Unknown	Unknown	Yes
Backwash Disposal Location	Unknown	Sewer	Sewer	Sewer	Sewer, Retention Pond or Dry Pit
Redundancy	No	Yes	No	No	Duplicates Recommended
Pre-treatment Sample Port	Assumed	Assumed	Assumed	Assumed	Yes
Post-treatment Sample Port	Assumed	Assumed	Assumed	Assumed	Yes
pH Adjustment	No	No	No	No	As required
Permit to Construct	No	No	Yes	No	Yes
Process Pipe Labeling	No	No	No	No	Yes
Surge Protection	Unknown	Unknown	Yes	Assumed (Packaged WTP)	Yes
Disinfection Type	Chlorination	UV	UV	Chlorination	UV or Chlorination
Disinfection Location	After Storage	After Storage	After Storage	During Storage	UV – After Storage
Chlorine Injection Location	Multiple	n/a	n/a	Clearwell (Storage)	
Automation					
Central Control Panel?	On RO	No	On RO	Yes	Suggested
Automatic Operation Capability	Unknown	No	Yes	Yes	Suggested
Instrumentation					
UV Transmittance	No	No	No	n/a	Suggested
UV Intensity	Yes	Yes	Yes	n/a	Suggested
Water Pressure	Yes	Unknown	Yes	Yes	Suggested
Colour	Unknown	No	No	Yes	Suggested
Turbidity	Unknown	No	No	Yes	Suggested
Flow Meter	Yes	Yes	Yes	Yes	Suggested
Other					

Table 9.8 Characteristics of PWDU Reverse Osmosis Systems

	Community A	Community C	Community E	Community F
Membrane Element Type	Thin Film Composite	Osmonics Thin Film	Osmonics Thin Film	Filmtec Fiberglassed Elements[1]
Pretreatment	Non-potable Treatment System, MMF, Cartridge Filters	Cartridge Filters	Cartridge Filters	Packaged WTP, GAC/Birm, Cartridge Filters
Recovery Rate (Treatment Efficiency)	50%	33% - 50%	50%	Up to 75%
Bypass?	No	No	No	No
Post Treatment	GAC, UV	UV	UV	Chlorination
Membrane Cleaning Method	None	None	None	H_2O_2

[1]Observations made during site visits suggest that these may in fact be GE or Sapphire elements

9.4.2.1 Community A

Until the winter of 2009, the Community A PWDU provided both bulk non-potable water and potable water. The initial treatment process consists of pre-oxidation with chlorine followed by multimedia and GAC filtration. A large portion of this filtered water is stored and chlorinated as necessary as non-potable water. The remainder is sent through a series of cartridge filters and a reverse osmosis membrane before being disinfected with UV light, chlorinated and dispensed to users. The potable treatment system is capable of providing high quality drinking water, however, the challenging feed water conditions (possibly including residual chlorine from the initial treatment process) result in frequent replacement of the membrane elements. This suggests that the treatment equipment design is not, in fact, appropriate for the application. More rigorous pretreatment to remove some of the parameters that are fouling the RO membrane may improve the overall operation of the system.

9.4.2.2 Community C

The Community C PWDU consists of filtration (MMF and GAC) followed by reverse osmosis. These unit processes are well suited to removing the chlorine residual, colour and DOC present in the feed water. The membrane elements are not oxidant resistant; the GAC filter protects them from damage by removing the chlorine residual leftover from the municipal disinfection system. If the GAC filter were to fail (media becomes exhausted etc), the membranes would also be expected to fail due to chlorine exposure. If this were to happen, the UV disinfection system could be overwhelmed by turbid water, potentially resulting in the passage of pathogens into the dispensing taps.

9.4.2.3 Community E

The PWDU in Community E employs a system almost identical to that in Community C. However, it does not enjoy the same popularity among residents. This is unlikely to be as a result of the design of the treatment process, which appears to be adequate for the feed water in Community E. Instead, the poor adoption might be caused by other factors identified in previous chapters such as water quality and/or dispensing area design.

9.4.2.4 Community F

The PWDU in Community F consists of a small reverse osmosis unit added on to the end of a larger packaged PWDU process. The RO is preceded by two mixed GAC/Birm filters, and dual cartridge filters. It polishes a portion of the treated water from the packaged WTP to remove any remaining TDS and colour. The water is then chlorinated and sent to a small, separate portion of the full-scale clearwell. The resulting water is of high quality and is provided free of charge to residents at a tap (hose bib) located at the water treatment plant (outside). The residents who use the water from the PWDU avoid the occasionally high TDS and colour present in the tap water as well as the iron that is imparted to the treated water as it travels through the distribution system. The PWDU system consistently produces high quality water and is well used by the community, suggesting that it is appropriate for the circumstances.

The system in Community F conforms to many of the guidelines. This is, in part, because it is part of a larger engineered water treatment plant, is monitored by the government and is maintained by a trained operator. The system in Community A is the least well-understood of the seven existing PWDUs due to its relatively remote location off the coast of Labrador, its status as a local service district and the recent shut-down of the water system, which resulted in the operator losing his job. These three factors made it particularly difficult to visit the site or make meaningful contact with the operator or local officials.

9.4.3 Standardized PWDU Design

The standardized PWDU design developed by CBCL Limited incorporates equipment from the ozonation and filtration systems as well as the reverse osmosis-based systems. It was developed to treat a sufficient quantity of water for a community of 500 people with 'high risk' surface water quality. A diagram of the proposed system is provided in Appendix B. More detailed drawings are available as part of the PWDU Design Project. Please note that nanofiltration has been substituted for reverse osmosis to minimize the energy demands of the system while ensuring excellent finished water quality.

Where possible and appropriate, the standardized design will conform to the existing PWDU guidelines. The standardized design will follow the recommendations for the design of ozone, reverse osmosis and UV disinfection systems provided in the municipal guidelines that are applicable for very small water treatment systems.

The standardized PWDU has been designed to remove both health-based and aesthetic parameters. Finished water quality has been assured through the inclusion of multiple treatment steps including oxidation with ozone, nanofiltration and UV disinfection. The current Newfoundland and Labrador water quality standards are based on disinfection systems using free chlorine and require a CT of 6 mg.min/L (contact time of 20 minutes x 0.3 mg/L free chlorine). This corresponds to minimal removal of *Giardia* and *Cryptosporidum* and 4-log removal of viruses at 10^{o}C (2-log removal of viruses at 0.5^{o}C).

The standardized PWDU design does not include chlorination, but rather, provides pathogen inactivation/removal through a combination of filtration (nanofiltration) and alternative disinfectants (UV, ozone). It is simpler, therefore, to discuss PWDU disinfection in terms of log removal values. In the GCDWQ, Health Canada recommends that municipal water treatment systems provide 3-log removal of *Giardia* and *Cryptosporidium* and 4-log removal of viruses.

The UV disinfection unit will assure 3-log removal of *Giardia* and *Cryptosporidium*, although these pathogens are also likely to be removed during the oxidation and/or nanofiltration steps. UV will only be able to provide 0.5-log removal of viruses, some of which are less susceptible to damage through UV light. The remaining virus removal will occur in three ways:

1. Destruction during the ozone oxidation step.

2. Physical removal during the nanofiltration step.
3. Inactivation during the initial chlorination of the municipal water system where employed.

Ozone destroys viruses very effectively. At < 1°C a CT of 1.8 mg.min/L is required to ensure 4-log removal of viruses. The standardized PWDU design calls for ten minutes of contact time between ozone and the feed water. Thus, as long as the ozone residual at the outlet of the contact chamber is above 0.18 mg/L, adequate virus destruction can be assumed as part of the oxidation step. The exact amount of log removal can be verified by measuring the concentration of ozone at the outlet of the ozone contact chamber.

Reverse osmosis and nanofiltration membranes are listed in the supporting documents of the GCDWQ as acceptable virus removal technologies. The caveat is that the total log removal achieved using reverse osmosis and nanofiltration membranes must be established through challenge testing when the system is initially installed and then confirmed periodically using direct monitoring methods.

Finally, viruses are also easily inactivated using free chlorine. A CT of 12 mg.min/L ensures the inactivation of 4-log of viruses. In communities where the municipal water system includes chlorination before the distribution system/PWDU intake, it is likely that sufficient virus inactivation will already have taken place before the feed water is directed to the PWDU.

Virus, *Giardia* and *Cryptosporidium* removal could be confirmed for the standardized PWDU during the initial demonstration phase by:

- Monitoring the ozone residual at the outlet of the contact chamber; and
- Conducting challenge testing and direct integrity tests on the nanofiltration unit.

The standardized design allows for optional modifications for communities with less challenging feed water. One option is to remove the ozonation equipment entirely and rely on the nanofiltration unit for colour removal. Some communities, who will be feeding PWDUs with groundwater, may only require filtration with multimedia and GAC for removal of turbidity and aesthetic parameters. All systems will include UV disinfection, regardless of the quality of the PWDU feed water, which will ensure adequate removal of *Cryptosporidium* and *Giardia*. The less complex options will not, however, ensure 4-log virus removal and should only be used in communities where chlorination is practiced.

9.4.4 NSF Certification for Water Treatment System Equipment

NSF International is a not-for-profit, non-governmental organization that sets standards for materials and equipment used in industries with significant human health or environmental risks including water treatment and food production. Lists of certified products can be found on their website. Most manufacturers will make a point of mentioning that their products are NSF certified or certified to NSF standards.

The following NSF standards are most relevant for water treatment equipment used in PWDUs:

- NSF/ANSI Standard 42 – Drinking Water Treatment Units, Aesthetic Effects;
- NSF/ANSI Standard 53 – Drinking Water Treatment Units, Health Effects;
- NSF/ANSI Standard 55 – Ultraviolet Microbiological Water Treatment Systems;
- NSF/ANSI Standard 58 – Reverse Osmosis Drinking Water Treatment Systems;
- NSF/ANSI Standard 60 – Drinking Water Treatment Chemicals, Health Effects; and
- NSF/ANSI Standard 61 – Drinking Water System Components, Health Effects.

Companies other than NSF can test products to establish whether they conform to established NSF standards. These include Canadian Standards Association International, Underwriters Laboratories Inc., Quality Auditing Institute, International Association of Plumbing and Mechanical Officials (Health Canada, 2004).

While we would not expect the overall PWDU systems to be covered by any one of the above, the systems should include components that conform to individual, applicable standards. This is because some components are not themselves certified but rather, made of certified materials. For example, the UV units should be certified under NSF/ANSI Standard 55 while the material used for the storage tank should be certified under NSF/ANSI Standard 61.

9.5 Storage

Water storage is incorporated into water treatment plants/water distribution systems to balance out peak demands from users. The existing PWDU guidelines stipulate that each PWDU must have at least 1,000 L of water storage. The guidelines also recommend that water not be left in the storage tank(s) for more than 48 hours at a time. The number of tanks, total available storage volume, daily reported flow and approximate storage residence time for each of the existing PWDU systems are presented in Table 9.9.

Table 9.9 Volume and Approximate Residence Times of PWDU Storage Facilities

Community	Number of Tanks	Total Volume (L)	Daily Flow (L/day)	Recirculation ?	Residence Time (hours)
Community A*	3	3,400	950	n/a	86
Community B	1	950	155	Yes	147
Community C	2	1,140	2,500	n/a	11
Community D	1	950	n/a	Yes	n/a
Community E	1	1,000	275	n/a	87
Community F	1	4,205	1,135	n/a	89
Community G	1	950	650	Yes	35

*Assumed from pictures provided by ENVC

The existing guidelines recommend the use of plastic storage tanks, but permit the use of tanks made of other materials. The stored water can be raw, partially treated or fully treated. Table 9.10 lists the types of storage tanks used in the existing PWDUs.

Table 9.10 Storage Water Type and PWDU Storage Tank Material

Community	Water Type	Material
Community A	RO Permeate	n/a
Community B	Ozonated	HDPE
Community C	RO Permeate	PE
Community D	Ozonated	HDPE
Community E	RO Permeate	FRP
Community F	Chlorinated	Concrete
Community G	Ozonated	HDPE

Table 9.10 indicates that most of the tanks used in the PWDUs are made of polyethylene. The exception is the PWDU in Community F, which feeds into a dedicated section of the concrete municipal clearwell, where it is chlorinated before being dispensed to users.

Overall, polyethylene is a good choice for storage containers. It is unlikely to impart flavours to the water and is easy to clean. However, the ozonation and filtration systems include periodic recirculation of ozonated water through the storage tank. This helps to ensure that the water stays 'fresh' and helps to mitigate the effects of the long retention times noted in Table 9.9. This may become an issue over time, however, as plastics are known to deteriorate when left in contact with ozonated water.

The standardized PWDU design includes a 1,000 L, food-grade, NSF certified HDPE storage tank after the nanofiltration unit. This volume is sufficient to provide of 5.5 L/person/day for a community of 182 people. The capacity of the storage tank can be increased to provide for higher usage rates and/or larger populations if necessary. The system is not expected to include ozone recirculation and all ozone will be removed from the water by a series of filters ahead of the storage tank.

9.6 Equipment Housing and Dispensing Areas

A variety of requirements and recommendations for the PWDU equipment housing and dispensing areas are laid out in the existing PWDU Guidelines. Many of these are very specific. A series of short lists of criteria have been created using the recommendations in this document in order to compare the seven existing systems.

9.6.1 Existing PWDUs

9.6.1.1 Dispensing Area Location

The location and access hours of the PWDU are the two biggest factors that determine how convenient it is for users. Users are more likely to make use of a more convenient PWDU, and may not adopt the technology if it is hard to access or if it is not open at times when they are able to get out to it. Table 9.11 summarizes some of the main factors that control the convenience of the PWDU for users.

Table 9.11 Convenience Factors

Community	Location	Indoor/Outdoor	Hours of Access	Access Control
Community A	2 km Outside of Town	Indoor	8:00 am – 12:00 pm	Key Lock
Community B	Water Distribution Stand Pipe	Indoor	24 hours a day	None
Community C	Town Hall	Indoor	During Town Hall office hours	Key Lock
Community D	Centre of Town	Indoor	7:00 am – 9:00 pm	Key Lock
Community E	Town Office	Indoor	8:00 am – 8:00 pm	Timed Lock
Community F	At the WTP in Town	Outdoor	24 hours a day	None
Community G	Centre of Town	Indoor	24 hours a day	None

9.6.1.2 Dispensing Taps

The type and number of taps present in the PWDU dispensing area can influence how the area is used and how long people have to wait to gather water. Users are likely to respond better to taps that allow them to use a variety of collection containers. Table 9.12 summarizes the characteristics of the taps provided in the PWDU dispensing areas.

Table 9.12 PWDU Dispensing Taps

Community	Number	Material of Construction	Are a variety of collection containers accommodated?
Community A	2	CPVC (indoor), Bronze and Copper (outdoor)	Yes
Community B	2	Chrome Plating (copper/brass internals)	Yes
Community C	1 (per unit)	PVC + Galvanized Steel	Yes
Community D	3	Stainless Steel	Yes
Community E	1	Flexible Stainless Steel	Yes
Community F	1	Galvanized Plating (copper/brass internals)*	Yes
Community G	3	Stainless Steel	Yes

*Assumed from photos

9.6.1.3 Communication

Proper communication between town representatives, PWDU operators and PWDU users can encourage safer, more efficient use of the PWDU. Some simple strategies, such as printed instructions and easily accessible water quality records can help breed familiarity and comfort with the system. Some methods of communication recommended in the existing PWDU Guidelines are summarized in Table 9.13.

Table 9.13 Communication with PWDU Users in Dispensing Areas

Community	Instructions Provided?	Emergency Numbers?	Water Quality Records Displayed?
Community A	No	No*	No
Community B	Yes	No	At Town Hall
Community C	No	No	At Town Hall
Community D	n/a	n/a	n/a
Community E	No	No	No
Community F	No	No	At Town Office
Community G	Yes	No	At Town Office

*Operator always present during access hours

9.6.1.4 Health and Safety

Some simple design elements can be included to encourage greater compliance with health and safety regulations. Other elements may make the PWDU more accessible for those with physical disabilities. Some of these are summarized in Table 9.14 below.

Table 9.14 Health and Safety Concerns in PWDU Dispensing Areas

Community	Is there public Access to Treatment Equipment?	Is the PWDU Accessible for Disabled Users?	Is Adequate Parking Available?	Is the Building Heated?
Community A	No	Yes	No car access	Yes
Community B	No	No	Yes	Yes
Community C	No	Not Really	Yes	Yes
Community D	No	No	No car access	Yes
Community E	No	No	Yes	Yes
Community F	No	Yes	Yes	No, outdoors
Community G	No	Yes	Yes	Yes

9.6.1.5 Contamination Prevention

Contamination prevention is also an important goal in the design of PWDUs. For example, the risk of cross-contamination increases if taps are designed such that it is possible to attach a common household hose. There are also concerns related to contamination from used or inadequately cleaned collection containers. Table 9.15 below summarizes the main contamination issues at each existing PWDU.

9.6.2 Standardized PWDU Building Design

The standardized PWDU design includes a building with two separate rooms. One room will house the treatment equipment and the other will house the dispensing area. Residents will only have access to the dispensing area. The PWDU equipment room will be heated, lighted and include enough space for the operator to maintain all of the different components of the process. The standardized PWDU design includes a dispensing area with three taps of varying heights as well as a bottle washing station. The dispensing area will be housed in the same building as the treatment equipment, but users will only have access to the taps.

