





Final Preliminary Design Report

Sachs Harbour Truckfill Station

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Sachs Harbour Truckfill Station PMIS # 3421 Contract # 339539

Prepared for:

Department of Public Works & Services Government of the Northwest Territories Inuvik Regional Office 3rd Floor Perry Building Inuvik, NT X0E 0T0

Prepared by:

Earth Tech Canada Inc.
Third Floor, Go Ga Cho Building
4916 – 47 Street
Yellowknife, Northwest Territories, X1A 2N9
(867) 873-6316

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Government of the Northwest Territories Department of Public Works and Services Inuvik Regional Office 3rd Floor, Perry Building Inuvik NT X0E 0T0

Attention:

Mr. John Bulmer, P.Eng.

Dear Sir:

Re:

Sachs Harbour Truckfill Station Final Preliminary Design Report Telephone

867-873-6316

Please find attached, nine (9) copies of the Final Preliminary Design Report for the above mentioned project. A separate copy has been sent directly to Vincent Tam.

Facsimile

867-873-6407 If

We trust this is satisfactory and we look forward to proceeding with the detailed design. If you have any questions please do not hesitate to contact the undersigned at (780) 453-0717.

Very truly yours,

EARTH TECH (CANADA) INC.

Per:

Glenn Prosko, P.Eng. Project Coordinator

Cc:

Vincent Tam, GNWT Robert Boon, Earth Tech Chris Wright, Earth Tech

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Encl.

DEPARTMENT OF PUBLIC WORKS & SERVICES GOVERNMENT OF NORTHWEST TERRITORIES

SACHS HARBOUR TRUCKFILL STATION – FINAL PRELIMINARY DESIGN REPORT

SEPTEMBER 2003

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1.0 INTRODUCTION

1.1 Background and Objectives

Sachs Harbour is located on Banks Island in the Beaufort Sea. This small community has an estimated population of 150 (2000). Sachs Harbour is currently serviced via water and sewage trucks. Access to Sachs Harbour is by scheduled and charter air service from Inuvik. Freight service is by a single annual supply barge departing from Hay River in June.

During August of 2002, the Department of Public Works and Services Government of the Northwest Territories (GNWT) completed a review of Sachs Harbour's water system management and infrastructure. This report included as **Appendix A**, identified several deficiencies related to the existing water supply system and the operation and maintenance practices in place at the time of the report. The major recommendation arising from this report was the need for a new water treatment facility in Sachs Harbour.

In July 2003, the Department of Public Works & Services issued a Call for Proposals (RFP) for the Sachs Harbour Truckfill Station. The intent of the RFP was to upgrade the existing water treatment facilities in Sachs Harbour to comply with current and future water quality requirements and to accommodate future increased water demands as a result of population growth.

As a result of the RFP, Earth Tech Canada was selected to provide engineering services related to the truckfill station. As part of the assignment the following goals need to be achieved at the conclusion of this project:

- Water Quantity The facility must have sufficient production capacity to meet the
 peak daily demands for Sachs Harbour in the year 2025. The combination of
 production, storage and pumping capacity must be capable of meeting both Sachs
 Harbour demands and the fire flow requirements.
- Water Quality The treated water from the water treatment plant must meet the
 current NWT and Canadian regulations. These regulations are contained within
 the Northwest Territories Public Health Act and the Guidelines for Canadian
 Drinking Water Quality. Earth Tech will outline the aforementioned regulations
 and supplement them with current and future water quality objectives across other
 jurisdictions in order to establish the recommended water quality goals for Sachs
 Harbour and this project.
- Operations The facility must be designed with operability at the forefront. This
 will encompass the ability to staff the operations with local resources. Another
 important issue for the operations staff that must be met is the easy access and
 maintainability for each piece of equipment.
- Financial The facility will be designed to accomplish all goals established, with the lowest life cycle costs. The operational and maintenance costs need to be accommodated by Sachs Harbour.

1.2 Report Format

The Design Brief is organized into the following sections:

- Background Provides a description of the existing water treatment facility and pilot testing that has been completed to date.
- Water Quantity Outlines the key parameters that are required to meet the Communities water demands until 2025.
- Water Quality First we will establish the water treatment goals for Sachs Harbour. Second, the raw water quality will be compared to the water treatment goals. Finally, there will be a brief discussion on each parameter not meeting the water quality goals.
- Water Treatment Processes A discussion of various treatment techniques available to address the water quality issues will be outlined.
- Water Treatment Trains Following the discussion of various treatment "tools", viable treatment trains utilizing various tools will be outlined that will be able to meet all treatment goals. An analysis of each viable treatment train will be conducted in order to establish the best treatment train.

Appendix B contains a glossary of terms that will be used throughout this report.

2.0 BACKGROUND

2.1 Existing Water Treatment Facility

In 1978, the GNWT completed the construction of an Intake and Truckfill Facility near Water Lake (also referred to as DOT Lake, MOT Lake and Water Supply Lake) in Sachs Harbour, NT. This water system includes one intake complete with a submersible pump feeding water from Water Lake into the Truckfill Facility. Raw water from Water Lake is chlorinated using a calcium hypochlorite solution that is mixed and stored in the facility. Disinfection using the calcium hypochlorite solution is not automatically controlled based on the raw water flow rate but manually set by the operator. Water that is chlorinated is directed to the truckfill station and distributed to Sachs Harbour via water truck. This facility is not equipped with an emergency generation set.