Table 9.15 Sanitation-Related Concerns in PWDU Dispensing Areas

Community	Is there Some Sort of Backflow Prevention on the Tap?	Is it Possible to Attach a Hose?	Can Collection Containers Come into Contact With the Tap?
Community A	No	No (potable), Yes (non-potable)	Yes
Community B	No	No	Yes
Community C	No	Yes	Yes
Community D	No	No	Yes
Community E	Squeeze Nozzle	Yes	Yes
Community F	Yes	Yes, but it is not permitted	Yes
Community G	No	No	Yes

9.7 Operation

The existing PWDU guidelines recommend a number of tasks related to the operation, maintenance and monitoring of the PWDU treatment systems. The tasks listed are general and apply to all systems regardless of the type of treatment included in the process. For specific tasks, operators are referred to the O&M manuals provided by the equipment manufacturer.

9.7.1 Operator Survey
A survey was conducted by CBCL Limited in February of 2010 to assess whether the PWDU operators were fulfilling the requirements of the PWDU guidelines. A copy of the survey can be found in Appendix D. The information collected added to knowledge gained through more informal phone and in-person conversations with operators in 2009. Attempts were made to contact all PWDU operators throughout the month of February. By the end of the month, operators from Community B, Community D, Community E, Community F and Community G had filled out the survey over the phone. The operator in Community A was no longer working for the community and the operator in Community C was not available to participate in the survey.

9.7.2 Operation and Maintenance Manuals
Operation and Maintenance (O&M) manuals are regularly provided to water treatment system operators by the consultant and/or equipment supplier. To fulfill the existing PWDU guidelines, a specified number of O&M manuals must be provided to the owner (town, etc) and to the ENVC as well. A survey of PWDU operators conducted in February 2010 found that four out of five of them had access to an Operation and Maintenance Manual provided by the equipment manufacturer and/or supplier. The manuals were not, however, in full compliance with the requirements for O&M manuals as outlined in the PWDU guidelines. In many cases, the manuals are specific to one piece of equipment and fail to take into account the treatment process as a whole (water quality, monitoring, instrumentation, interactions between various pieces of equipment). In order to properly operate, maintain and monitor the PWDUs, operators need a better reference that can help them to integrate the information presented in the various equipment-specific manuals into a set of tasks to be conducted on a regular, logged basis.

9.7.3 Operational Responsibility
As part of the survey, the PWDU operators were asked to provide their official job titles. Responses ranged from 'Systems Maintenance Man' to 'Heavy Equipment Operator'. All of the operators surveyed had numerous responsibilities besides the PWDUs and the water supply system. Some common tasks included garbage collection (3/5) and snow removal (2/5). Other tasks listed by at least one operator included operation of wastewater services, road maintenance, public building maintenance and utility vehicle maintenance.

9.7.4 Time Spent
All five of the operators who participated in the survey reported spending between one and five hours per week operating and maintaining the PWDU. The former operator in Community A, who did not participate in the survey, previously indicated that he used to spend 20 hours per week at the PWDU. His tasks included dispensing water for users, a task not reported by any of the other operators.

9.7.5 Certification and Education
Only one of the operators who participated in the survey had any form of operator certification. Operator certification is voluntary in Newfoundland and Labrador, however, operators are strongly encouraged to participate in onsite training and seminars conducted throughout the province. Three of the five operators surveyed reported having participated in a water treatment or distribution course. Many of the PWDU operators would likely benefit from more education, particularly if it included hands-on training and information about very small water treatment systems.

9.7.6 Tasks

The tasks performed by operators to operate and maintain the PWDUs are discussed in detail in Chapter 6 of this document. The only task that is directly specified in the existing PWDU standards is the cleaning and sanitization of the dispensing area, which is to be done once a week. Three of the five operators surveyed cleaned their dispensing areas once a week, while the two others cleaned them either monthly or twice annually.

The existing PWDU guidelines could be updated with a more specific list of tasks (similar to that discussed in chapter 6) to be completed by operators along with recommended frequencies. A standardized O&M log could also be included to encourage compliance. One advantage of a standardized PWDU design is that a generic 'PWDU O&M Manual' can be developed and distributed to all PWDU operators and used for training purposes.

9.7.7 Monitoring

The existing PWDU guidelines do not require that operators maintain records of water usage, water quality or maintenance activities. Instead, they indicate that the ENVC is responsible for twice a year water quality monitoring and ensuring that the PWDUs comply with their Permits to Operate. According to the guidelines the responsibility for performance monitoring during the first year (or full warranty period) falls to the consultant or equipment manufacturer who provided the equipment. Requirements are to be set on a site-by-site basis and results are to be provided to the Town and to the ENVC.

As discussed in Chapter 6, a number of the operators at the existing PWDUs do keep daily records. For the most part, these consist of totalizer readings and/or a maintenance log, but one operator (Community F) keeps a daily record of twelve different system parameters. Record-keeping similar to that performed by the operator in Community F could be implemented at the other existing PWDUs and for the new, standardized PWDUs. Potential parameters to be monitored include.

All Systems:

- Date;
- Time;
- Total flow in;
- Total flow out;
- Turbidity;
- Colour;
- TDS;
- pH;
- Chlorine residual (in);
- UV Transmittance; and
- Maintenance performed.

Reverse Osmosis Systems:

- Feed flow, pressure;
- Product flow;
- Reject flow, pressure; and
- Recirculating flow.

Ozone Systems:
- % Ozone; and
- Atmospheric ozone.

Daily records will permit operators, inspectors, equipment manufacturers and future consultants to quickly and accurately assess the operation of the PWDU equipment. This will likely improve troubleshooting during equipment shut-downs.

9.8 Safety

The existing PWDU Guidelines state that:

'All operations must be conducted in accordance with current Newfoundland and Labrador Occupational Health and Safety Act regulations for the safety of employees and the general public.'
(ENVC, 2008)

Although this statement is well-intentioned, no specific guidance is provided about which regulations are most applicable to PWDU operators. Given the length of the Occupational Health and Safety Act and the fact that that few of the existing operators have participated in water treatment and/or distribution courses more explanation is required. This is especially important for operators of systems that employ ozone. Operator safety is discussed in many sections of the Municipal Guidelines, including the section on ozone. However, as mentioned previously, those guidelines were written for large-scale water treatment plants. Many of the safety requirements they present are not applicable to the operators of very small systems such as the PWDUs.

A number of recommendations for how designers and operators can ensure PWDU user safety are provided in various sections of the existing PWDU guidelines including:
- Ensuring adequate disinfection by locating UV units after the storage tank;
- Minimizing contamination by maintaining cleanliness of equipment and of the dispensing area;
- Minimizing contamination of taps by preventing the use of hoses;
- Limiting storage time to prevent contamination/water quality deterioration;
- Monitoring for ozone;
- Providing heat and lights in the dispensing area;
- Posting instructions and water quality information in the dispensing area;
- Restricting access to the treatment equipment to PWDU operators;
- Recommending particular materials of construction for the various elements of the dispensing area to prevent contamination; and
- Recommending the use of rubber mats in the dispensing area to prevent slips and falls.

Many of the recommendations provided in the two guidance documents will, if properly applied, ensure that the operator and the PWDU users remain safe while operating, maintaining and using the PWDU. At present, however, these recommendations are scattered throughout the two documents. CBCL Limited recommends that the existing safety guidelines for operators and the public be adapted as required, grouped under one heading in the PWDU guidelines and separated under logical subheadings.

For example, the safety section could include the following sections:

- Safety:
    - Operator Safety:
        - Designing for Operator Safety;
        - Safety During PWDU Construction;
        - Safe Operation of PWDUs;
    - User Safety:
        - Designing for User Safety;
        - Maintaining a Safe Environment for Users; and
        - How to Dispense Water Safely.

Alternatively, safety requirements could be kept in relevant sections but indicated appropriately. For example, each major section could have a subsection at the end labeled 'safety considerations'. This subsection would contain all the guidelines related to safety for that section.

9.9 Process Flow Diagrams

The existing PWDU guidelines require that the consultant in charge of developing the PWDU provide a process flow diagram (PFD) showing the relationships between the major components of the treatment system. PFDs were obtained by CBCL Limited for Communities B, D and G during the initial stages of the study. PFDs have been developed for all of the variations of the standardized PWDU design and are available as part of the work submitted for the PWDU Design and Construction Project (093046).

9.10 Pilot Studies

The existing PWDU guidelines recommend a pilot study to determine whether the proposed treatment is able to effectively treat the PWDU feed water to within GCDWQ. No pilot studies were conducted during the construction of the existing PWDUs. The first standardized PWDU installation will be used as a pilot to prove the effectiveness of the proposed standardized treatment process.

9.11 Summary of Proposed Modifications to Existing PWDU Guidelines

1. Overall format:
    a. The existing format does not present the requirements for the design of PWDU systems in a consistent, logical way. The document could be reorganized into numbered sections with headings such as 'Capacity', 'Design of Treatment Equipment', 'Operation', 'Monitoring' and 'Safety'.
    b. Appropriate portions of referenced documents should be adapted to small systems and integrated directly into the PWDU guidelines.
2. Equipment capacity recommendations should be revised to acknowledge the limited availability of appropriate, NSF certified treatment equipment at PWDU flow rates. Sources of NSF certified equipment at the sizes required could be indicated within the document.
3. Operation:
    a. Should include reference to record keeping by operators. This could take the form of a 'recommended maintenance log'.
    b. Should include a list of recommended regular maintenance tasks.

4. Storage Tanks:
    a. Increase storage to 5.5 L/person/day.
5. Materials of Construction:
    a. All parts coming into contact with ozone in air – 316L SS.
    b. All parts (pipes, valves, storage tanks etc) in contact with ozone in water – 304L SS or 316L SS.
6. Ozonation Equipment:
    a. The section on ozone in the Municipal Guidelines should be adapted for small systems and inserted directly into the PWDU Guidelines.
7. RO Equipment:
    a. The section on reverse osmosis in the Municipal Guidelines should be adapted to include recommendations for PWDU-sized systems and inserted directly into the PWDU Guidelines.
    b. Specific recommendations should be made with respect to the design and operation of RO systems.
8. UV Equipment:
    a. The section on UV disinfection in the municipal guidelines should be adapted for small systems and inserted directly into the PWDU guidelines.
9. Safety:
    a. Specific safety requirements (specific to design, construction and operation) should be written into the PWDU guidelines and summarized under a section labeled ‘safety’.
10. Monitoring:
    a. More frequent water usage and water quality monitoring should be required.
    b. Operator monitoring should continue to be supplemented by twice annual ENVC water sampling and monthly bacteriological sampling by the Department of Government Services.

9.12 Recommended Modifications to Existing PWDUs

The existing PWDU guidelines were written based on the experiences of the operators and users of the seven existing PWDUs. As a result, most of the PWDUs comply, more or less, with the guidelines, even though several were built before the guidelines were published (and likely influenced the creation of the guidelines). Some important deviations were noted in many of the systems:

1. Residence time in the water storage tanks.
2. Construction of dispensing areas.
3. Materials of construction used in treatment systems (piping, valves, etc.).
4. System operation.
5. Water usage and water quality monitoring.

Specific recommendations for each PWDU are as follows:

- Community A:
    - Improve membrane pretreatment process to reduce fouling/deterioration of membrane elements;
    - Improve dispensing area/equipment;
    - Institute regular (daily/weekly) water usage and water quality monitoring by the operator;
- Community B:
    - Install ORP monitoring, oxidation or added filtration to remove excess DOC/colour;
    - Improve dispensing area/equipment;
    - Institute regular (weekly) water quality monitoring by the operator;

- Community C:
  - Inappropriate piping should be replaced on the treatment system;
  - The operator should be trained to clean and replace the membrane elements in order to improve membrane recovery (treatment efficiency);
    - The relationship between the proper operation of the pretreatment system and the performance of the reverse osmosis unit should be emphasized;
  - Dispensing equipment should be upgraded;
  - Institute regular (daily/weekly) water usage and water quality monitoring by the operator;
- Community D:
  - Install ORP to ensure system flexibility;
  - Provide more operator training;
  - Institute regular (daily/weekly) water usage and water quality monitoring by the operators;
- Community E:
  - Replace membrane elements to improve treatment performance;
  - Investigate the causes of elevated turbidity and lead concentrations;
  - Train operator to clean and replace the membrane elements;
  - Improve dispensing area/equipment;
  - Institute regular (daily/weekly) water usage and water quality monitoring by the operators;
- Community F:
  - Dispensing equipment should be upgraded to be in compliance with the PWDU guidelines;
  - An enclosed dispensing area should be constructed;
- Community G:
  - Modify ozonation process to ensure adequate manganese removal; and
  - Institute regular (weekly) water quality monitoring by the operator.

CHAPTER 10 RECOMMENDED IMPROVEMENTS TO PWDU OPERATION AND MAINTENANCE

The overall acceptance of a PWDU is influenced by factors such as the design and quality of the treatment equipment, the dispensing area where residents gather their water, the costs associated with operating and maintaining the system, the socioeconomic circumstances in each community and the quality of the water being produced by the PWDU. Many of these factors are difficult to change in the short term, but there are actions that can be taken by the provincial government and the communities themselves to improve PWDU operation and increase PWDU adoption. The operation and maintenance of the PWDU equipment and the dispensing areas may be improved by providing PWDU operators with central and/or regional support. This may become more feasible as the 40 proposed PWDUs are built in 2010 and 2011. The three potential O&M scenarios discussed in this chapter are:

1. Maintaining individual PWDU operators in each community.
2. Developing regional O&M networks of communities located close to one another.
3. Developing a province-wide PWDU O&M network supervised by PWDU O&M Coordinators.

It should be noted, however, that in some communities with PWDU water quality concerns, actual design modifications are required in addition to increased operator support. Also, no matter which O&M scenario is eventually chosen, the PWDU operators will have to be provided with PWDU-specific training.

10.1 PWDU O&M Support Strategies

10.1.1 Individual PWDU Operators

All seven of the existing PWDUs have (or had) a local PWDU operator, who is responsible for ensuring that the treatment equipment functions correctly and that the dispensing area remains clean and sanitary. As discussed in Chapters 6 and 7, the operators perform their duties with varying levels of competence but face similar challenges such as poor incoming feed water quality, lack of water-treatment training, and the need to devote time to other tasks such as the municipal water system, snow clearing and/or garbage collection.

A list of PWDU operator tasks was developed in Chapter 6 based on the existing PWDU Guidelines and CBCL recommendations. Table 10.1 provides a list of task frequencies as specified in the existing PWDU Guidelines (or as recommended by CBCL Limited) and indicates how often the PWDU operators reported completing each of the tasks during a telephone survey conducted in February 2010.

Table 10.1 Frequency of Operator Tasks in Participating Communities

Task	Recommended	Community A	Community B	Community C	Community D	Community E	Community F	Community G
Check to Make Sure the System is Operating	Daily	Daily*	Daily	Daily*	Daily	Daily	Daily	Daily
Inspect the Treatment Equipment	Weekly	n/a	Daily	n/a	Weekly	Daily	Daily	Weekly
Test the Quality of the Treated Water	Weekly	n/a	Never	n/a	Never	Never	Daily	Weekly
Backwash the Filters	As necessary	n/a	Weekly	n/a	Daily	Daily	Weekly	Daily
Clean the Storage Tank	Four times a year	n/a	Monthly	n/a	Never	Never	Annually	Annually
Clean the UV Lamps	Twice monthly	n/a	Annually	n/a	Never	Monthly	Monthly	Annually
Fully Clean and Sanitize the Dispensing Area	Weekly	n/a	Weekly	n/a	Weekly	Monthly	Twice Annually	Weekly

*Determined in prior phone conversations

In Table 10.1, n/a stands for 'not available'. As discussed in detail in Chapters 6 and 9, not all of the PWDU operators were available to take the survey, despite many attempts to contact them by phone.

Most of the operators in the five communities surveyed maintain only minimal monitoring and maintenance records for the PWDUs, as shown Table 10.2.

Table 10.2 Water Quantity, Water Quality and Maintenance Records Kept in Participating Communities

	Community B	Community D	Community E	Community F	Community G
Total Daily Flow Out	✓	X	✓	X	X
Total Daily Flow In	X	X	X	X	X
Volume Used	X	X	X	✓	X
Level Reading	X	X	X	✓	X
Turbidity	X	X	X	✓	X
Colour	X	X	X	✓	X
pH	X	X	X	✓	X
Maintenance Performed	✓	X	X	✓	✓
No records are Maintained	X	✓	X	X	X

The operator in Community F keeps the most detailed records, and provided CBCL Limited with a copy of the log sheet he completes on a daily basis. The completed sheets are mailed to the provincial government. Four communities keep records of parameters such as the daily flow out of the system (Community B, Community E) or specific maintenance activities (Community B, Community G). One community, Community D, reported that they kept no records of maintenance, water use or water quality.

As discussed in Chapter 6, to effectively operate the existing PWDUs, operators should be putting in approximately one hour each day (325 hours each year). If an individual operator is paid $20/hr, this results in a total annual labour cost of $6,500.

Many of the current PWDU operators devote only a fraction of that time to their PWDU because it is only one of many things they are responsible for within the community. To improve PWDU O&M in these communities, it will be necessary to emphasize the importance of the PWDUs and the need to perform all recommended tasks on a regular basis. Record-keeping must also be encouraged. Increased operator training will help, however, it may be necessary to train more than one operator in each community. Operator turnover has been high during the study – with four out of seven communities having to hire a new operator within the past twelve months. In most of these cases, operator pay was a factor. To keep PWDU operators working, it may be necessary to provide them with some additional remuneration for their services.

Given the existing O&M challenges in the participating communities, individual PWDU operators are the least preferred O&M strategy of the three presented in this section. The provincial government would likely continue to lack access to PWDU operating data and have only minimal influence over the quality of care provided to the PWDUs.

One way to ensure that each local operator is able to provide adequate care to the PWDU in his or her community would be provide support, in the form of office space and tools, to each community. If the community (and/or the provincial government) were to account for these additional costs associated with running the PWDU the total cost would be higher. Despite these additional supports, local operators may still encounter challenges if they are not provided with adequate training. Additional supports are not likely to be required in communities with established, trained water supply operators.