The existing water intake line is approximately 160 m of 200 mm insulated DR 21 HDPE pipe. Information from the current foreman in Sachs Harbour indicates that the intake screen was removed and cleaned in February 2002. During this time a new discharge pipe and submersible pump were also installed. In February 2002, no significant excavation or earthwork was involved and it is not likely that the intake was replaced or modified. The buoys were tied to the end of the intake just for identification purpose and not for holding the intake screen in place. The existing raw water pump is a Crown S6-150 submersible centrifugal pump equipped with a 3.7 kW Franklin motor (230 V/1 Phase/60 Hz). The community has an identical pump on the shelf as spare. The intake is located at about 7 meters of water with the intake screen approximately 3.5 meters below the surface of Water Lake.

The calcium hypochlorite system consists of a mixing tank (200 L), a solution tank (200 L), agitators (2 – JL Wingert Model P-31 Code 1297 and Model P-11 Code 0296) and a dosing pump (Chempulse Model 45-050K/KIM) rated at 19 L/hour at a maximum pressure of 690 kPa. The frequency and stroke of the dosing pump are both manually set by the operator.

Earth Tech, due to inclement weather and limited time on site, has primarily based information provided in this section on the GNWT review in 2002. Once the process has been selected, these systems and other system components (pipe, valves, switchgear etc.) will be reviewed for their suitability of reuse.

2.2 Pilot Testing

Recognizing the need to upgrade the water treatment system in Sachs Harbour with a simple easy to operate system, the GNWT is currently planning on conducting pilot testing utilizing Water Lake in October 2003. This pilot testing will concentrate on the use of cartridge filtration as a means to provide filtration in Sachs Harbour and other small northern communities with excellent raw water characteristics. In conjunction with providing results on the suitability of cartridge filtration for Sachs Harbour, this pilot testing will be used to seek approval from regulatory authorities for the use of cartridge

filtration for meeting the Canadian Drinking Water Quality Guidelines (CDWQG) including the removal of Giardia and Cryptosporidium.

2.3 Site Requirements

As part of the preliminary design investigation, the requirement for a topographic survey and geotechnical investigation was reviewed as follows:

Topographic Survey

Earth Tech obtained some key site elevations during the initial site trip that will be sufficient for the design phase. A complete topographic survey would be beneficial for the access road design, however, the construction contract will be set-up to accommodate any lack of information. The expense to perform a survey is not recommended at this time.

Geotechnical Investigation

It is expected that the building will be sized to accommodate a small cartridge filtration treatment system and as such, will be a skid mounted structure placed on a gravel pad. A significant foundation will not be required for this type of building thus eliminating the need for a geothechnical investigation. The design will also account for some minor movement in the active layer.

It should be noted that if an alternative process is selected such as conventional or membrane, the building will not be skid mounted and will require a sizable foundation to accommodate the structure (i.e. piles, thermo-siphon system, etc.). In this case, a geotechnical investigation would be required. Refer to the process evaluation section for further information.

3.0 WATER QUANTITY

Earth Tech Canada has reviewed data received from the Bureau of Statistics for the Northwest Territories relating to population.

Population data has been collected from the Bureau of Statistics for Sachs Harbour and is presented below in **Table 1**. This table also presents the predicted average and maximum day demands based on the MACA formulae. The per capita average day demand calculation is based on 90 Lpcd * (1 + 0.00023 * Population). The maximum day is calculated using a maximum day peaking factor applied to the average day demand, which MACA has set at 2.1 for trucked community systems.

Table 1
Bureau of Statistics Population for Sachs Harbour and MACA Demand Projections

	Bureau of	Projected Average	Projected Maximum		
Year	Statistics	Water Usage*	Water Usage*		
	Population	(Litres/day)	(Litres/day)		
1991	132	12241	25705		
1996	140	13006	27312		
1997	153	14255	29935		
1998	161	15027	31556		
1999	150	13966	29328		
2000	153	14255	29935		
2004	161	15027	31556		
2009	169	15801	33183		
2014	179	16773	35224		
2019	185	17358	36453		
2025	192	18043	37890		

^{* -} Based on MACA Guidelines for Trucked Water Systems
Interpolated Values

Table 1 contains the average day and maximum day demand projections for Sachs Harbour without the addition of any process wastes from potential water treatment processes. The amount of process wastes can vary tremendously (10% conventional to 40 % for some membranes) based on the process being used and therefore this will be evaluated in **Section 6**.

Based on the information contained within this section, the following values will be used for the evaluation of water treatment processes and the design of the water treatment plant:

- 2025 Population 192
- 2025 Average Daily Demand –18,043 L/day
- 2025 Peak Day Factor 2.1
- 2025 Peak Day Demand 37,890 L/day

4.0 WATER QUALITY ISSUES

4.1 Water Treatment Goals

Earth Tech Canada has reviewed legislation pertaining to drinking water quality requirements for the Northwest Territories (NWT) as set out in the Public Water Supply Regulations (1990) under the Public Health Act. These NWT requirements follow the Guidelines for Canadian Drinking Water Quality (GCDWQ, 6th Edition). However, given the heightened awareness of water quality regulations due to outbreaks of waterborne disease in the past few years, it is pertinent, when considering the design of any new water treatment facility, that water quality goals be set based on existing and anticipated regulations across North America wherever practical and cost effective.

Unfortunately for purveyors of water, drinking water regulations tend to be a "moving target", and are continually evolving as a greater understanding of the health effects of contaminants in drinking water is developed. Historically, drinking water regulations in Canada have a history of mimicking drinking water regulations developed by the United States Environmental Protection Agency (USEPA). Therefore, before we can establish a reasonable set of water quality objectives for Sachs Harbour to serve into the future, it is prudent not only to summarize the present NWT and Canadian Federal regulations and guidelines, but also the USEPA regulations of relevance to the Community. This summary is contained in **Appendix C**.

Based on the various water quality regulations presented in **Appendix C**, the following table indicates Earth Tech's recommended water quality goals for the upgrade to the Sachs Harbour water treatment plant.