10.1.2 Regional Operator

Small communities in Newfoundland and Labrador and in other parts of Canada have been known to establish regional maintenance networks to overcome some of the barriers that prevent them from fully operating and maintaining their water treatment systems on their own. For example, the communities Parson's Pond, St. Paul's, Cow Head and Daniel's Harbour have come together to streamline their water treatment operations. One certified water treatment operator travels from community to community regularly to conduct all forms of complex maintenance on each system, take records and conduct water quality testing (Parsons and Pittman, 2008).

Small communities in Saskatchewan currently have the option to hire a regional/contract operator to run their water supply systems. This option allows a number of small communities to share the services of one trained operator instead of investing in the education and training of a local operator. Saskatchewan Environment recommends that each regional operator be limited to a maximum of three communities (Saskatchewan Environment, 2002).

The communities participating in the PWDU study are scattered around the province. More than twenty other communities, however, have recently decided to install PWDUs and may be interested in partnering with one or more of the communities who already have a PWDU (or even a full-scale water supply system) to share an operator. The cost to each individual community will depend upon the number of communities participating in the regional O&M network and the cost of travel between them. Saskatchewan Environment recommends limiting regional operation networks to three communities to ensure that each water system receives adequate care. The program in Saskatchewan, however, was designed for full-scale water treatment systems. As discussed in Chapter 6, the PWDUs require approximately six hours of O&M each week. Assuming that some time would also need to be allotted for travel and administrative duties, a regional PWDU operator should be able to service five

PWDUs, provided they are located within a short distance of one another. Community staff would still need to check the PWDU on a daily basis to ensure that it is operating continuously.

A number of regional operators would be required to service all of the existing PWDUs and the new PWDUs due to the distances separating the participating communities. As of April, 2010, eight potential regional networks (including 28 communities) have been identified by CBCL. A map of the potential regional networks is included in Appendix G. The cost of this scenario may be high because there are very few communities located close enough together to form appropriately sized regional networks. The largest potential network would include five communities on the Burin Peninsula. Most of the remaining networks would be made up of only three communities. The regional operator would need to work nearly full-time hours each week to provide six hours of O&M to each system and to account for travel time. To pay the operator accordingly, each community would have to provide a portion of a full-time salary and pay for some of the travel costs. The smaller networks may choose to hire a part-time regional operator.

10.1.3 Province-wide PWDU O&M Network

One way to ensure that the PWDUs receive an adequate amount of care despite the circumstances described in the previous section would be to designate one central or multiple regional PWDU O&M coordinator(s) to oversee individual, local operators. Together, the coordinators and local operators would form a province-wide PWDU O&M network. Initially, only one coordinator would be required to oversee the seven existing PWDUs. In order to minimize travel requirements and ensure that each PWDU can be checked once a month, additional coordinators should be hired as the proposed new PWDUs come online in 2010 and 2011.

The PWDU O&M coordinator(s) would be responsible for monitoring the operation of all of the existing and proposed PWDUs by reviewing data collected by individual local PWDU operators. Other tasks might include monthly site visits, major equipment maintenance and/or local operator training.

Local operators would continue to conduct daily PWDU checks, but would now become be responsible for recording system parameters such as flow rate, pressure, total volume dispensed and water quality parameters such as finished water colour or turbidity. These records would be communicated to the PWDU O&M Coordinator by mail, phone or, preferably, through a secure internet database. Alternatively, the monitoring portion of the local operator position could be performed by having instrumentation installed on the PWDU that could communicate system operating data to the coordinator in real time.

Figure 10.1 presents the responsibilities of the PWDU O&M coordinators and the local operators in the proposed PWDU O&M network.

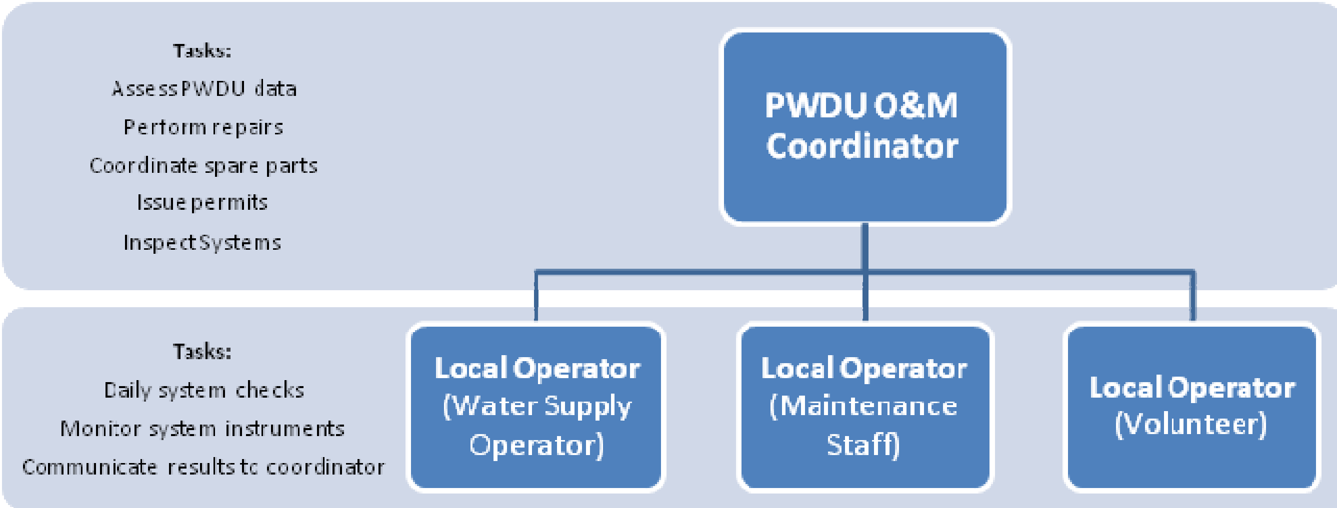


Figure 10.1 Breakdown of Tasks for Coordinators and Local Operators in the Proposed Provincial PWDU O&M Network

A province-wide PWDU O&M network will likely prove to be less expensive than a series of regional networks because fewer staff, vehicles and pieces of equipment will be involved. The anticipated cost of a province-wide PWDU O&M network is investigated in detail in Section 10.2.

10.1.4 Summary

The simplest way to provide O&M for the existing and proposed PWDUs would be to continue to allow each community to manage their system individually. This scenario could result in many of the PWDUs being inadequately cared for and may consequently expose PWDU users to unnecessary health risks. To minimize these risks, each local operator could be provided with training and/or additional support such as equipment and office space, however, this could increase the total and individual O&M costs substantially. Regional operators may prove to be even more expensive because most of the communities are located too far from one another to form regional networks large enough to reap the benefits of a shared operator. Given the number of communities who will eventually have PWDUs, the large distances between them, and the commitment of the Government of Newfoundland and Labrador to ensuring clean, safe drinking water to the residents of the participating communities, the development of a PWDU O&M network, to be overseen by PWDU O&M Coordinators, is thought to be the most effective option of the four presented in this chapter

10.2 Cost Analysis of Province-wide PWDU O&M Network

The final O&M scenario investigated in this section is the creation of a PWDU O&M network to be overseen by a number of PWDU O&M coordinators. The costs presented in this chapter assume that four PWDU O&M coordinators will be hired to supervise different parts of the province. They also assume that local operators will have access to their own vehicle, tools and office space.

Each PWDU O&M coordinator will require all of the support equipment presented in Table 10.3 in order to visit the various communities and perform repairs.

Table 10.3 Initial Costs Associated with Each PWDU O&M Coordinator

Support Costs	
Office Equipment	$ 3,500
Truck	$ 20,000
Water Quality Testing Kits	$ 1,000
Hand Tools	$ 1,000
Total	**$ 25,500**

The total cost to provide this for four coordinators is anticipated to be approximately $102,000. Additional equipment may eventually be required.

There will also be ongoing annual costs such as salary, administrative costs, and travel costs. These are summarized in Table 10.4.

Table 10.4 Annual Costs Associated with Each PWDU O&M Coordinator

Annual Costs	
Salary	$52,000
Benefits (30% of Salary)	$15,600
Administrative Costs	$5,000
Utility Truck Costs	$3,000
Gas (500 km/Week)	$3,250
Total	**$78,850**

Local operators may be volunteers or municipal staff, but in either case should be compensated for the time they spend checking the PWDUs. To calculate the total cost of this O&M scenario, it was assumed that an annual local operator stipend of $2,000 would be provided by the community or the provincial government. Local operators could also be provided with simple water quality testing kits that would allow them to record week to week variations in water quality parameters such as colour or turbidity. These results could then be sent to and assessed by the PWDU O&M coordinator(s). The total annual cost for the four PWDU O&M coordinators and the 40 local operators is anticipated to be approximately $409,400. If costs were shared equally among the communities, each would pay $8,771 a year.

Alternatively, each community could be responsible for the local operator stipend while the provincial government assumes the full cost of the PWDU O&M coordinators. This would result in a total annual O&M labour cost of $2,000 for each community and a total annual cost of $315,400 for the provincial government.

10.3 Centralized PWDU Parts Storage Facility

Many of the existing PWDUs are installed in communities located in particularly rural parts of the province. As a result, shipping costs for consumables such as cartridge filters and replacement parts such as membrane elements can be exorbitant. There also tends to a be a significant delay in the delivery as a result of the distances involved, which in some cases has resulted in PWDUs being taken offline for short periods.

A centralized storage facility would permit communities to invest in spare parts in bulk, minimizing shipping costs. The parts would then be close at hand in the event of an emergency, minimizing the time that the PWDU spends offline.

The main obstacle to creating a centralized storage facility is that the existing PWDUs do not contain standardized equipment. Three of them are ozonation-filtration processes from one equipment supplier while the remaining four use equipment, including reverse osmosis units, from different manufacturers. In order to make bulk purchasing feasible, it may be necessary to adjust the existing PWDU treatment systems such that they can accommodate more standardized spare parts and consumables. The costs of doing so will likely overwhelm the savings accrued by buying spare parts in bulk and storing them in a central location.

During the next two years, however, many more PWDUs will be built across the province. Each will use a standardized treatment system that will include both ozonation and membrane filtration, as well as UV disinfection. To minimize shipping costs and times, a central storage facility may be constructed. Depending on the final number of PWDUs constructed and their locations throughout the province, it may also become feasible to construct multiple regional storage facilities. At that point, it may become feasible to replace some pieces of equipment in the existing PWDUs such that they will be able to accommodate spare parts and consumables identical to those used in the new, standardized PWDUs.

CHAPTER 11 PWDU EDUCATION

11.1 Operator Training Modules

Operator training and certification are currently optional in Newfoundland and Labrador. In recent years, however, the Department of Environment and Conservation has invested a significant amount of effort to improve the training available to water and wastewater system operators. These include an annual three day workshop in Gander, a series of one-day courses and three mobile training units that provide hands-on training to operators in their own communities.

Trained operators are more capable of assessing their systems and troubleshooting any difficulties that may arise. Only one of the seven PWDU operators is certified (Water Distribution 1) and four have participated in operator training courses.

The equipment in many of the existing PWDUs is more sophisticated than that found in many existing water supply systems around the province. Currently, there are no water treatment courses available to operators that focus specifically on PWDUs. PWDU-specific training will provide operators with the skills they need to operate, maintain and assess their systems. Three one day PWDU operator training course curriculum summaries are presented in Appendix E.

11.2 Public Education Package

Chapter 7 contains a lengthy discussion of the various socioeconomic drivers and local barriers that contribute to the adoption of the PWDU concept within the participating communities. One way to overcome some of the barriers to PWDU adoption may be to educate residents about the advantages of using the PWDU for drinking water and provide them with simple ways to ensure that the water they collect is stored safely.

Appendix F is a public education package that includes:

- A brochure explaining the advantages of PWDU water;
- A graphic that can be printed onto stickers and distributed to users to remind them to keep their water collection containers clean;
- A Powerpoint presentation that can be used in presentations to community officials, residents and/or PWDU operators; and
- A 'cheat sheet' to help presenters prepare for the Powerpoint presentation.

The public education package is appropriate for individual community visits, but could also be adapted for media outlets such as radio, television or government websites.

CHAPTER 12 REFERENCES

Alaska Department of Environmental Conservation (n.d.) Village Safe Water Program. Retrieved from: http://www.dec.state.ak.us/water/vsw/pdfs/vswbrief.pdf, 11/6/2009.

Chapelle, F.H., Bradley, P.M., McMahon, P.B. and Lindsey, B.D. (2009) *What does 'water quality' mean?* Ground Water 47 (6) pp. 752-753.

Department of Environment and Conservation (2005) Guidelines for the Design, Construction and Operation of Water and Sewerage Systems. Government of Newfoundland & Labrador, Department of Environment and Conservation, Water Resources Management Division, St. John's, NL, A1B 4J6 Canada.

Department of Environment and Conservation Newfoundland and Labrador (2008) *Sustainable Options for the Management of Drinking Water Quality in Small Water Systems*. Government of Newfoundland & Labrador, Department of Environment and Conservation, Water Resources Management Division, St. John's, NL, A1B 4J6 Canada.

Department of Environment and Conservation (2008) Selection Criteria and Guidelines for the Design, Construction and Operation of Potable Water Dispensing Units. Government of Newfoundland & Labrador, Department of Environment and Conservation, Water Resources Management Division, St. John's, NL, A1B 4J6 Canada.

Department of Environment and Conservation (2010, March 1) *Canadian Water Quality Index.* Government of Newfoundland and Labrador, Retrieved from: http://www.env.gov.nl.ca/env/Env/waterres/WQMA/WQI/CanadianWQI.asp.

Garande, T. and Dagg, S. (2005) *Public Participation and Effective Water Governance at the Local Level: A case study from a small, under-developed area in Chile*. Environment, Development and Sustainability, 7, pp. 417-431.

Hardie, D. and Alasia, A. (2009) *Domestic Water Use: The relevance of rurality in quantity used and perceived quality*. Statistics Canada, Rural and Small town Canada Analysis Bulletin 7 (5).

Health Canada (2008) *Guidelines for Canadian Drinking Water Quality – Summary Table* Retrieved from Health Canada's website: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php.

Khan, A.A., Paterson, R. and Kahn, H. (2004). *Modification and Application of the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) for the Communication of Drinking Water Quality Data in Newfoundland and Labrador.* Water Quality Research Journal of Canada 39 (3) pp. 285-293.

Miller, P., Keefe, F., Kendall, A., Stead, T. and Caines, B.(2009) *Operating Potable Water Dispensing Units in NL.* Presented in March, 2009 at the 2009 Clean and Safe Drinking Water Workshop in Gander, NL.

Municipal Affairs (2009) New Framework Simplifies Gas Tax Processes. Retrieved from http://www.releases.gov.nl.ca/releases/2009/ma/0409n10.htm, 11/6/2009.

Najm, I.N., Patania, N.L., Jacangelo, J.G. and Krasner, S.W. (1994) Evaluating surrogates for disinfection byproducts. Journal AWWA 86 (6) pp. 98-106.

Park, A. (2005) *Report on PWDUs in Newfoundland and Labrador. Government of Newfoundland & Labrador*, Department of Environment and Conservation, Water Resources Management Division, St. John's, NL, A1B 4J6 Canada.

Parsons, J. and Pittman, M. (2008) *Regional Maintenance*. Presented in March, 2008 at the 2008 Clean and Safe Drinking Water Workshop in Gander, NL.

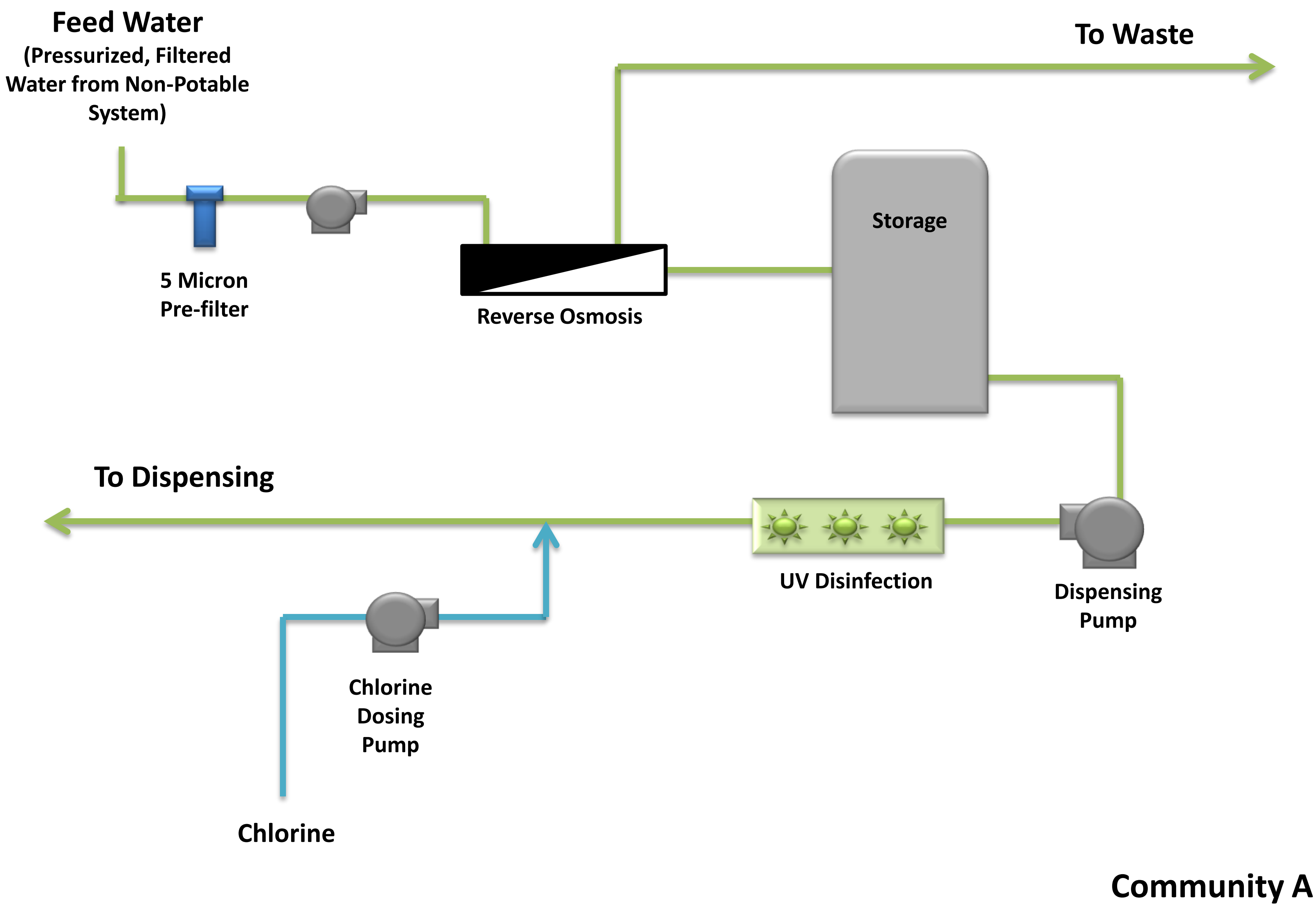
Sabau, G. and Haghiri, M. (2008) *Household willingness-to-engage in water quality projects in western Newfoundland and Labrador: a demand-side management approach.* Water and Environment Journal, 22, pp 168-176.