Table 5
Water Quality Goals

Parameter	Current Guidelines	Anticipated NWT/GCDWQ Future Guidelines	Goal for Sachs Harbour
All parameters listed under the current GCDWQ	GCDWQ	GCDWQ	GCDWQ except where superseded within this table
Turbidity ¹	MAC = 1.0 NTU $AO = 5.0 NTU$	Conventional Treatment MAC = 0.3 NTU Membrane Treatment MAC = 0.1 NTU AO = 5.0 NTU	Conventional Treatment MAC = 0.3 NTU Membrane Treatment MAC = 0.1 NTU AO = 5.0 NTU
Trihalomethanes	IMAC = 100 ug/L	LRAA: 80 ugL	LRAA: 80 ugL

Parameter	Current Guidelines	Anticipated NWT/GCDWQ Future Guidelines	Goal for Sachs Harbour
Haloacetic Acid	None	LRAA: 60 ug/L	LRAA: 60 ug/L
Giardia cysts	None	99.9% removal or inactivation (currently under review)	99.9% removal or inactivation
Viruses	None	99.99% removal or inactivation (currently under review)	99.99% removal or inactivation
Cryptosporidium oocysts	None	99.9% removal or inactivation (currently under review)	99.9% removal or inactivation

Notes:

- The GCDWQ specify two discrete limits for turbidity; A MAC of 1 NTU leaving the plant, to
 ensure that disinfection is not compromised by the masking of micro-organisms within particles,
 and an AO of 5 NTU at the point of consumption, to ensure that the cloudiness of the water does
 not reach unpalatable levels to the consumer.
- 2. Refer to Appendix B for Glossary of Terms.

4.2 Raw Water Quality

The second step in identifying appropriate water treatment technologies involves analyzing the raw water source. Unfortunately, the extent of raw water quality monitoring in Sachs Harbour is limited. However, **Table 6** presents a summary of average and maximum raw water quality characteristics from the samples that have been collected. These values are compared to the water treatment goals established in **Table 2** with shaded boxes indicating values in excess of the goals. Individual raw water quality test results are contained within **Appendix D**.

Table 6
Summary of Water Treatment Goals and Average and Maximum Raw Water Quality

	Water Treatment Goal	Average	Maximum
Alkalinity		127.3	132
Arsenic	IMAC = 0.006 mg/L	<0.001	<0.001
Calcium		39.7	46.6
Chloride	AO ≤ 250 mg/L	51.5	66.2
Colour	AO ≤ 15 TCU	5	5
Fluoride	MAC = 1.5 mg/L	0.05	0.06
Iron	AO ≤ 0.3 mg/L	0.081	0.094
Magnesium		27.3	29.8
Mercury	MAC = 0.001 mg/L	<0.0005	<0.00005
Nitrite & Nitrate	MAC = 10 mg/L	<0.008	<0.008
рН	AO = 6.5-8.5	8.23	8.32
Potassium		1.18	1.48
Sodium	AO ≤ 200 mg/L	11.1	13.3
Sulphate	AO ≤ 500 mg/L	25.8	36
Total Dissolved Solids	AO ≤ 500 mg/L	275.3	336
Total Hardness		194.3	234
Total Organic Carbon		2.8	2.8
Turbidity	Conventional Treatment MAC = 0.3 NTU Membrane Treatment MAC = 0.1 NTU		
	AO = 5.0 NTU	2	3.3

Notes:

- 1. The average and maximum raw water quality presented is based on 1 sample collected on August 15, 2002 and 2 samples taken July 25, 2003 (These results are draft and have not yet been finalized.)
- 2. See Appendix E for Summary of Guidelines for Canadian Drinking Water Quality.

Analysis of **Table 6** indicates that only the turbidity parameter exceeds the goals for Sachs Harbour indicating that the source water from Water Lake is very good. It should be noted that there is no raw water sample data for manganese, haloacetic acids, viruses, Giardia, or Cryptosporidium and therefore no comparison to these goals is shown.

Subsequent to the analysis of the raw water quality and the identification of raw water quality parameters not meeting the water quality goals and which impact the water treatment process selection, each of these parameters needs further discussion. The following sections will provide additional information on each of the key parameters identified.

4.3 Turbidity

While raw water from Water Lake is typically of low turbidity (< 5 NTU), Sachs Harbour does draw raw water directly from a surface water source. Turbidity measurements relate to the optical property of water and therefore are generally considered an aesthetic property by many people. However, controlling turbidity is very important for health reasons also. Turbidity can serve as a source of nutrients for waterbourne bacteria, viruses and protozoa, which can be trapped within particulate causing the turbidity. In

addition, effective disinfection can be hampered due to turbidity as microorganisms can "hide" within particulate and not be fully subjected to the disinfection process.

4.4 Disinfection

It is considered that Sachs Harbour faces a low risk for the contamination of the water supply due to Giardia or Cryptosporidium. This statement is made considering the lack of agricultural and industrial activity near Water Lake and the experience of Earth Tech on remote water sources.

Giardia or Cryptosporidium are particularly resistant to traditional disinfectants, and have been implicated in several outbreaks of water borne disease in North America over the last two decades. Concern is particularly high in the drinking water community over Cryptosporidium, which is essentially completely resistant to chlorination.

No sampling for pathogens such as Giardia and Cryptosporidium has yet been performed on the raw water. However, turbidity spikes can potentially provide a pathway for contamination of the supply with Giardia and/or Cryptosporidium if infected wildlife is near the raw water source. Presently, raw water is treated only using chlorination for secondary disinfection, i.e. for the formation of chlorine residual to protect against growth in the water trucks and holding tanks (i.e. distribution system). Contact times between the point of chlorination and the first customer are inadequate to provide effective inactivation of Giardia and viruses. Chlorination is totally ineffective against Cryptosporidium.