Saskatchewan Environment (2004) *Regional/Contract Operator Program* Retrieved from: http://www.saskh20.ca/DWBinder/EPB286RegionalContractOperatorProgram.pdf , 2010-01-21.

Statistical data obtained from the Community Accounts website: http://www.communityaccounts.ca/communityaccounts/onlinedata/getdata.asp, Accessed in November and December 2009.

APPENDIX A

Treatment Equipment Schematics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(Pressurized, Filtered Water from Non-Potable System)
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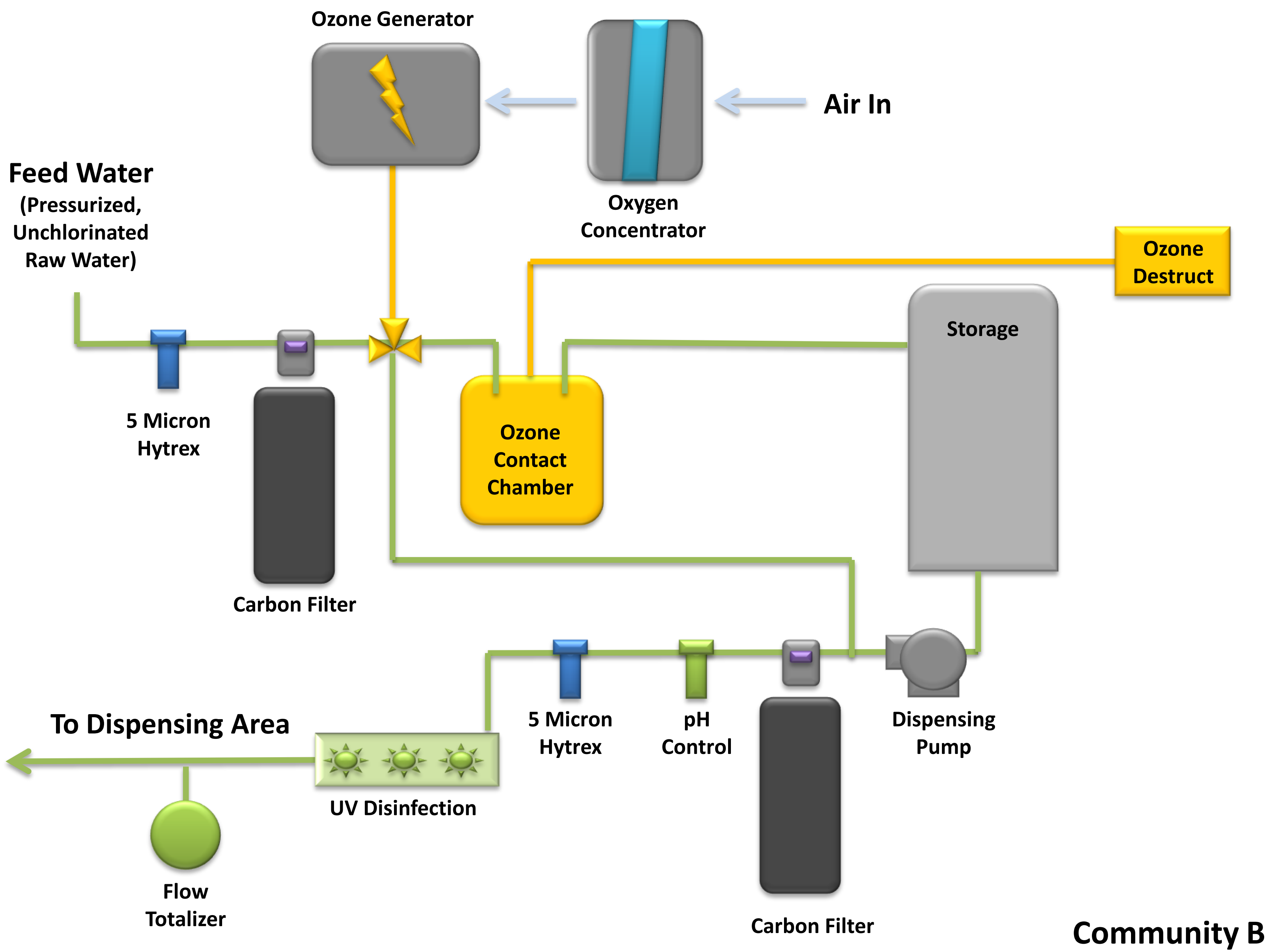
Reverse Osmosis
To Dispensing
UV Disinfection
Dispensing Pump
Chlorine Dosing Pump
Chlorine
Community A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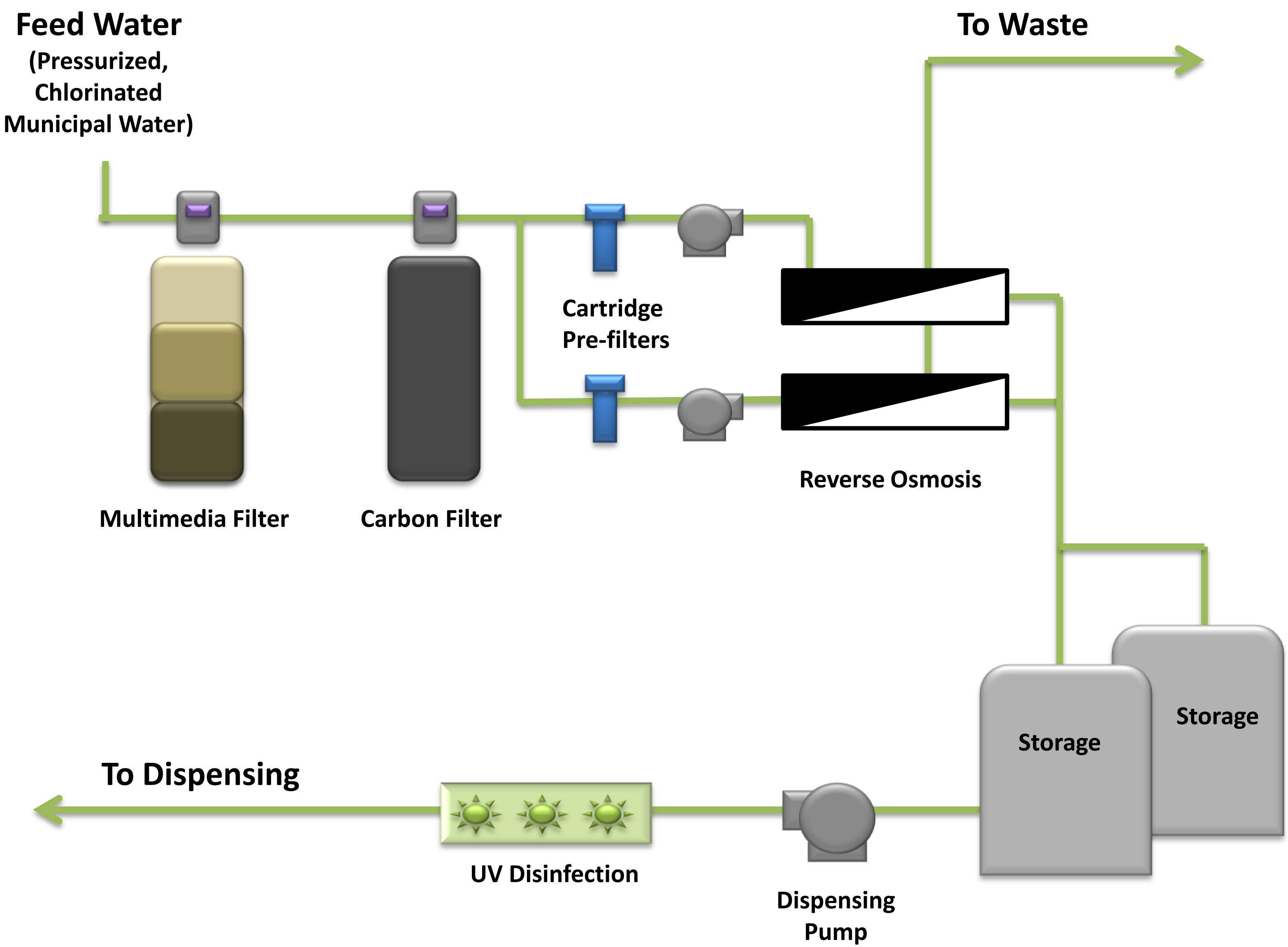
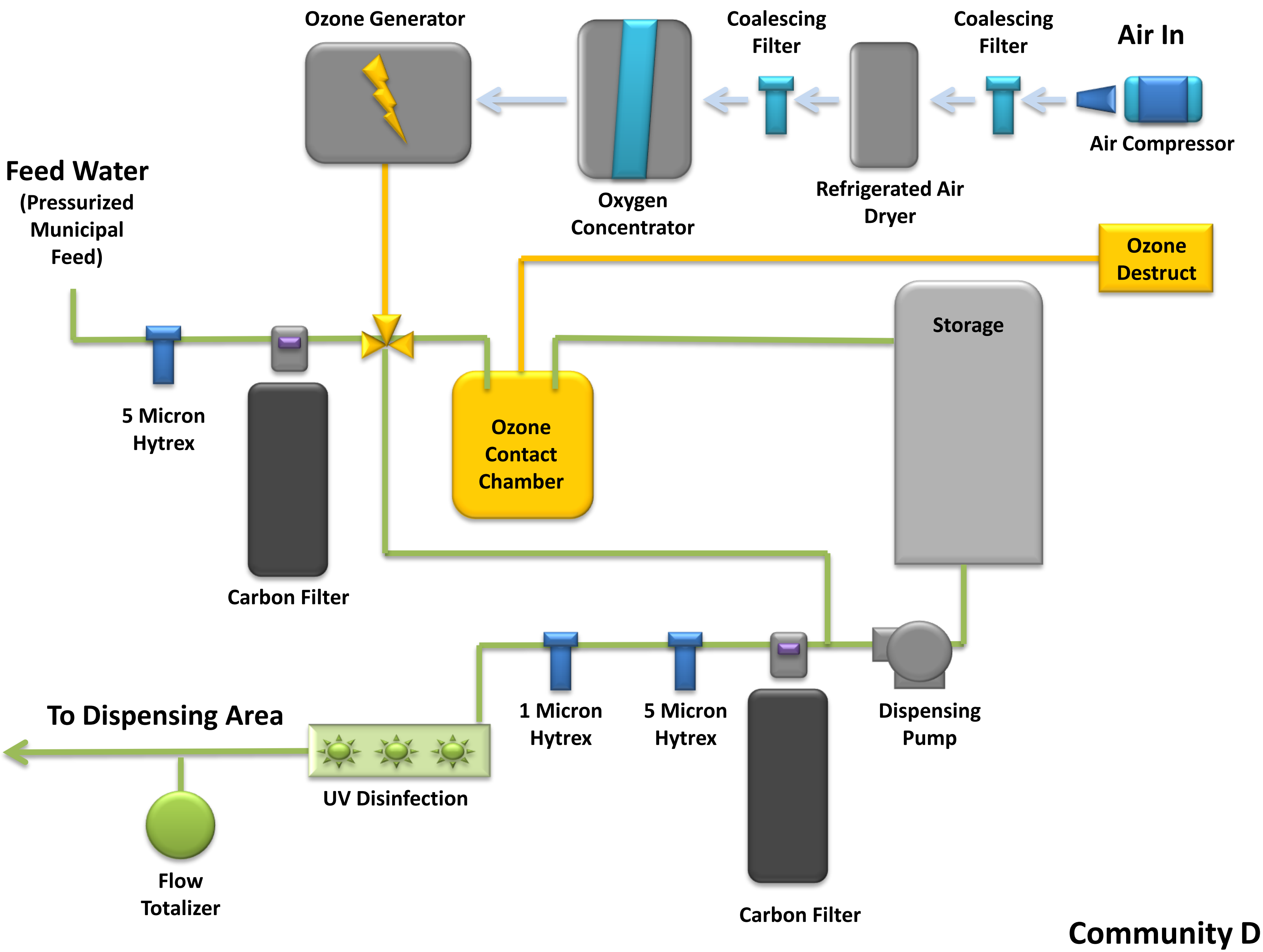
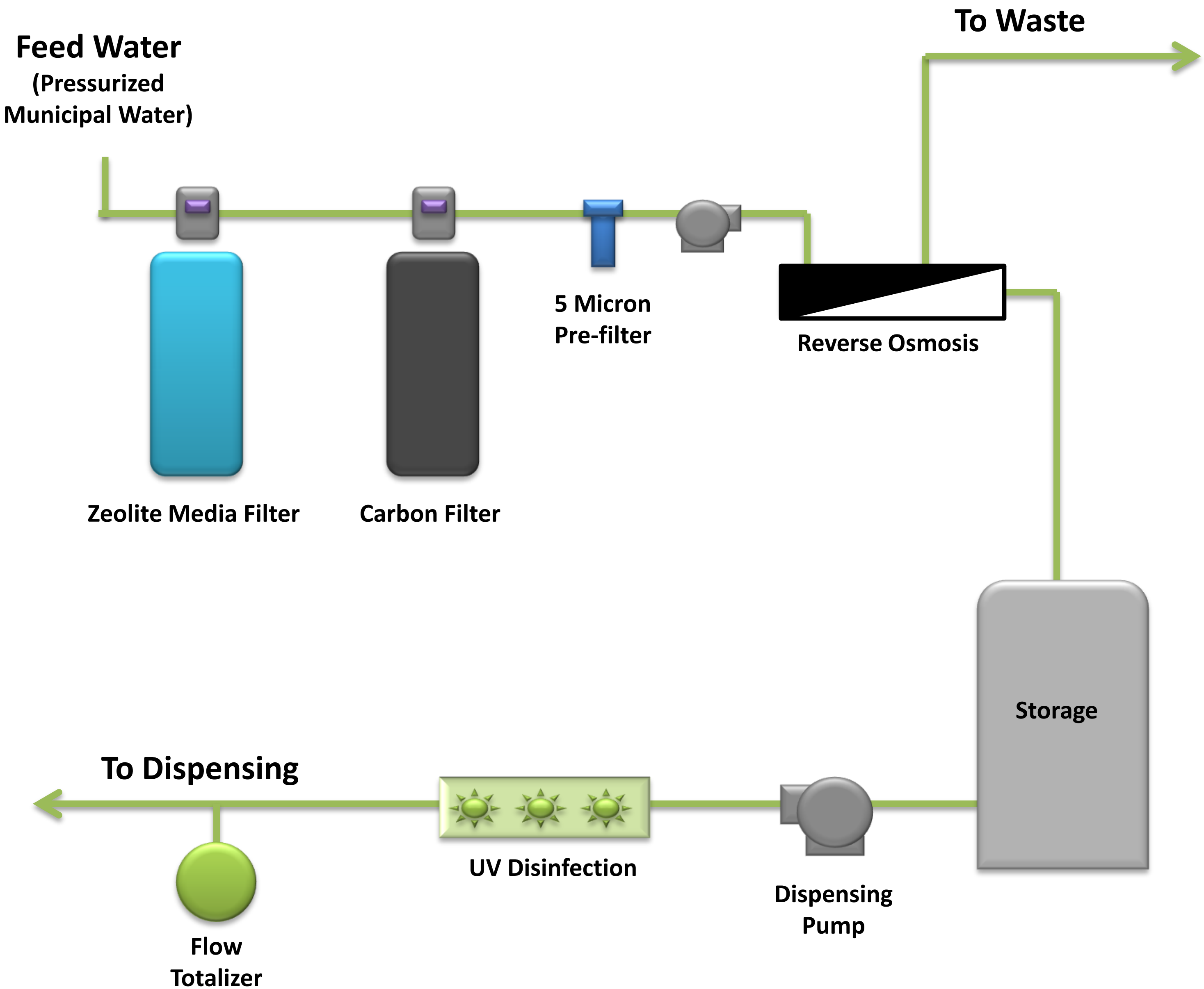
Oxygen Concentrator
Air In
Feed Water
(Pressurized, Unchlorinated Raw Water)
Ozone Destruct
Storage
5 Micron Hytrex
Ozone Contact Chamber
Carbon Filter
To Dispensing Area
5 Micron Hytrex
pH Control
Dispensing Pump
UV Disinfection
Flow Totalizer
Carbon Filter
Community B