5.0 WATER TREATMENT PROCESS OPTIONS

Water treatment requirements depend heavily upon the raw waters characteristics. Facilities that will treat water from Water Lake need to be able to address all of the parameters identified in Section 4.

As a starting point in the formulation of viable treatment trains, it is valuable to consider some of the potential treatment techniques in the treatment "toolbox" which might be viable for Sachs Harbour. **Table 7** lists each of these techniques, and summarizes treatment goals these techniques might be used to address, as well as their typical efficiency in addressing these goals. Each of the techniques identified in the table below are discussed later in this section, however as only one of the treatment techniques identified is capable of meeting all of the water quality goals, others must be combined to create viable treatment trains.

Table 7
Possible Treatment Techniques

Treatment	Treatment Objective								
Technique	Bacteria	Giardia	Cryptosporidium	Viruses	Turbidity Removal				
Cartridge Filtration (0.35 or 1 micron absolute filter size)	*	***	***	*	***				
Pressure Filtration	*	**	**	☆	***				
Clarification- Filtration	女女女	女女女	女女女	女女女	****				
Microfiltration Membranes	***	****	***	汝	***				
Ultrafiltration Membranes	***	***	***	女女女	***				
Chlorination	***	**	*	***					
Ultraviolet(UV) Disinfection	****	****	***	***					

Note:

The treatment processes based on Earth Tech's experience are rated subjectively as follows:

No stars:

No removal

★:

Poor

☆☆:

Mediocre

会会会:

Average

☆☆☆☆:

Good

女女女女女:

Excellent

The following paragraphs present a brief description of each of the various treatment techniques.

5.1 Cartridge Filtration

Typically, cartridge (or bag) filtration has been used to effectively filter Giardia and lower the solids content from surface water down to 1 micron. However, the GNWT is currently pilot testing a 0.35 micron cartridge filter in Colville Lake and a similar system has been installed in Kugluktuk, Nunavut. Water is flushed through a replaceable woven polypropylene bag that is housed inside of a stainless steel vessel. A gasket system maintains the integrity of the system, eliminating possible bypassing or cross-contamination of the water being filtered. These systems work on the same basic principle of MF or UF membranes (See Section 5.7) or size exclusion and therefore are only used under pressure.

In other jurisdictions, 3 micron cartridge filtration has been given a 2.0 to 2.5 log Giardia credit¹. However, using 1 micron absolute pore size (Harmsco filtration) would enable a regulator to grant a Cryptosporidium credit given that Cryptosporidium oocycts are in the size range of 2-4 microns.

The GNWT is also in the process of pilot testing an additional cartridge filtration system in Sachs Harbour and the main objective of the pilot studies (Sachs Harbour and Colville Lake) is to arrive at an agreement with the Department of Health on the effectiveness of this technology for small water systems. Provided that the GNWT can come to an agreement with the Department of Health for a 2 log Cryptosporidium removal credit, this technology would be suitable for Sachs Harbour.

5.2 Pressure Filtration

Filtration is one of the most commonly used water treatment techniques in use today. Pressure filters are used in smaller applications while gravity filtration is commonly used in larger applications. Pressure filters would allow water to be directly pumped from Water Lake into a pressure vessel containing anthracite and sand media. The filter media will remove sediment, turbidity and a level of pathogens. Pathogen removal would be in the order of 2 log removal for both Giardia and Cryptosporidium. Water treated using pressure filters would require an additional 1 log credit for the inactivation of Giardia that could be achieved with chlorination.

Pressure filtration will require storage of the filtered water in order to achieve the required disinfection and to provide water for backwashing of the filters. Backwash water will need to be disposed of in an environmentally acceptable manner.

5.3 Clarification/Filtration

The processes of clarification and filtration are the most common water treatment techniques used across North America. In order for any form of clarification to work properly, it must be preceded by proper pre-treatment namely coagulant addition and flocculation. The pre-treatment results in the formation of particulates known as "flocs" which are slightly denser than water.

Several clarification techniques are considered viable, including horizontal sedimentation, high rate sedimentation with plate or tube settling modules, dissolved air flotation (DAF), and ballasted sedimentation (ActiFlo©). All of the clarification processes identified with the exception of DAF rely on gravity to settle the flocs formed in the pre-treatment step. Horizontal sedimentation consists of a large open rectangular basin where flocs settle slowly. High rate sedimentation provides additional settling modules which increased the rate that the flocs settle by encouraging the flocs to get more dense. ActiFlo© impregnates the flocs with small sand particles which greatly

¹ List of Approved Alternative Filtration Device for Meeting the Requirements of the Surface Water Treatment Rule http://www.state.ak.us/dec/deh/water/filtration.htm

increase the rate of settlement of each floc. DAF employs the use of a cloud of microbubbles, following flocculation, to attach them to the floc, and float them to the surface, where they can be easily removed.

When coagulation, flocculation, sedimentation and filtration are used this treatment scheme is commonly referred to as "Conventional Treatment" such as in Aklavik and Fort MacPherson, NWT. An appropriate sedimentation time for raw water experienced in Sachs Harbour would be on the order of 3-4 hours.

5.4 Chlorination

Chlorination is primarily used within the water treatment industry as a primary disinfectant (i.e. a disinfectant used to kill pathogens). Within Sachs Harbour, chlorination is the only method of treatment presently practiced. Chlorine can take many forms, including gaseous chlorine, sodium hypochlorite, or calcium hypochlorite. For the purposes of further evaluation under this study, chlorination using powdered calcium hypochlorite will be utilized as it is now.