Feed Water
(Pressurized,
Chlorinated
Municipal Water)
To Waste
Cartridge
Pre-filters
Reverse Osmosis
Multimedia Filter
Carbon Filter
Storage
Storage
To Dispensing
UV Disinfection
Dispensing
Pump

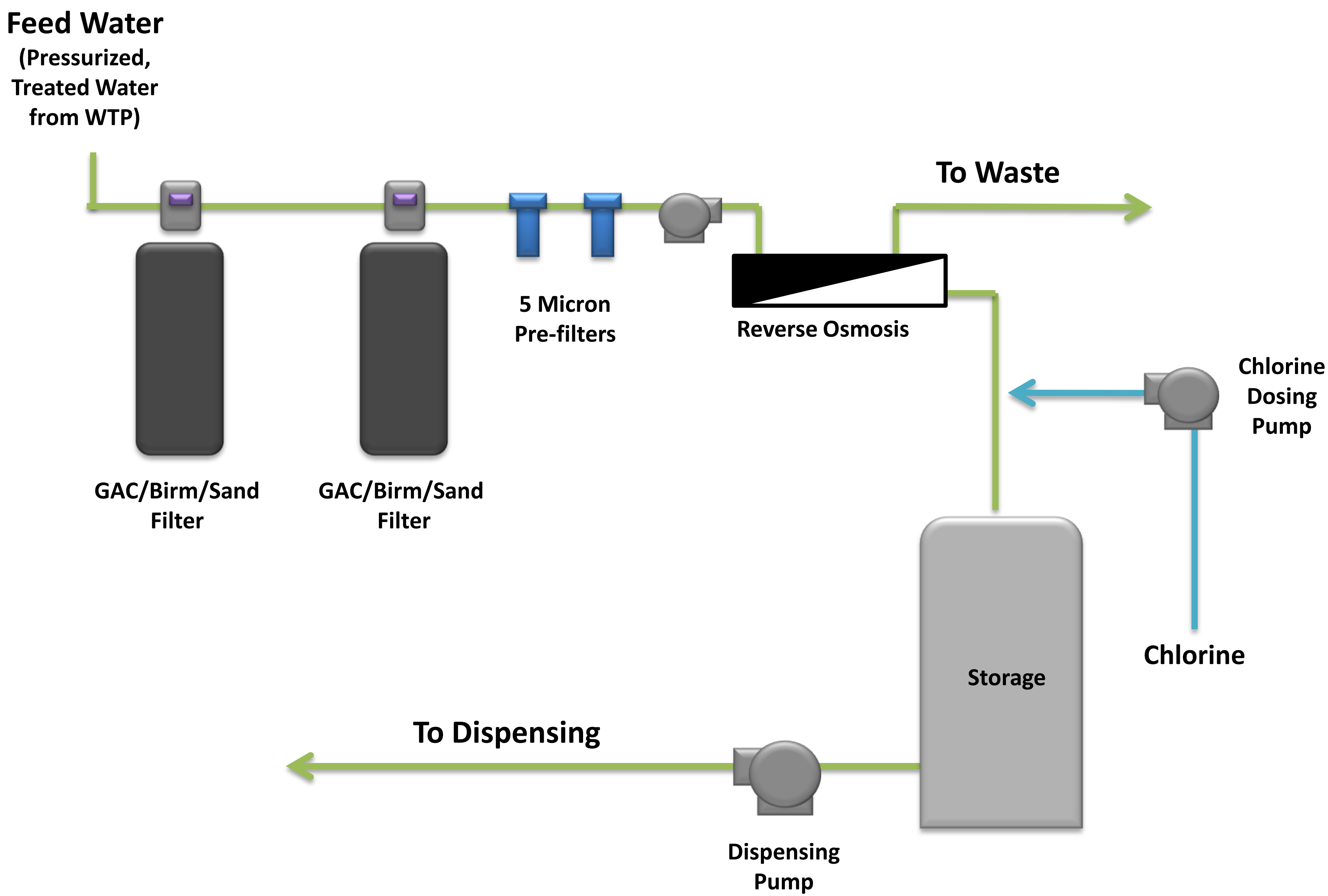
Community C


Ozone Generator
Coalescing Filter
Coalescing Filter
Air In
Air Compressor
Oxygen Concentrator
Refrigerated Air Dryer
Feed Water
(Pressurized Municipal Feed)
Ozone Destruct
Storage
5 Micron Hytrex
Ozone Contact Chamber
Carbon Filter
To Dispensing Area
1 Micron Hytrex
5 Micron Hytrex
Dispensing Pump
UV Disinfection
Flow Totalizer
Carbon Filter
Community D

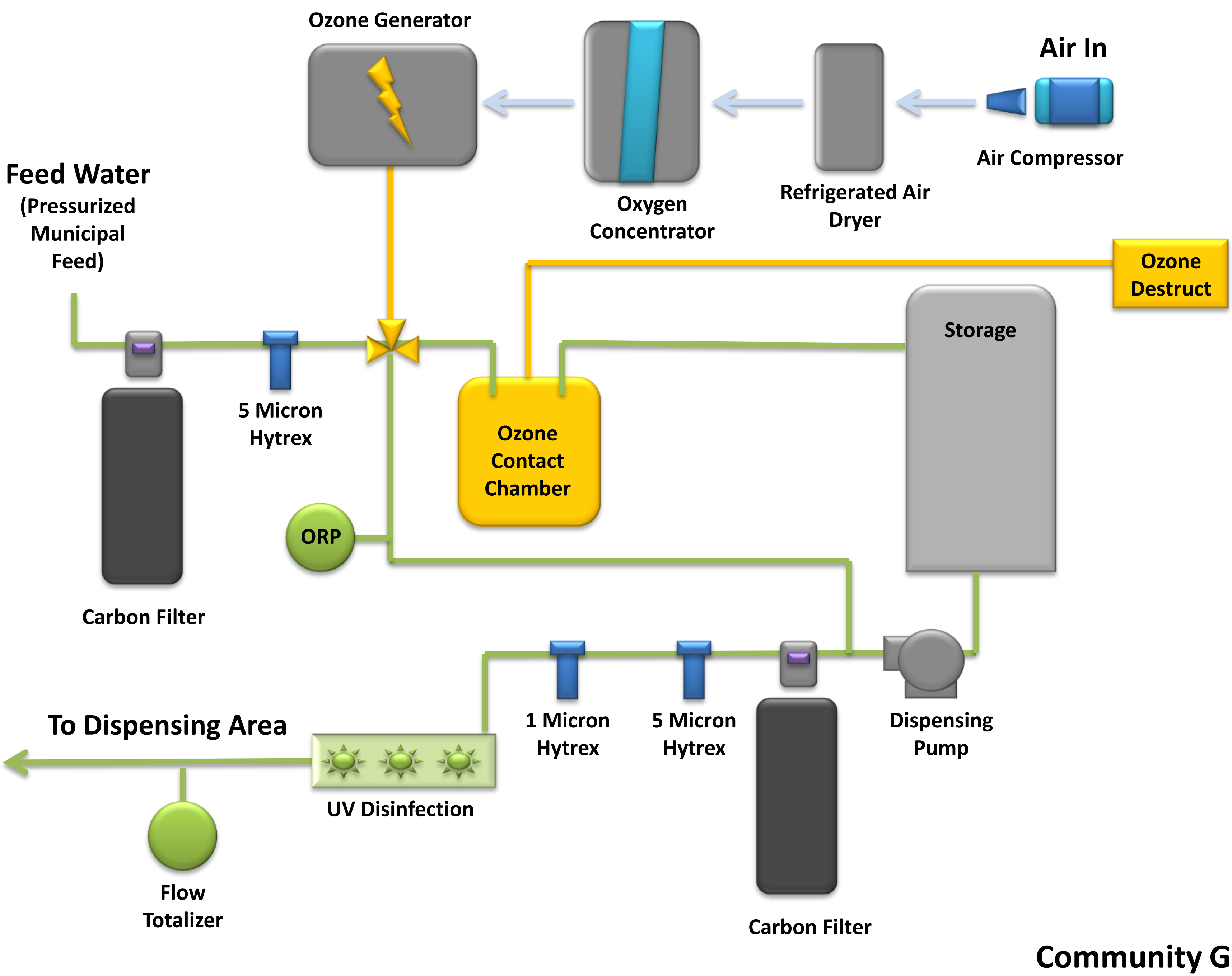


Feed Water
(Pressurized
Municipal Water)
To Waste
5 Micron
Pre-filter
Reverse Osmosis
Zeolite Media Filter
Carbon Filter
Storage
To Dispensing
UV Disinfection
Dispensing
Pump
Flow
Totalizer

Community E

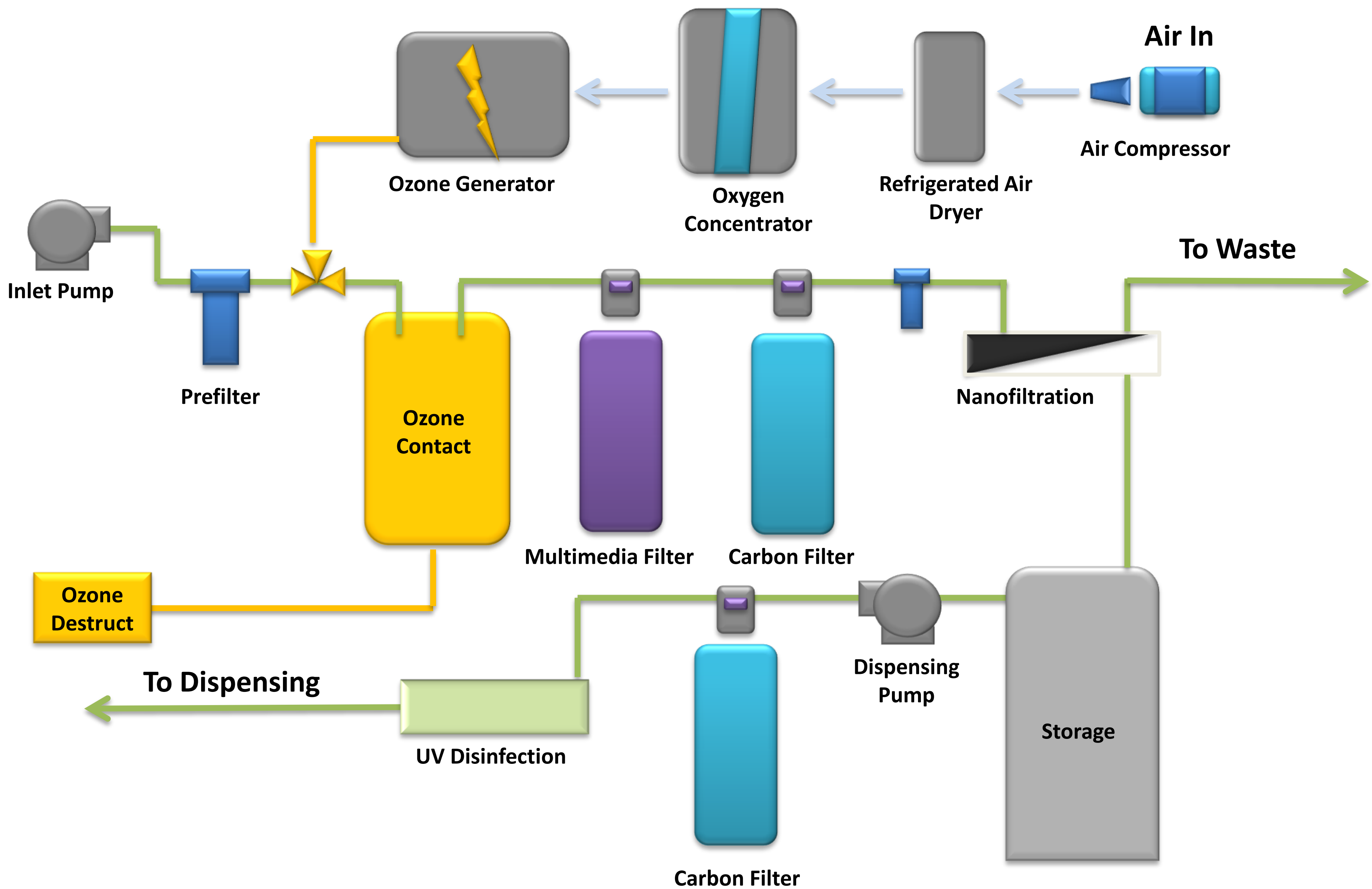

Feed Water
(Pressurized, Treated Water from WTP)
To Waste
5 Micron Pre-filters
Reverse Osmosis
Chlorine Dosing Pump
GAC/Birm/Sand Filter
GAC/Birm/Sand Filter
Storage
Chlorine
To Dispensing
Dispensing Pump

Community F


Ozone Generator
Air In
Air Compressor
Oxygen Concentrator
Refrigerated Air Dryer
Feed Water
(Pressurized Municipal Feed)
Ozone Destruct
Storage
5 Micron Hytrex
Ozone Contact Chamber
ORP
Carbon Filter
To Dispensing Area
1 Micron Hytrex
5 Micron Hytrex
Dispensing Pump
UV Disinfection
Flow Totalizer
Carbon Filter
Community G

APPENDIX B

Proposed Standardized PWDU Treatment System


Air In
Air Compressor
Refrigerated Air
Dryer
Oxygen
Concentrator
Ozone Generator
Inlet Pump
Prefilter
Ozone
Contact
Multimedia Filter
Carbon Filter
To Waste
Nanofiltration
Ozone
Destruct
Dispensing
Pump
Storage
To Dispensing
UV Disinfection
Carbon Filter

APPENDIX C

Water Quality Results

Table C-1 Historic Arsenic Levels in Raw and Tap Water from Participating Communities

Community	Arsenic (ug/L)							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	1.4	2.5	1.0	8	0.8	1.0	0.5	9
B	1.3	5.0	0.3	10	1.1	5.0	0.5	14
C	0.7	1.0	0.5	6	0.8	1.0	0.5	14
D	1.6	5.0	0.5	9	1.1	5.0	0.5	14
E	0.6	1.0	0.5	4	0.8	1.0	0.5	13
F	1.6	5.0	0.3	11	1.2	5.0	0.5	12
G	1.0	5.0	0.1	10	1.1	5.0	0.5	16

Table C-2 Historic Lead Levels in Raw and Tap Water from Participating Communities

Community	Lead (ug/L)							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	0.5	2.0	0.3	8	0.3	0.5	0.3	9
B	0.8	3.0	0.3	16	2.9	6.0	0.5	18
C	0.7	2.5	0.3	13	2.2	7.8	0.5	18
D	0.6	2.0	0.3	21	6.9	**27.0**	0.5	19
E	0.5	1.0	0.3	6	1.0	4.0	0.3	17
F	1.6	8.0	0.5	27	0.5	2.0	0.3	16
G	0.6	1.0	0.3	20	4.7	**12.0**	0.5	18

Disinfection By-Products

Table C-3 Historic Total Trihalomethane Levels in Tap and PWDU Water from Participating Communities

Community	Total Trihalomethanes (ug/L)							
	Tap				PWDU			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	**135**	**460**	6	12	1	1	0	2
B	48	**103**	2	23	0	0	0	1
C	32	61	0	21	5	5	4	2
D	76	**383**	0	16	n/a	n/a	n/a	n/a
E	**179**	**300**	64	21	14	21	7	2
F	**164**	**326**	94	16	29	36	21	2
G	48	**170**	10	26	37	54	19	2

Table C-4 Historic total Haloacetic Acid Levels in Tap and PWDU Water from Participating Communities

Community	Total Haloacetic Acids (ug/L)							
	Tap				PWDU			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	**256**	**726**	0	8	0	0	0	2
B	**128**	**189**	46	9	0	0	0	1
C	**89**	**242**	0	6	0	0	0	2
D	**154**	**1118**	0	9	n/a	n/a	n/a	n/a
E	**152**	**242**	68	10	0	0	0	2
F	**82**	**185**	12	8	0	0	0	2
G	**205**	**440**	63	8	16	31	0	2

Aesthetic Parameters

Table C-5 Historic Colour Levels in Raw and Tap Water from Participating Communities

Community	Colour (TCU)							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	**95**	**171**	**35**	8	**29**	**53**	2	9
B	**42**	**57**	**20**	16	**31**	**45**	**19**	18
C	**63**	**108**	**35**	13	**50**	**105**	6	18
D	**196**	**325**	**112**	22	**146**	**345**	**53**	16
E	**47**	**54**	**39**	6	**34**	**51**	**24**	17
F	**167**	**355**	**50**	26	5	15	0	15
G	**38**	**141**	5	20	**24**	**92**	4	18

Table C-6 Historic Iron Levels in Raw and Tap Water from Participating Communities

Community	Iron (ug/L)							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	621	1500	250	8	564	1210	10	9
B	161	290	20	16	171	340	5	18
C	150	240	60	13	160	350	80	18
D	390	600	190	22	455	620	270	16
E	148	220	5	6	212	340	5	17
F	311	500	170	27	183	400	10	16
G	250	955	26	20	263	730	5	18

Table C-7 Historic Manganese Levels in Raw and Tap Water from Participating Communities

Community	Manganese (ug/L)							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	8	20	1	8	14	60	1	9
B	32	**87**	5	16	**147**	**2410**	1	18
C	19	41	5	13	20	37	5	18
D	11	20	3	22	15	58	5	16
E	16	30	5	6	17	60	1	17
F	16	30	3	27	12	20	1	16
G	25	80	2	20	23	40	5	18

Table C-8 Historic pH Levels in Raw and Tap Water from Participating Communities

Community	pH							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	**5.9**	**6.1**	**5.3**	8	**6.4**	8.5	**5.6**	9
B	6.5	7.1	**6.0**	16	**5.7**	6.6	**4.9**	18
C	**5.0**	**5.6**	**4.6**	13	**4.7**	**6.4**	**3.9**	18
D	**4.7**	**5.1**	**4.3**	22	**4.2**	**4.9**	**3.3**	16
E	**6.4**	6.6	**6.3**	6	6.5	6.9	**6.0**	17
F	**5.5**	7.5	**4.8**	26	6.7	7.3	**6.0**	15
G	**6.1**	6.6	**4.5**	20	**4.6**	**5.3**	**4.2**	18

Table C-9 Historic TDS Levels in Raw and Tap Water from Participating Communities

Community	TDS (mg/L)							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	49	62	26	8	69	97	29	8
B	16	45	7	14	14	18	8	18
C	26	32	14	13	30	47	15	18
D	37	80	17	22	55	142	16	16
E	17	22	14	6	27	35	17	17
F	361	**1040**	87	24	200	245	149	15
G	24	44	13	16	30	42	14	18

Table C-10 Historic Turbidity Levels in Raw and Tap Water from Participating Communities

Community	Turbidity (NTU)							
	Raw Water				Tap			
	Average	Max.	Min.	#	Average	Max.	Min.	#
A	19.3	73.9	3.0	8	2.3	7.5	0.2	9
B	0.9	5.2	0.1	16	0.7	2.1	0.1	18
C	1.3	9.6	0.1	13	1.0	9.5	0.0	18
D	0.6	2.4	0.2	22	0.6	1.0	0.3	16
E	1.2	2.4	0.5	6	0.8	2.2	0.3	17
F	1.7	5.7	0.2	26	0.8	1.6	0.3	15
G	0.7	1.6	0.2	20	0.6	1.3	0.2	18

Table C – 11 PWDU Feed Water Quality Results April 2009 to March 2010 (Average)

	Units	Average						
		A	B	C	D	E	F	G
Calculated TDS	mg/L	51	13	15	22	18	161	20
Hardness	mg/L	14	7	4	6	7	56	6
Total Alkalinity	mg/L	5	7	3	3	7	5	3
Bromide (Br-)	mg/L	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Dissolved Chloride (Cl)	mg/L	26.2	2.0	7.8	9.6	3.7	52.7	9.2
Colour	TCU	102	47	76	191	58	3	23
Dissolved Fluoride (F-)	mg/L	0.05	0.10	0.05	0.05	0.05	0.05	0.09
Nitrate	mg/L	0.00	0.05	0.00	0.05	0.09	0.08	0.07
Nitrite	mg/L	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Nitrate + Nitrite	mg/L	0.04	0.04	0.08	0.04	0.06	0.06	0.06
Nitrogen	mg/L	0.15	0.05	0.03	0.08	0.03	0.03	0.05
DOC (C)	mg/L	6.2	5.3	6.2	14.1	6.9	1.9	3.3
TOC (C)	mg/L	3.8	5.9	6.6	16.0	7.0	2.0	3.8
pH	pH	6.2	6.5	5.1	4.9	6.6	6.2	5.8
Total Phosphorus	mg/L	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Total Suspended Solids	mg/L	1.2	1.0	1.2	0.5	1.1	7.6	0.9
Dissolved Sulphate (SO4)	mg/L	1.6	1.0	1.0	1.2	1.0	48.3	1.0
Total Kjeldahl Nitrogen	mg/L	2.1	0.3	0.3	0.4	0.2	0.1	0.2
Turbidity	NTU	20.5	0.7	0.7	0.5	0.8	0.3	0.6
Conductivity	uS/cm	110	22	43	51	29	294	45
Total Mercury (Hg)	ug/L	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Total Calcium (Ca)	mg/L	2.0	2.0	0.7	0.9	1.8	14.9	1.4
Total Magnesium (Mg)	mg/L	2.0	0.3	0.6	0.8	0.6	3.5	0.5
Total Potassium (K)	mg/L	0.8	0.1	0.3	0.3	0.2	1.2	0.2
Total Sodium (Na)	mg/L	14	1	4	5	3	32	5
Total Aluminum (Al)	ug/L	72	100	184	488	112	89	72
Total Arsenic (As)	ug/L	1	1	1	1	1	1	1
Total Barium (Ba)	ug/L	8	6	3	3	6	3	10
Total Boron (B)	ug/L	7	3	3	3	3	26	4
Total Cadmium (Cd)	ug/L	0	0	0	0	0	0	0
Total Chromium (Cr)	ug/L	1.2	1.0	1.0	1.0	1.0	1.0	1.1
Total Copper (Cu)	ug/L	31	65	525	48	159	1	1587
Total Iron (Fe)	ug/L	741	191	161	398	239	121	191
Total Lead (Pb)	ug/L	2	1	4	12	6	0	5
Total Manganese (Mn)	ug/L	47	16	20	13	15	14	17
Total Nickel (Ni)	ug/L	2	1	1	45	1	1	1
Total Selenium (Se)	ug/L	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Uranium (U)	ug/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Zinc (Zn)	ug/L	57	24	75	51	31	12	57
Total Trihalomethanes (THMs)	ug/L	148	97	30	n/a	34	163	60
Total Haloacetic Acids (HAAs)	ug/L	235	147	68	n/a	33	64	140

Table C- 12 PWDU Feed Water Quality Results April 2009 to March 2010 (Maximum)

	Units	Maximum						
		A	B	C	D	E	F	G
Calculated TDS	mg/L	68	21	19	25	22	173	26
Hardness	mg/L	20	8	6	7	9	58	7
Total Alkalinity	mg/L	14	18	3	3	9	12	6
Bromide (Br-)	mg/L	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Dissolved Chloride (Cl)	mg/L	34.0	3.0	10.0	11.0	6.0	61.0	11.0
Colour	TCU	240	56	110	290	73	3	89
Dissolved Fluoride (F-)	mg/L	0.05	0.50	0.05	0.05	0.05	0.05	0.20
Nitrate	mg/L	0.00	0.06	0.00	0.06	0.16	0.11	0.11
Nitrite	mg/L	0.00	0.01	0.00	0.01	0.01	0.01	0.01
Nitrate + Nitrite	mg/L	0.06	0.12	0.12	0.06	0.09	0.11	0.11
Nitrogen	mg/L	0.29	0.18	0.08	0.23	0.05	0.07	0.16
DOC (C)	mg/L	9.4	8.0	9.8	19.0	8.8	2.5	10.0
TOC (C)	mg/L	4.1	9.0	9.2	17.0	8.0	2.4	11.0
pH	pH	6.4	6.9	6.0	5.3	6.9	6.7	6.5
Total Phosphorus	mg/L	0.2	0.0	0.0	0.0	0.0	0.5	0.0
Total Suspended Solids	mg/L	2.0	2.0	3.0	0.5	2.0	49.0	3.0
Dissolved Sulphate (SO4)	mg/L	4.0	1.0	1.0	2.0	1.0	52.0	1.0
Total Kjeldahl Nitrogen	mg/L	8.6	0.5	0.4	0.5	0.4	0.3	0.4
Turbidity	NTU	97.0	1.1	1.3	0.6	1.5	0.5	1.4
Conductivity	uS/cm	140	39	62	64	37	310	52
Total Mercury (Hg)	ug/L	0.05	0.02	0.02	0.03	0.02	0.02	0.02
Total Calcium (Ca)	mg/L	3.3	2.6	0.8	1.1	2.0	18.0	1.7
Total Magnesium (Mg)	mg/L	2.8	0.4	0.8	1.0	0.9	4.0	0.7
Total Potassium (K)	mg/L	1.0	0.2	0.3	0.5	0.3	1.5	0.3
Total Sodium (Na)	mg/L	17	2	6	7	5	39	5
Total Aluminum (Al)	ug/L	190	140	230	610	170	160	200
Total Arsenic (As)	ug/L	1.00	1.00	1.00	1	1.00	1.00	1.00
Total Barium (Ba)	ug/L	24	10	3	3	8	3	13
Total Boron (B)	ug/L	10	3	10	3	7	43	10
Total Cadmium (Cd)	ug/L	0	0	0	0	0	0	0
Total Chromium (Cr)	ug/L	2.0	1.0	1.0	1.0	1.0	1.0	2.0
Total Copper (Cu)	ug/L	130	330	2800	99	460	1	3000
Total Iron (Fe)	ug/L	2500	270	200	560	410	420	540
Total Lead (Pb)	ug/L	5	4	8	26	19	1	12
Total Manganese (Mn)	ug/L	150	28	23	16	43	27	36
Total Nickel (Ni)	ug/L	4	1	1	110	1	4	1
Total Selenium (Se)	ug/L	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Uranium (U)	ug/L	0.5	0.1	0.1	0.1	0.1	0.1	0.2
Total Zinc (Zn)	ug/L	130	56	130	87	96	18	150
Total Trihalomethanes (THMs)	ug/L	220	140	75	n/a	100	230	100
Total Haloacetic Acids (HAAs)	ug/L	360	160	190	n/a	95	73	230

Table C- 13 PWDU Treated Water Quality Results April 2009 to March 2010 (Average)

	Units	Average						
		A	B	C	D	E	F	G
Calculated TDS	mg/L	0.75	12.09	0.83	25.8	0.54	6.00	23.18
Hardness	mg/L	1	7	1	7	1	1	6
Total Alkalinity	mg/L	3	6	3	10	3	3	3
Bromide (Br-)	mg/L	0.3	0.2	0.2	0.3	0.3	0.3	0.3
Dissolved Chloride (Cl)	mg/L	0.5	1.2	0.6	7.6	0.5	2.8	9.3
Colour	TCU	2.5	**14.0**	2.5	2.5	2.5	3.0	2.5
Dissolved Fluoride (F-)	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Nitrate	mg/L	0.00	0.06	0.00	0.20	0.00	0.03	1.04
Nitrite	mg/L	0.00	0.01	0.00	0.01	0.00	0.01	0.01
Nitrate + Nitrite	mg/L	0.03	0.06	0.03	0.13	0.03	0.03	0.73
Nitrogen	mg/L	0.10	0.06	0.03	0.09	0.03	0.03	0.06
DOC (C)	mg/L	0.4	**3.6**	0.3	0.7	0.5	0.3	0.3
TOC (C)	mg/L	0.8	**3.8**	0.6		0.6	0.2	0.3
pH	pH	**6.0**	6.4	**5.3**	6.4	**5.9**	**6.2**	**5.0**
Total Phosphorus	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Suspended Solids	mg/L	1	1	1		1	1	1
Dissolved Sulphate (SO4)	mg/L	1.00	0.91	1.00	1.00	1.00	1.00	1.73
Total Kjeldahl Nitrogen	mg/L	0.16	0.32	0.09	0.15	0.06	0.06	0.18
Turbidity	NTU	0.1	0.5	0.3	0.3	0.5	0.2	0.4
Conductivity	uS/cm	3	20	7	46	3	14	51
Total Mercury (Hg)	ug/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Calcium (Ca)	mg/L	0.1	2.1	0.1	1.4	0.1	0.2	1.4
Total Magnesium (Mg)	mg/L	0.1	0.4	0.1	0.8	0.1	0.1	0.5
Total Potassium (K)	mg/L	0.1	0.2	0.1	0.3	0.1	0.1	0.2
Total Sodium (Na)	mg/L	0.5	1.3	0.2	5.9	0.2	2.5	4.5
Total Aluminum (Al)	ug/L	5	86	18	187	5	5	146
Total Arsenic (As)	ug/L	1	1	1	1	1	1	1
Total Barium (Ba)	ug/L	3	7	3	24	3	3	14
Total Boron (B)	ug/L	3	3	3	12	3	13	6
Total Cadmium (Cd)	ug/L	0	0	0	0	0	0	0
Total Chromium (Cr)	ug/L	1	1	1	1	1	1	1
Total Copper (Cu)	ug/L	10	22	24	1	113	1	167
Total Iron (Fe)	ug/L	25	130	31	44	25	25	61
Total Lead (Pb)	ug/L	1	1	2	1	7	0	3
Total Manganese (Mn)	ug/L	1	4	1	13	1	1	20
Total Nickel (Ni)	ug/L	1	1	1	9	1	1	3
Total Selenium (Se)	ug/L	1	1	1	1	1	1	1
Total Uranium (U)	ug/L	0	0	0	0	0	0	0
Total Zinc (Zn)	ug/L	9	24	56	9	79	6	23
Total Trihalomethanes (THMs)	ug/L	11	1	2	0	16	6	11
Total Haloacetic Acids (HAAs)	ug/L	3	3	3	0	3	3	3

Table C – 14 PWDU Treated Water Quality Results April 2009 to March 2010 (Maximum)

	Units	Maximum						
		A	B	C	D	E	F	G
Calculated TDS	mg/L	1.00	16	2.00	35	1.00	9.00	29.00
Hardness	mg/L	1	8	1	12	1	1	9
Total Alkalinity	mg/L	3	8	3	24	3	5	3
Bromide (Br-)	mg/L	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Dissolved Chloride (Cl)	mg/L	0.5	2.0	1.0	11.0	0.5	4.0	10.0
Colour	TCU	2.5	**27.0**	2.5	2.5	2.5	**8.0**	2.5
Dissolved Fluoride (F-)	mg/L	0.1	0.5	0.1	0.1	0.1	0.1	0.1
Nitrate	mg/L	0.00	0.09	0.00	0.29	0.00	0.03	1.40
Nitrite	mg/L	0.01	0.01	0.00	0.01	0.00	0.01	0.01
Nitrate + Nitrite	mg/L	0.03	0.10	0.06	0.29	0.03	0.03	1.90
Nitrogen	mg/L	0.26	0.28	0.03	0.16	0.10	0.06	0.21
DOC (C)	mg/L	0.9	**6.6**	0.5	1.9	1.6	0.6	0.3
TOC (C)	mg/L	2.0	**5.3**	1.2	1.9	1.7	0.3	0.3
pH	pH	6.2	6.8	5.8	7.3	6.2	6.6	6.4
Total Phosphorus	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.03
Total Suspended Solids	mg/L	1	1	4	1	1	1	2
Dissolved Sulphate (SO4)	mg/L	1.00	1.00	1.00	1.00	1.00	1.00	6.00
Total Kjeldahl Nitrogen	mg/L	0.70	1.40	0.20	0.20	0.20	0.10	0.30
Turbidity	NTU	0.3	0.9	0.8	0.4	**1.5**	0.3	0.8
Conductivity	uS/cm	4	25	12	59	4	18	67
Total Mercury (Hg)	ug/L	0.01	0.06	0.05	0.01	0.01	0.02	0.01
Total Calcium (Ca)	mg/L	0.1	2.5	0.1	3.0	0.1	0.3	2.5
Total Magnesium (Mg)	mg/L	0.1	0.4	0.1	1.2	0.1	0.1	0.7
Total Potassium (K)	mg/L	0.1	1.0	0.1	0.5	0.1	0.2	0.3
Total Sodium (Na)	mg/L	1.0	1.5	0.5	7.0	0.2	3.3	5.1
Total Aluminum (Al)	ug/L	5	140	130	**530**	5	5	270
Total Arsenic (As)	ug/L	1	1	1	3	1	1	1
Total Barium (Ba)	ug/L	3	11	3	40	3	3	36
Total Boron (B)	ug/L	5	5	3	21	3	24	20
Total Cadmium (Cd)	ug/L	0	0	0	0	0	0	0
Total Chromium (Cr)	ug/L	1	1	1	3	1	1	4
Total Copper (Cu)	ug/L	16	74	55	2	240	3	780
Total Iron (Fe)	ug/L	25	230	76	120	25	25	190
Total Lead (Pb)	ug/L	2	3	3	1	**9**	0	**9**
Total Manganese (Mn)	ug/L	1	16	1	26	1	1	**78**
Total Nickel (Ni)	ug/L	1	5	1	17	3	1	10
Total Selenium (Se)	ug/L	1	1	1	1	1	1	1
Total Uranium (U)	ug/L	0	1	0	0	0	0	0
Total Zinc (Zn)	ug/L	15	60	130	10	210	9	64
Total Trihalomethanes (THMs)	ug/L	12	1	3	0	28	7	18
Total Haloacetic Acids (HAAs)	ug/L	3	3	3	0	3	3	3

APPENDIX D

Surveys

Questions for PWDU Operators – Dispensing Areas

This list of questions is being sent to the operators of all existing PWDUs in Newfoundland and Labrador. Although you may have provided this information to representatives of CBCL and/or the provincial government at an earlier date, this questionnaire has been prepared in order to gather information in a more formal, permanent way that can be traced back to the source. The information gathered during this survey will be used in the design of new PWDU systems for other communities in the province. It may also be used to suggest improvements to current PWDU systems to make them safer and more convenient for operators and users. You, as an operator, are an invaluable source of information thanks to your day to day experience with the system and your contact with PWDU users. Your help in this matter is greatly appreciated.

1. How much do residents pay for the water?

2. How do they pay for it? (Coins, smartcard, municipal taxes…)

3. Where in the town is the PWDU located?
    a. How far is this location from the residences/workplaces of the users?

4. Is there parking for at least two vehicles within 30 m (100 ft) of the PWDU entrance?

5. Is the dispensing area located in a heated building?

6. When is the dispensing area open (hours, days)?
    a. What is the rationale behind these access hours?

7. How is access to the dispensing area controlled?

8. Is the dispensing area accessible for disabled users?

9. Do residents have access to the PWDU treatment area? Is this area locked?

10. Do people use carts to transport collection containers from their cars to the dispensing area?

11. Are written/typed instructions provided in the dispensing area?

12. Are water quality results displayed in the dispensing area?

13. Are emergency numbers posted in the dispensing area?

14. Is the system constantly pressurized or do users have to pressurize the system before they can dispense water from the system?

15. Are there any sanitation related concerns?

16. Taps:
    a. How many are there?
    b. What are they made of?
    c. Is there a sink or drain to collect spills/splashes?
    d. Can users fit a variety of collection containers under the tap?
    e. Can users connect a hose to the tap?
    f. Do the taps have any sort of backflow prevention?