Chlorine is an excellent disinfectant for bacteria, but is less effective against some other common pathogens of concern, including viruses and Giardia. Unfortunately, it is essentially completely ineffective against Cryptosporidium. In addition to its benefits as a primary disinfectant, it is an outstanding secondary disinfectant, able to protect the distribution system from biological re-growth, due to its ability to form a residual and decay reasonably slowly.

5.5 UV Disinfection

UV disinfection has been the focus of intense research in the drinking water industry, due to the finding that Cryptosporidium can be inactivated cost effectively using this technology. Until a few years ago, the use of UV for primary disinfection in drinking water was rare, as systems were designed to kill pathogens, and large UV fluences (or dosages) were required. More recent research led to the breakthrough finding that much lower fluences could be effective, not through killing the pathogens, but by causing an alteration of the DNA structure, precluding the oocyst from reproducing.

UV disinfection utilizes light within the UV spectrum, typically consisting of wavelengths from 230-300 nm with 254 nm being the standard for low-pressure UV lamps. UV systems differ in the types of lamps used and include low-pressure mercury lamps, low-pressure high output mercury lamps and medium pressure lamps. These lamps differ in the amount of power required, wavelength and operating life. Although properties of the lamps differ, the disinfection effectiveness is based on UV fluence (or dose), and is defined as the radiant energy of all wavelengths passing from all directions through a cross sectional area and is expressed in mJ/cm². Research efforts within the last five years are suggesting a UV dose of 40 mJ/cm² will consistently achieve greater than 99.9% reductions for both Giardia and Cryptosporidium.





Figure 1.0: UV Irradiation causes disruption of DNA, eliminating the possibility of reproduction

UV disinfection consists simply of a UV reactor placed within water pipelines. The necessity to provide redundancy generally mandates the placement of multiple UV reactors in parallel. The UV reactors are designed to ensure complete hydraulic mixing is achieved, which ensures that the UV dose is applied uniformly to the water passing through the reactor. UV does not provide for any residual disinfectant and therefore must be followed by chlorination for the distribution system.

5.6 Micro/Ultra Membrane Filtration

Interest in low pressure membrane filtration techniques such as micro- (MF) or ultrafiltration (UF) has grown significantly in recent years, as unit costs have declined rapidly through advances in research & development efforts.

Microfiltration (MF) and Ultrafiltration (UF) membranes work on the same principal of size exclusion to treat raw water. MF membranes have typical pore sizes between 0.1 – 0.2 microns and UF membranes have a typical pore size of 0.01 microns. This difference is important in terms of the amount of virus protection each membrane can deliver. MF membranes are considered to have almost no virus rejection with UF membranes having some. It is important to note that neither MF or UF can eliminate all viruses and additional disinfection (usually chlorination) is always required. Most municipalities are currently opting to purchase UF membranes over MF membranes, as the costs are nearly identical and would like to get more protection for the same cost.

Besides the increasingly attractive cost of membranes, an additional strong attraction to the technology is derived from the fact that it possesses nominal pore sizes smaller than the nominal size of both Giardia and Cryptosporidium cysts (pore sizes in the 1-7 micron range), thereby representing a physical barrier to passage of the pathogens into the treated water, as long as the membranes remain intact.

In other jurisdictions, including Alberta and under the USEPA, UF membranes have been be granted the following log removal credits for pathogens of concern:

UF: 99.99% Giardia, 99.99% Cryptosporidium

As such, UF membranes are capable of meeting Sachs Harbour's removal goal for these pathogens in a single process.

6.0 WATER TREATMENT TRAINS

Armed with an understanding of the capabilities of the various unit processes to deal with Sachs Harbour's water quality issues and the available treatment techniques, it is possible to conceptualize potential treatment trains composed of these processes designed to meet all of the goals identified. **Figures 2** through **4** illustrate schematically process trains considered viable for Sachs Harbour. Each of these treatment process trains is described in more detail the following sections. All options identified will include the provision of chlorination in order to achieve the required distribution residual.

6.1 Clarification-Filtration-UV (Future)-Chlorination (Figure 2)

Any of the clarification-filtration options can be utilized to meet a majority of the water quality goals including iron, manganese and turbidity. The only goals that the clarification-filtration technique cannot meet are the disinfection goals for viruses, Giardia, or Cryptosporidium. Clarification-filtration can achieve 2.5 log reduction of Giardia and 2 log reduction of Cryptosporidium. This option will also require a storage tank as it is not practical to size the treatment scheme for the fire flow of 1,000 L/min. Therefore, an additional 0.5 log reduction for Giardia would be granted for the storage tank.

The level of treatment achieved by clarification-filtration-chlorination would be greater than the current GCDWQ and will be capable of meeting the new turbidity guidelines. Although the goal for Cryptosporidium has been set at 3 log (in line with proposed USEPA guidelines) this treatment scheme is only capable of meeting 2 log. Given that this scheme provides treatment in excess of the current guidelines, UV disinfection will be shown as a future option, to be added if and when the GCDWQ adopt a Cryptosporidium goal.

Another significant disadvantage of this option is that chemical sludges are produced both by the clarification and filtration processes. As these sludges cannot be directly sent to the wastewater system in Sachs Harbour via a sewer connection, there will be on-going costs to store and transport these sludges. Operation of this option would require constant operator attention to ensure that the water chemistry is optimized to provide effective coagulation and filtration. Changes in raw water quality can require significant changes in chemical dosages. Therefore, it may be difficult to contract someone within Sachs Harbour with the training required to operate this type of plant.

6.2 Cartridge Filtration-UV (Future)-Chlorination (Figure 3)

This option would utilize cartridge filters to achieve turbidity removal and pathogen removal. This option would allow the treatment scheme to operate at a flow rate 1,000 L/min enabling the plant to run without storage.