17. Have you had any operational problems associated with the dispensing areas?

18. What do you think is working well in the current dispensing area?

19. What do you think could be improved in the current dispensing area?

20. Do you have any other comments to share?

PWDU Operator Survey 2010

1. Do you currently hold any form of operator certification from the provincial government?

- ◯ Yes
- ◯ No

2. If yes, to what level have you been certified?

____

* 3. Have you participated in any of the following operator training courses provided by the Department of Environment and Conservation or the Atlantic Canada Water and Wastewater Association?

- ☐ Water Treatment - Level 1
- ☐ Water Treatment - Level 2
- ☐ Wastewater Treatment - Level 1
- ☐ Wastewater Treatment - Level 2
- ☐ Water Distribution - Level 1
- ☐ Water Distribution - Level 2
- ☐ Wastewater Collection - Level 1
- ☐ Wastewater Collection - Level 2
- ☐ Very Small Systems
- ☐ Onsite Training
- ☐ I have not taken any training courses provided by DOEC.
- ☐ Other (please specify)

____

PWDU Operator Survey 2010

4. How often do you perform the following tasks (choose the most accurate answer)?

	Once a Day	Once a Week	Once a Month	Four Times a Year	Twice a Year	Once a Year	Never
Check to make sure the system is operating?	☐	☐	☐	☐	☐	☐	☐
Inspect the treatment equipment?	☐	☐	☐	☐	☐	☐	☐
Test the quality of the treated water?	☐	☐	☐	☐	☐	☐	☐
Backwash the filters?	☐	☐	☐	☐	☐	☐	☐
Clean the storage tank?	☐	☐	☐	☐	☐	☐	☐
Clean the UV lamps?	☐	☐	☐	☐	☐	☐	☐
Flush the treatment equipment?	☐	☐	☐	☐	☐	☐	☐
Disinfect the treatment equipment?	☐	☐	☐	☐	☐	☐	☐
Fully clean and sanitize the dispensing area?	☐	☐	☐	☐	☐	☐	☐

* 5. How much time do you devote to the potable water dispensing unit (PWDU) each week?

- ☐ Less than 1 hour
- ☐ Between 1 and 5 hours
- ☐ Between 5 and 10 hours
- ☐ More than 10 hours

Other (please specify)

[ ]

* 6. Which of the following do you keep a record of?

- [ ] Total daily flow out
- [ ] Total daily flow in
- [ ] Volume used
- [ ] Level reading
- [ ] Turbidity
- [ ] Colour
- [ ] pH
- [ ] Maintenance performed
- [ ] No records are maintained
- [ ] Other (please specify)

* 7. What is your official job title?

* 8. What other community services do you perform or manage outside of your PWDU duties?

- [ ] None
- [ ] Operation of municipal water supply system
- [ ] Operation of municipal wastewater collection/treatment system
- [ ] Garbage collection
- [ ] Snow removal
- [ ] Clerical duties (administration)

Other (please specify)

9. Do you have access to an Operation and Maintenance Manual provided by the equipment manufacturer and/or supplier?

- ( ) Yes
- ( ) No

PWDU Operator Survey 2010

* 10. Does your PWDU have a 'Permit to Operate' from the Department of Environment and Conservation?

- Yes
- No
- Not sure

11. Has the PWDU been shut down at any point in the last 12 months?

- Yes
- No

12. If yes, why was it shut down?

* 13. Would you be willing to operate and maintain a PWDU in a neighbouring community if your transportation costs were covered?

- Yes
- No

Comments

14. Do you have any recommendations for new PWDU operators that you'd like to share?

15. Do you have any other questions or comments about your PWDU, the PWDU study or the planned construction of PWDUs in communities around Newfoundland and Labrador?

PWDU Survey

St. Lawrence Date ____________

1. Do you follow any documented procedures to protect the water quality during the collection, transportation, storage, and use of PWDU water? Yes __ , No ___

2. Do you collect water for users that are unable to collect their own water?
Yes ___, No ___

3. If you collect water for other users, for how many?
____ families, _____ individuals

4. If you collect water for other users, why cannot the user collect water from the PWDU?
Family/individual is physically unable ___
Family/individual does not have transportation ___
Other reason ____

5. What size (s) of water collection containers do you use?
10 L __, 20 L __, 20 L water cooler bottle (dispenser bottle) __, Other __________

6. What type of collection container do you use?
Clear plastic __, Coloured plastic __, Glass __, Barrel__, Bucket __, Other ______

7. Do the containers have a wide or narrow neck?
Wide Neck ____, Narrow Neck ____

8. Where did you get the water collection container?
Bought water, reusing container __, Bought empty container __, Other _______

9. Are the containers capped? Yes __ No __

10. How is collection container cleaned? _________________________________

11. How often is collection container cleaned? ______________________________

12. How much water do you collect at one PWDU visit? ____L, or ____ gallons

13. How is collected water stored in your home?
Refrigerator _____, Household dispensing unit (cooler) ______, floor/shelve _______

14. How long is collected water stored in your home? ____ days

15. Collected water which is consumed in your home is:
Used directly from the container at room temperature___,
Used from a household dispensing unit (cooler) ___,

16. If a household dispensing unit (cooler) is used, is it cleaned? Yes__, No __
If yes, how often is dispenser cleaned? _________________________

17. What is the water used for?
Drinking __, Brushing teeth __, Cooking __, Other (specify) ____________

18. How much water from the PWDU do you use per day? _______ L, or ____ gallons

19. Are you concerned with non-tax payers using the PWDU?
Yes __ No __ No opinion __

20. What is your preference for payment for PWDU water?
    On tax rate (water bill) ___,   Pay per use (coin or card) ______

21. What is your overall opinion of the PWDU?   1 is low, 10 is high

Accessibility	1	2	3	4	5	6	7	8	9	10
Convenience	1	2	3	4	5	6	7	8	9	10
Water Quality	1	2	3	4	5	6	7	8	9	10
Water Quantity	1	2	3	4	5	6	7	8	9	10
Construction Cost	1	2	3	4	5	6	7	8	9	10
Water rate Cost	1	2	3	4	5	6	7	8	9	10

APPENDIX E

Operator Education

Operator Training and Certification Curricula

Unit 1: Operation of Potable Water Dispensing Units

Total Teaching Time ~ 6 hours

Water Supply (30 minutes)
- Hydrologic Cycle
- Surface Water Sources
- Groundwater Sources

Water Quality (1 hour)
- Guidelines for Canadian Drinking Water Quality
  - Health Based Parameters
    - Pathogens
    - Metals
    - Disinfection By-Products
    - Other
  - Aesthetic Parameters
    - Colour
    - Iron
    - Manganese
    - Dissolved Solids
- Water Quality Requirements in Newfoundland and Labrador
  - Existing Regulations
  - Water Quality Index
- Achieving Excellent Water Quality Using PWDUs

Monitoring the Treatment System (30 minutes)
- Flow Meters
- Pressure Gauges
- Turbidity
- Water Quality Testing

PWDU Water Quantity and Quality Log (2 hours)
- Rationale
- Basic Record-Keeping
- Communicating Results

Basic Math Review (2 hours)
- Operations (Addition/Subtraction/Multiplication/Division)
- Fractions, Decimals and Percentages
- Solving for x
- Averages
- Simple Water Treatment Equations (Area, Volume, Flow, Velocity, Per Capita)
- Using Math to Assess System Performance

Unit 2: PWDU Treatment Equipment

Total Teaching Time ~ 5.5 hours

Water Treatment (30 minutes)
- Municipal Water Systems
- Point of Use/Point of Entry Systems
- Potable Water Dispensing Units

Pumps (1 hour)
- How Pumps Work
- Pump Types
- Maintenance
- Safety

Ozonation (1 hour)
- System Components
- Treatment Mechanisms
- Assessing Ozone Performance
- Maintenance
- Troubleshooting
- Safety

Filtration (30 minutes)
- How Filters Work
- Filter Media Types
- Control Valves
- Maintenance
- Safety

Nanofiltration (1 hour)
- Theory
- Maintenance
- Troubleshooting
- Safety

Storage (30 minutes)
- Rationale
- Level Control
- Residence Time
- Cleaning the Storage Tank
- Safety

Disinfection (1 hour)
- Why Disinfect?
- Chlorination and By-products

- UV DisinfectionTheory
- Maintenance
- Troubleshooting
- Safety

Dispensing (30 minutes)

- Importance of the PWDU Dispensing Area
- Dispensing Area Maintenance
- Communicating with PWDU Users
- Safety

Unit 3: Hands-On Technical Training for PWDU Operators

Total Teaching Time ~ 6.5 hours

Sampling Procedures (30 minutes)
- Raw Water Sampling
- Treated Water Sampling
- Tap Water Sampling
- Preventing Contamination
- Preserving Samples
- Filling out Chain of Custody Forms
- Shipping Samples

Handheld Water Quality Testing Equipment (1 hour)
- Turbidity
- Colour
- pH
- Other

Using the Automated PWDU Control System (1 hour)
- Basic Overview of Automated Operation
- Turning Equipment On and Off
- Checking Alarms
- Assessing System Operation
- Troubleshooting

Multimedia Filtration Maintenance (1 hour)
- Control Valves
- Bypassing Filters
- Changing Media

Nanofiltration Maintenance (1 hour)
- Assessing Performance
- Flushing the Membrane
- Replacing Membrane Elements

Pump Maintenance (1 hour)
- Pumping Curves
- Operating Pumps
- Replacing Pumps

UV Unit Maintenance (1 hour)
- Cleaning UV Lamps
- Replacing UV Lamps

APPENDIX F

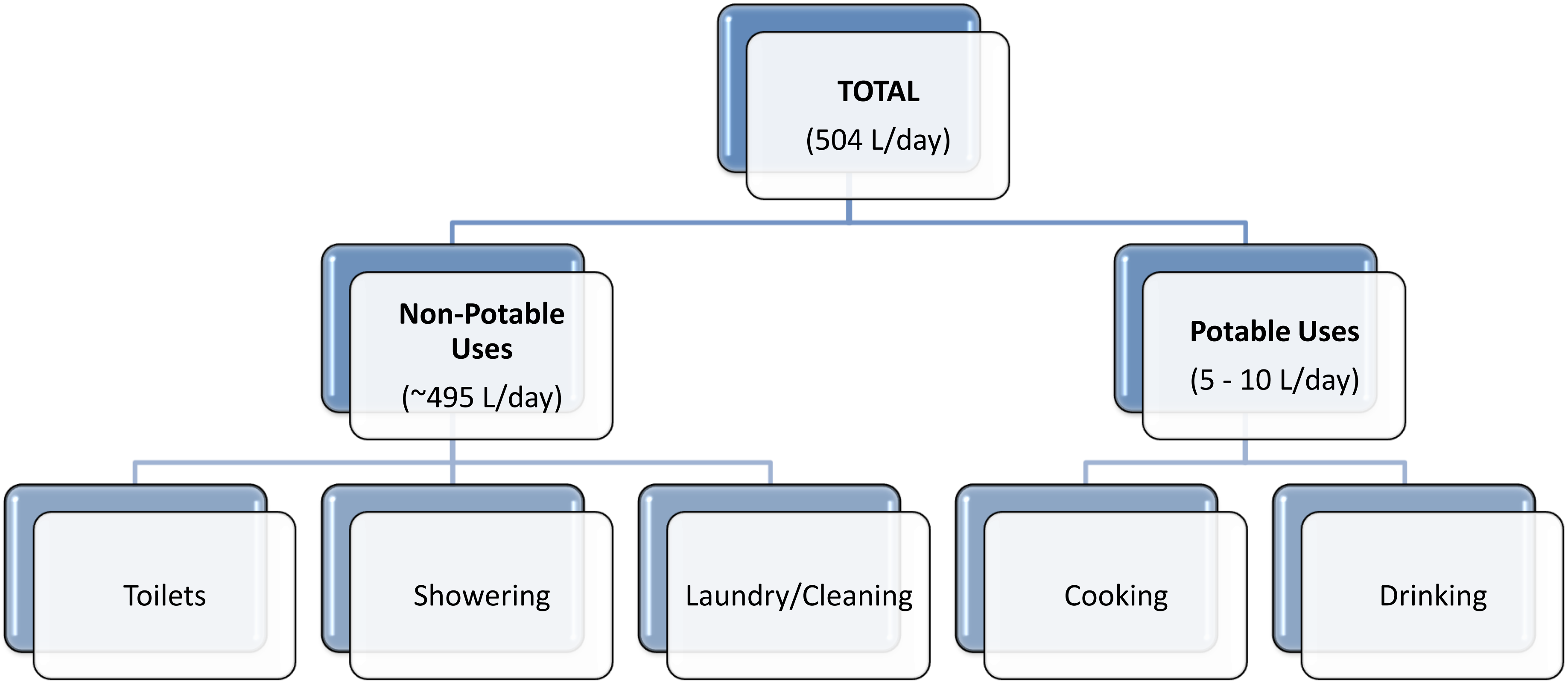
Public Education Package

Potable Water Dispensing Units (Drinking Water Stations)

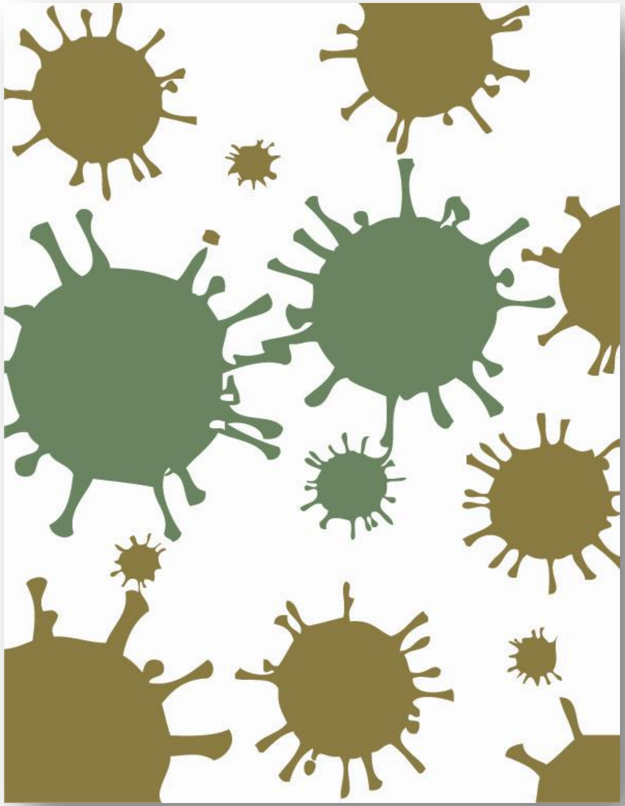
Public Education Module

Developed by CBCL Limited

Water Use in Newfoundland and Labrador



Common Water Contaminants



Pathogens, such as bacteria and viruses, can quickly compromise the safety of your drinking water.

Common Water Contaminants

Other contaminants, such as arsenic, lead, trihalomethanes and haloacetic acids can affect your health over time.

Common Water Contaminants

Some contaminants affect the taste, odour or colour of the water but do not present a health-risk

Examples include:

- Iron
- Manganese
- Dissolved Salts
- Colour

Water Supply, Treatment and Distribution

Water Supply, Treatment and Distribution

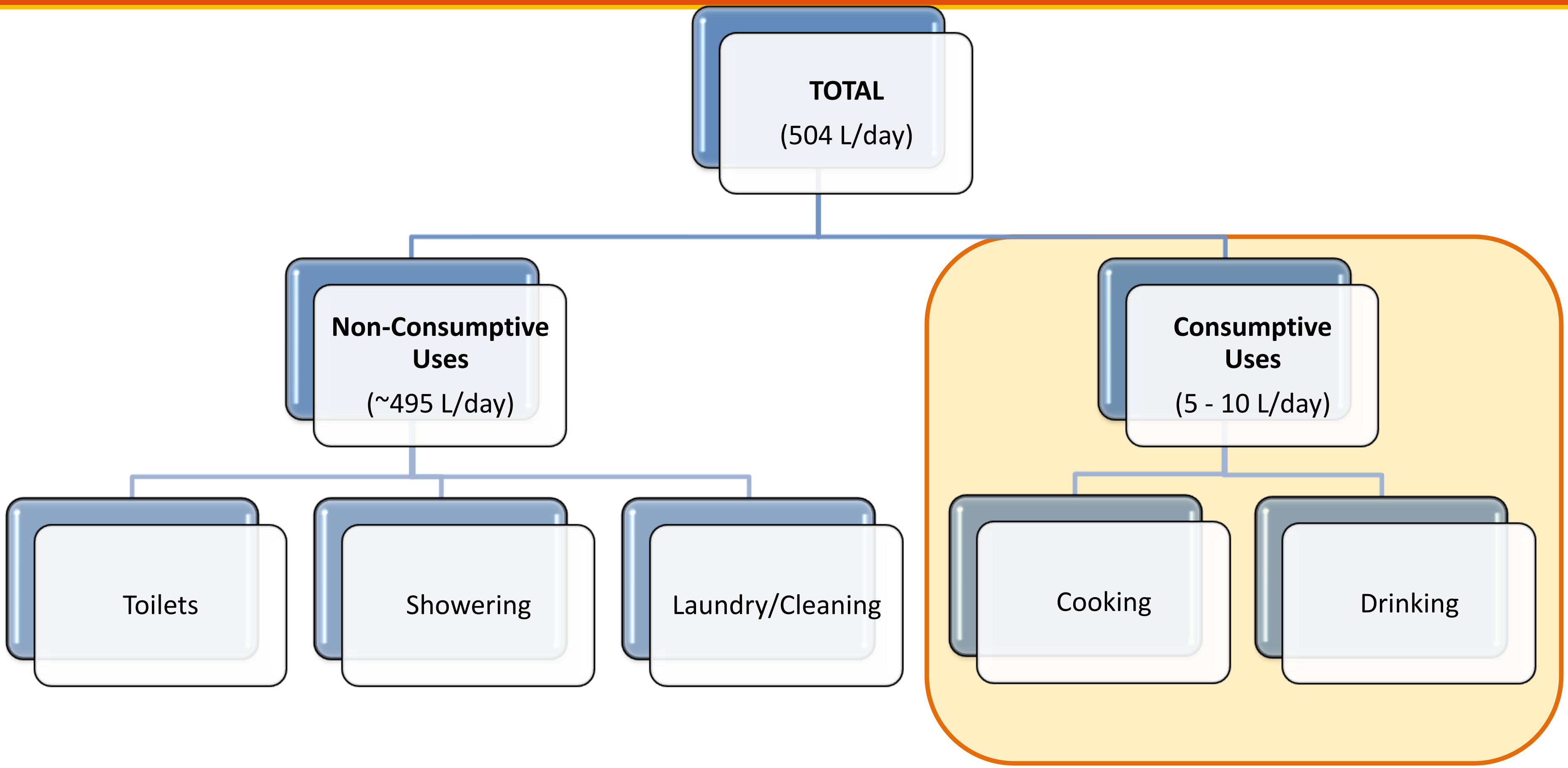
What is a potable water dispensing unit?