Cartridge filtration can achieve 2.5 log reduction of Giardia and 2 log reduction of Cryptosporidium provided agreement can be achieved with the Health Authority. Similar to the clarification-filtration-chlorination option, cartridge filtration would provide

treatment greater than the current GCDWQ and will be capable of meeting the new turbidity guidelines. Again, although the goal for Cryptosporidium has been set at 3 log (in line with proposed USEPA guidelines) this treatment scheme is only capable of meeting 2 log. Given that this scheme provides treatment in excess of the current guidelines, UV disinfection will be shown as a future option, to be added if and when the GCDWQ adopt a Cryptosporidium goal.

6.3 UF Membrane Filtration-Chlorination (Figure 4)

Utilization of ultrafiltration (UF) membrane filtration under this option could be achieved using membranes that are pressure driven in configuration. The membranes will be capable of removing turbidity and achieving pathogen removal.

As UF membranes do not require any chemical for treatment they only produce a waste stream that is essentially concentrated raw water. This is potentially a huge advantage (needing regulatory confirmation) as the water can be directly sent back to the environment, in this case directly back to Water Lake. However, the amount of wasted water is greater than other treatment technologies. Also, as no chemicals are required and membrane systems are typically very automated, the level of operator attention is minimal. Since NF membranes can be granted a 99.99% removal credit for Giardia, Cryptosporidium, and viruses, no additional disinfection would be required in theory for waters treated using this approach. However, as a chlorine residual is required under the NWT regulations and for the distribution system, chlorination is required as a secondary disinfectant.

6.4 Process Evaluation & Selection

In the preceding sections three viable treatment trains have been presented and discussed. Several advantages and disadvantages of each have been identified and will be critical in the evaluation of the options. Therefore, advantages and disadvantages of each option have been summarized in **Table 8**.

² While in theory, membranes are an absolute barrier to the passage of pathogens, regulators commonly mandate a nominal additional inactivation credit downstream of the membranes, as part of a multi-barrier approach.

Table 8
Water Treatment Train Options – Advantages and Disadvantages

Treatment Train	Advantages	Disadvantages			
Clarification-Filtration- UV (Future)-Chlorination	Proven technology in the NWT (Aklavik and Fort MacPherson are similar except without UV)	 Production of chemical sludges that need to be stored and disposed of by truck Operators must posses knowledge of chemistry in order to deal with changes in raw water quality Future UV disinfection requires a large amount of power Requires water to be stored within the plant 			
Cartridge Filtration-UV (Future)-Chlorination	 Simple to operate Simple to maintain No water storage required Low capital cost 	 Cost of replacement cartridge filters Requires regulatory approval for removal of Giardia and Cryptosporidium Future UV disinfection requires a large amount of power 			
UF Membrane Filtration- Chlorination	 One step treatment train to meet all water quality goals Limited operator intervention, simple operation Wastes can be disposed of directly to the environment 	 Amount of waste generated is greater than other options High capital and maintenance cost 			

It is indicated from the table above that Cartridge Filtration-UV (Future)-Chlorination option is likely the best option for implementation in Sachs Harbour, based on meeting the water quantity, water quality and operational requirements identified in this report. The only requirement that has not been discussed is the financial requirements of the treatment train options.

Table 9 summarizes the financial requirements for each of the treatment trains presented. A breakdown of the order of magnitude costs, including assumptions is presented in **Appendix F**.

Table 9
Summary of Order of Magnitude Costs for Each Treatment Train

Treatment Train	Estimated Capital Cost	Estimated O&M Cost (20 year life cycle)	Total NPV Cost
Clarification-Filtration-UV (Future)-Chlorination	\$1,476,600	\$142,000	\$2,980,000
Cartridge Filtration-UV (Future)-Chlorination	\$1,292,400	\$132,000	\$2,687,000
UF Membrane Filtration- Chlorination)	\$2,009,520	\$142,000	\$3,513,000

A further analysis of the advantages and disadvantages has been performed as illustrated in **Table 10** – Decision Analysis Worksheet. Each treatment train is given a weight and rating for cost, resource availability, maintainability and if pilot tested previously. The rating is then multiplied by the weighting and an overall score is established. Based on this analysis, the Cartridge Filtration-UV (Future)-Chlorination again shows its preference, attaining the highest score.

The summary of scores obtained by each treatment train is as follows:

Treatment Train	Score
Clarification-Filtration-UV (Future)-Chlorination	292
Cartridge Filtration-UV (Future)-Chlorination	340
UF Membrane Filtration-Chlorination	240

Table 10 Decision Analysis Worksheet

		EVALUATE ALTERNATIVES						
		on/Filtration/)/Chlorination		Filtration/UV (Future) Chlorination	UF Membranes-Chlorination			
MUST (Mandatory, Measurable, Realistic)	Information	Go/No Go	Information	Go/No Go	Informati on	Go/No Go		
Meet all of the Water Quality Goals (Table 5)	Yes (Crypto in the Future)	Go	Yes (Crypto in the Future)	Go	Yes	Go		

WANT (Desirable)	Wt	Information	Sc	Weighted Score	Information	Sc	Weighted Score	Information	Sc	Weighted Score
Lowest NPV Cost	8	\$2,980,000	6	48	\$2,687,000	10	80	\$3,513,000	4	32
Local resources can operate plant	10	Yes?	8	80	Yes	10	100	Yes	6	60
Maintainability	8		8	64		10	80		6	48
Pilot Tested	10	Based on Aklavik	10	100	Pilot Testing Planned Oct 2003	8	80	Tulita	10	100
TOTAL WEIGHTED SCORE				292			340			240

6.5 Recommendation

Considering that the Cartridge Filtration-UV (Future)-Chlorination is capable of meeting all of the current water quantity, water quality and operational requirements and is the least expensive, it is the recommended treatment train. Furthermore, the UV system could be added in the future, if and when the GCDWQ adopts a Cryptosporidium goal.

This treatment train is capable of meeting all the objectives outlined by the GNWT and Sachs Harbour and will provide a secure easy-to-operate water treatment plant well into the future.

APPENDIX A PAST REPORTS

REVIEW of COMMUNITY WATER MANAGEMENT and . WATER SYSTEM INFRASTRUCTURE

Sachs Harbour, NT

A Project towards Providing Safer Drinking Water in the NWT Communities

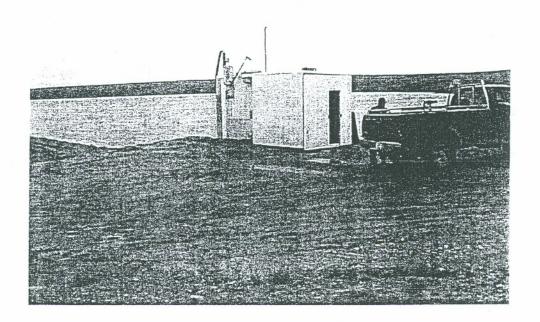
Safe Water



Reviewed by:

Public Works and Services Municipal and Community Affairs Health and Social Services

REVIEW of COMMUNITY WATER MANAGEMENT and WATER SYSTEM INFRASTRUCTURE



Sachs Harbour, NT

Safe Water 4



Prepared by:

Water & Sanitation Asset Management Division Department of Public Works and Services



REVIEW of COMMUNITY WATER MANAGEMENT and WATER SYSTEM INFRASTRUCTURE

Sachs Harbour, NT

Report Complet	ion Dates
Report Phase	Date
Field Work	August 12-16, 2002
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Pi elo	IInspection/Review.Staff	
Technical Staff	Title/Organization	Telephone Number
Kim Philip	Sr. Engineer, PW&S	(867) 920-3489
Vincent Tam	Sr. Engineer, PW&S	(867) 873-7834
Loretta Ransom (Team Leader)	Intern Engineer, PW&S	(867) 873-7713

Questions about this report may be directed to the Field Inspection/Review Staff or to Water & Sanitation at (867) 873-7834 or (867) 920-3489

Water & Sanitation Asset Management Division Department of Public Works and Services Third Floor - Stuart M. Hodgson Building P.O.Box 1320, Yellowknife, NT XIA 2L9 Telephone: (867) 920-8088

Fax: (867) 873-0226

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Much of the information contained in this report is based on discussions with the local staff mentioned above. Apologies are made in advance for any errors, omissions or misinterpretations.

Water & Sanitation Asset Management Division Department of Public Works and Services Third Floor - Stuart M. Hodgson Building P.O.Box 1320, Yellowknife, NT X1A 2L9 Telephone: (867) 920-8088 Fax: (867) 873-0226

DISCLAIMER OF LIABILITY

The information contained in this Review of Community Water Management and Water System Infrastructure ("Review") has been prepared and compiled in accordance with the principles and practices established by the Government of the Northwest Territories (GNWT) Department of Public Works and Services for the evaluation of community water supply systems. It constitutes a technical and operational "snapshot" of the of the water supply system at a specific point in time based in part on a limited inspection of the facility and limited discussions with community and government staff (both federal and territorial). Neither the GNWT, nor any other person, including, without limitation, employees, agents, or independent contractors of the GNWT involved in the Review:

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1. EXECUTIVE SUMMARY

As part of the overall GNWT "Workplan towards Providing Safer Drinking Water in NWT Communities", the Departments of Public Works and Services (PW&S), Municipal and Community Affairs (MACA), and Health and Social Services (H&SS) have commenced joint reviews of community water supply systems. The aim is to ensure the safety and adequacy of all public water supply systems in non-taxed-based communities across the Northwest Territories. The scope of the review includes an assessment of existing infrastructure; roles and responsibilities; system operations, maintenance and management; and water sampling, testing and reporting. The goal is to identify potential problems and provide recommendations to improve the overall efficiency of the system. Technical Support Services, Asset Management Division, Public Works and Services, conducted a review of the Sachs Harbour water supply system infrastructure from August 12-16, 2002.

The truckfill station is a single room Bally freezer building. The truckfill is connected to a single intake containing a submersible pump with a floating intake. When the disinfection system is connected raw water is drawn into the intake via the pump, into the truckfill facility and chlorinated as it is delivered to the water truck. When the chlorination system is not connected or not working raw water is delivered through the truckfill and is batch chlorinated in the water truck. The water truck and truckfill station is the responsibility of the Hamlet. This should include day-to-day operations such as mixing chlorine, testing chlorine residuals, adjusting the rate of chlorine injection, and minor maintenance, general housekeeping, trucked water delivery and maintenance of water truck. The local H&SS Community Health Representative assists with water quality sampling. Since the time of the review, the Regional EHO has requested that water operators take samples rather than CHR.

The community currently has a water licence, expiring June 30, 2009, which allows them to draw their raw water from Water Lake. Total residual chlorine, free residual chlorine, and total and faecal coliform are tested, although not routinely (this is currently under change). Water quality data, covering 1996 to 2002, are well within acceptable limits determined by the *Guidelines for Canadian Drinking Water Quality* (GCDWQ).