A potable water dispensing unit is a small-scale water treatment system located in a convenient, central location that treats enough water to fulfill the consumptive needs of a community.

What is a potable water dispensing unit?

Residents gather water from the potable water dispensing unit using their own water containers.

What is a potable water dispensing unit?



Why use a potable water dispensing unit?

Clean, safe drinking water that is cost effective:

- For the user; and
- For the community

Water from a potable water dispensing unit is safer than spring water and more environmentally-friendly than bottled water.

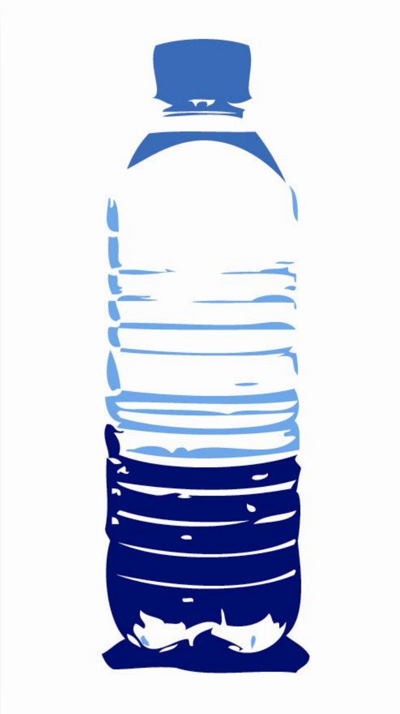
Bottled Water

Environmental Impacts

- Energy is required for the production and eventual disposal of plastic water bottles

Cost Impacts

- Bottled water is significantly more expensive than municipal tap water or PWDU water



Cost Comparison

Source	Cost (1 L of safe drinking water)
Tap Water	$0.0007
Potable Water Dispensing Unit	$0.02
Bottled Water	$3.00

Spring Water

Roadside springs and other untreated sources of water are popular throughout the province

Untreated sources of water are:

- Untested
- Unmonitored
- Unsafe

Frequency of Bacterial Testing

Source	Frequency of Testing
Roadside Spring	Never
Bottled Water	Once every three years
Potable Water Dispensing Unit	Once a month

Who pays for it?

Initial Capital Costs

– Includes equipment, building, construction and installation
– Provincial government pays 90%
– Municipality pays 10%

Ongoing Operating Costs

– Includes power, labour and replacement parts
– Municipality pays 100%

Who runs it?

The government of Newfoundland and Labrador is considering different options to help communities operate and maintain their drinking water stations:

1. **Hands-on Operator Training**
2. **Regional Operation Networks**
3. **Province-wide O&M Coordinators**

Gathering Water

Water collection containers should be cleaned with warm water and bleach or detergent before they are filled with water from the drinking water station.

Storing Water

Water should be stored in a closed, airtight container.

Refrigeration may reduce the chance of contamination.

Contact

Melanie Doyle, Engineer
Municipal Engineering and Planning
Department of Municipal Affairs
Phone: 709-729-0832
Fax: 709-729-7491
Email: melaniedoyle@gov.nl.ca

Robert Picco
Manager, Surface Water Section
Water Resources Management Division
Department of Environment and Conservation
Phone: 709-729-2563
Fax: 709-729-0320
Email: rpicco@gov.nl.ca

PWDU Cheat Sheet – For Presenters

Presentation Script

This document will provide you with a bare bones script, that, along with the PWDU Powerpoint Presentation, will help you present the PWDU concept to communities throughout Newfoundland and Labrador with confidence.

Slide 1: Title Slide

Hi, my name is _____________ and I am here as a representative of the Department of ______________. Today I'd like to talk to you about one of the latest developments of the Drinking Water Safety Initiative, potable water dispensing units.

Slide 2: Water Use in Newfoundland and Labrador

A study conducted by Statistics Canada in 2006 found that the province of Newfoundland and Labrador had a per capita residential water usage of 504 L/person/day. This is the highest per capita usage in Atlantic Canada. Of these 500 L, only about 5 to 10 L are required for 'potable' uses such as drinking, preparing food and brushing teeth. The remaining 490 L of water used by each resident each day are required for 'non-potable' applications such as laundry, showers and toilets.

Slide 3: Common Water Contaminants

Most water treatment systems are designed to remove pathogens, which are dangerous bacteria, viruses or other microorganisms that can quickly affect your health. Pathogens are removed using filtration, chlorine, ozone, ultraviolet radiation or a combination of these.

Slide 4: Common Water Contaminants

Some chemicals in the water do not have obvious health effects if a person is exposed to them for only a short time, but have serious health consequences if exposure occurs over a long period of time. These include low concentrations[1] of lead and arsenic as well as disinfection byproducts such as trihalomethanes (THMs) and haloacetic acids (HAAs).

Slide 5: Common Water Contaminants

Some contaminants, such as iron, manganese, dissolved salts and colour, are not known to affect human health[2] but can affect the look, smell and taste of the water. High concentrations of these 'aesthetic' parameters usually drive people to buy bottled water or gather water from alternative locations.

Slide 6: Water Supply, Treatment and Distribution

In many communities, water from a lake, river or well is filtered and disinfected to remove the contaminants discussed in the previous slides.

Slide 7: Water Supply, Treatment and Distribution

After the water has been treated and/or disinfected, it is sent to residents through a water distribution system. Unfortunately, after a number of years, the pipes in many distribution systems are affected by corrosion and/or deposits and can actually impart colours, tastes or odours to the treated water.

Slide 8: What is a potable water dispensing unit?

A potable water dispensing unit is a small-scale water treatment system located in a convenient, central location that treats enough water to fulfill the consumptive needs of a community.

Slide 9: What is a potable water dispensing unit?

Residents gather water from the potable water dispensing unit using their own water containers.

Slide 10: What is a potable water dispensing unit?

A potable water dispensing unit treats only enough water to provide each resident of the community with enough water for drinking, cooking and brushing teeth.

Slide 11: Why use potable water dispensing units?

Potable water has to be of very high quality so that people don’t get sick from pathogens or other contaminants in the water. It should also be appealing, this means that it should be free of colours, tastes and odours. Potable water dispensing units provide clean, safe drinking water at a price well below that of a full-scale drinking water treatment plant.

Slide 12: Bottled Water

Bottled water is widely used in rural Newfoundland and Labrador as an alternative to using tap water for drinking and cooking. Bottled water is significantly more expensive than tap water or PWDU water and has a larger environmental impact because of the need to manufacture all those plastic bottles.

Slide 13: Cost Comparison

PWDU water is less expensive than bottled water.

Slide 14: Roadside Springs

Roadside springs are also popular throughout the province. Although these springs often provide water that looks safe, they are not monitored, and may contain microorganisms or toxic chemicals such as arsenic that could affect your health.

Slide 15: Frequency of Bacterial Testing

PWDUs are tested for bacteria once a year, unlike bottled water plants, which are tested every three years and roadside springs, which are never tested.

Slide 16: Who pays for it?

New PWDUs will be paid for by individual communities with the help of the Government of Newfoundland. Communities will be expected to pay 10% of the total cost to install a PWDU, which is expected to be approximately $250,000. In contrast, a full-scale water treatment plant for a small rural community may cost upwards of $1.5 millon.

Ongoing PWDU operating costs will be covered by the community.

Slide 17: Who runs it?

The government of Newfoundland and Labrador is considering different options to help communities operate and maintain their drinking water stations:

1. Hands-on Operator Training
2. Regional Operation Networks
3. Province-wide O&M Coordinators

Slide 18: Gathering Water

Water collection containers should be cleaned with warm water and bleach or detergent before they are filled with water from the drinking water station.

Slide 19: Storing Water

Water should be stored in a closed, airtight container. Refrigeration may reduce the chance of contamination.

Slide 20: Contact Information

To learn more, get in touch with Melanie Doyle at the Department of Municipal Affairs or Bob Picco at the Department of Environment and Conservation.

Additional Information

Water Use in Canada and Newfoundland and Labrador

Environment Canada (2010) *Municipal Water and Wastewater Survey: Municipal Water Use 2006 Summary Tables*.

(http://www.ec.gc.ca/Water-apps/MWWS/pdf/MWWS2006_Summary_Tables_updatedJan22.pdf)

Bottled Water in Canada

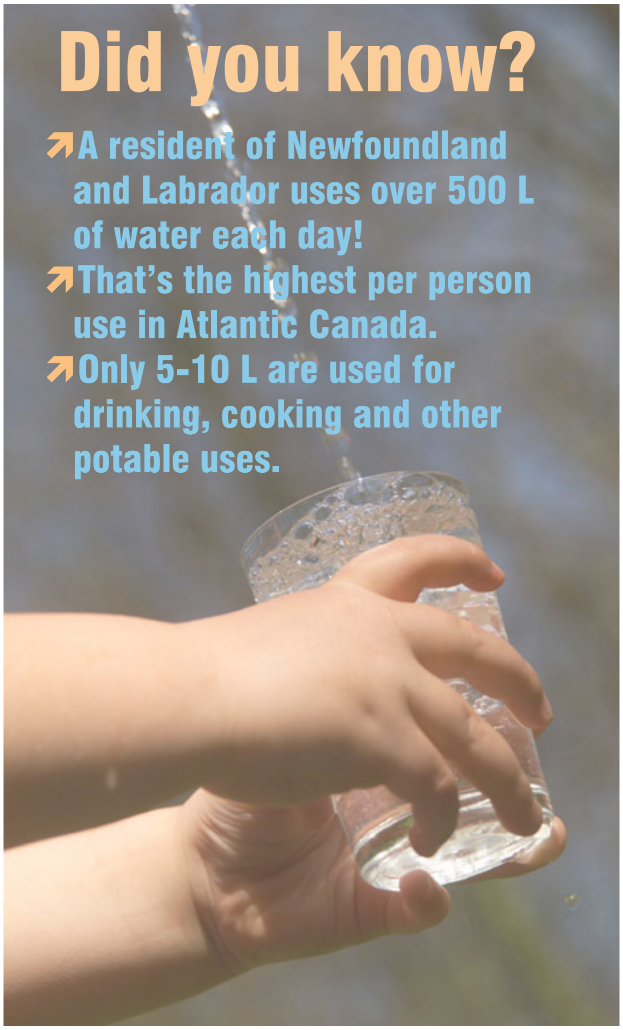
Health Canada (n.d.) *Frequently Asked Questions About Bottled Water.*

(http://www.hc-sc.gc.ca/fn-an/securit/facts-faits/faqs_bottle_water-eau_embouteillee-eng.php)

Guidelines for Canadian Drinking Water Quality

Health Canada (2008) *Guidelines for Canadian Drinking Water Quality – Summary Table* Retrieved from Health Canada's website: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php.

Clean and Safe Drinking Water in Your Community



Did you know?

- A resident of Newfoundland and Labrador uses over 500 L of water each day!
- That's the highest per person use in Atlantic Canada.
- Only 5-10 L are used for drinking, cooking and other potable uses.

Drinking Water Stations

As part of the Drinking Water Safety Initiative the Government of Newfoundland is helping small, rural communities in Newfoundland and Labrador build drinking water stations to supply their residents with clean and safe drinking water.

Drinking water stations (Potable Water Dispensing Units) are advanced water treatment systems that dispense high quality, potable water at a centralized location.

Residents collect water from the drinking water station in their own containers for:

- Drinking
- Cooking
- Brushing Teeth
- Making Ice Cubes

Why build a drinking water station?

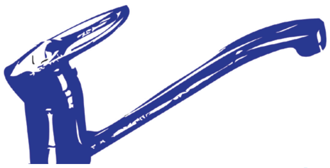
Drinking water stations provide high quality drinking water that is **cost-effective** for the community and for residents.

Approximate Cost of a Water Supply Upgrade for a Community of 500 People

Drinking Water Station	$250,000
Full Scale Drinking Water Treatment Plant	$1,500,000

Clean and Safe Drinking Water in Your Community

Where do you get your water from?



kitchen tap?

- While tap water is usually clean and safe, many small, rural communities have a history of short and long-term boil water advisories.

roadside springs?

- These are unmonitored, untested & potentially unsafe.
- Studies have found that many roadside springs are contaminated with fecal bacteria.

bottled water?

- Bottled water can be expensive.
- Bottled water is not checked for bacteria as often as tap water.

Water from a drinking water station is an affordable, clean and safe alternative option!

Gathering & Storing Drinking Water

Keep your water jugs clean!

When gathering and storing water from a drinking water station

- Always clean your bottles with hot water, soap and/or bleach to minimize the chance of contamination.
- Water should be kept cool and stored in a closed container. Alternatively, water bottles can be mounted onto a refrigerated water cooler.

Where you can learn more:

Government of Newfoundland and Labrador - Department of Environment and Conservation
http://www.env.gov.nl.ca/env/Env/waterres/water_resources.asp
Department of Municipal Affairs
http://www.ma.gov.nl.ca/ma/capital_works/drinkingwater.html
Health Canada - Guidelines for Canadian Drinking Water Quality
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php

Contact:

Melanie Doyle, Engineer
Municipal Engineering and Planning
Department of Municipal Affairs
Phone: 709-729-0832
Fax: 709-729-7491
Email: melaniedoyle@gov.nl.ca

Robert Picco, Manager, Surface Water Section
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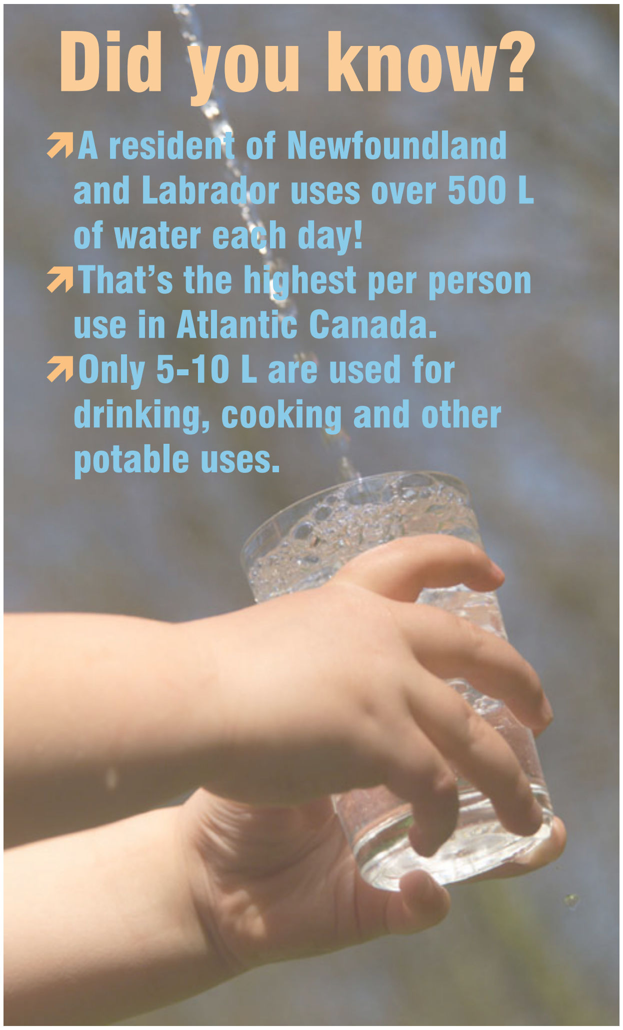

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Residents collect water from the Potable Water Dispensing Unit in their own containers for:

- Drinking
- Cooking
- Brushing Teeth
- Making Ice Cubes

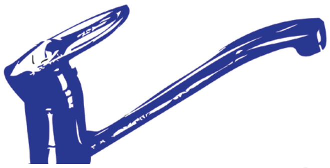
Why build a Potable Water Dispensing Unit?

Potable Water Dispensing Units provide high quality drinking water that is **cost-effective** for the community and for residents.

Approximate Cost of a Water Supply Upgrade for a Community of 500 People	
Potable Water Dispensing Unit	**$250,000**
Full Scale Drinking Water Treatment Plant	$1,500,000

Clean and Safe Drinking Water in Your Community

Where do you get your water from?



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Where you can learn more:

Government of Newfoundland and Labrador - Department of Environment and Conservation
http://www.env.gov.nl.ca/env/Env/waterres/water_resources.asp
Department of Municipal Affairs
http://www.ma.gov.nl.ca/ma/capital_works/drinkingwater.html
Health Canada - Guidelines for Canadian Drinking Water Quality
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php

Contact:

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Water Resources Management Division
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Email: rpicco@gov.nl.ca

Graphic for a Sticker (to be distributed and stuck onto collection containers)

APPENDIX G

Potential PWDU Regional O&M Networks

Protected Public Water Supplies of Newfoundland & Labrador