The current small system water treatment facility is truck fill only. The original system was installed in 1978. The water treatment system in Sachs Harbour has quite a varied history. Originally the system consisted of a single intake, pumphouse (which is now the current truckfill facility), a circulating water supply line to a water treatment truckfill facility, and an underground water supply line to various buildings (AES (Atmospheric Environmental Station)) within close proximity to the truckfill building. In 1986 the water supply line from the pumphouse to the truckfill froze. The costs to reactivate the line were estimated to be very high. It is also believed that things were further complicated by the fact that the truckfill was located on private property and the owner may have make demands about having access to water from the facility. It is believed that the truckfill was eventually declared surplus. It would have been at this time that the pumphouse was modified and began acting as a much more simplified truckfill station for community water supply. Therefore, the truckfill was no longer connected to any underground water supply lines. The old truckfill facility is still located, abandoned, not far from its original location and remnants of the supply line from the pumphouse to the truckfill are still evident.

In 1989 a passenger plane landing at Sachs Harbour crashed into Water Lake. This obviously created much concern in the community. Many community members felt that their drinking water would now be contaminated from fuels, etc. and some also felt that they did not want to drink the water out of the respect for those who died in the incident. After time and testing the community eventually went back to using Water Lake as its source. During that time it had also been suggested that Picnic Lake, a possible

alternative source, be investigated. Although, it still remains a possible alternative nothing further has come of that possibility. The water quality of Water Lake is very good, therefore, an alternative source is not currently necessary.

To add to the history of the Sachs Harbour water supply system, there are records that a Capital Upgrading Project for the truckfill facility began in the early 1990s (around 1992), which include the installation of a backup generator. This project, however, was never completed. The exact reasons have not been documented.

In 1997 duties for the operation and maintenance of the water treatment facility was turned over to the Hamlet of Sachs Harbour from the Department of Public Works and Services (Inuvik). A few upgrades were completed before the transfer, which included new Calcium Hypochlorate tanks (mixing and solution tank) plus a mixer, and a newly calibrated Hack 2000 for testing free and total residual chlorine. Training was also provided for pulling the intake line and on the intake/heat trace.

In December 2001 pump failure occurred in the truckfill facility intake. A contracting company that was currently completing a separate project in the community was hired to install a new pump. The project was completed but the heat trace line was not taped onto the discharge pipe. The contractor attempted to remove the pump again for heat trace line hook-up, but the pull cable broke resulting in the cables becoming jammed in the intake line. The incident eventually lead to freeze up of the intake pipe. Dowland Contracting Ltd, hired to come in from Inuvik, eventually thawed the intake line by steaming. The discharge pipe, intake screen, pump, and heat trace cable were all replaced. The pump is now fully functional.

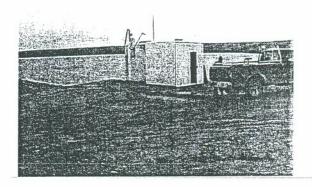
The current facility is old, running past its life expectancy. During the review a number of deficiencies were noted, which will be discussed further in this report. The major recommendation being given is that a new water treatment facility is needed and a planning study should be initiated as soon as possible to evaluate the feasibility of a new facility.

There were a number of O&M issues identified during the review, which are discussed throughout this report. Also, some community representatives expressed concern that there was a lack of general government support for the community.

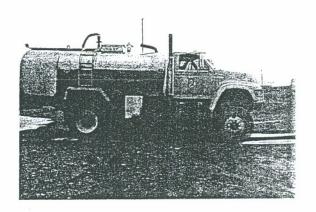
2. WATER SUPPLY SYSTEM

The Sachs Harbour water supply system, consisting of a truckfill and intake system, was completed in 1978. The system draws water from Water Lake (also referred to as DOT Lake, MOT Lake and Water Supply Lake). The floating intake is 115.82 meters of 200 mm HDPE insulated piping extending outward into the lake from the pumphouse. The intake end floats at about 6-7 meters below the surface. A heat trace is located in the intake for freeze protection. A submersible pump is located in the intake line. Water is drawn into the intake, through truckfill facility to the trucfill arm into the water truck for filling. The water truck driver first turns on the chlorine injection pump in the facility and turns on the submersible pump by a switch outside on the truckfill arm. When not using the chlorine injection pump, the water truck is batch chlorinated. The community is using powdered chlorine or liquid chlorine bleach for disinfection (depending on the situation at the time; discussed further in report).

The community has two water delivery trucks, but only one is currently in use. This is an F Series truck with a 1000 imperial gallon tank, purchased in 1997. The other truck, purchased in 1990, is an F700 Ford with a 1000 imperial gallon tank. The truck had the tank removed for servicing during the review.

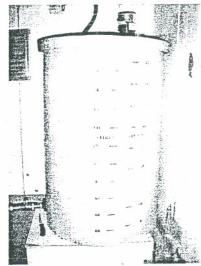


Truckfill Building



Water Delivery Truck





Chlorine Mixing Tank

3. SYSTEM LAYOUT

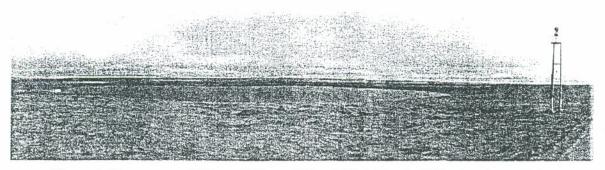


Figure 1. Panorama of Water Lake and Truckfill (white building in picture left).

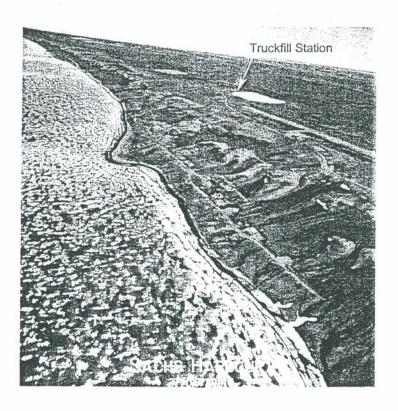


Figure 2. Aerial view of community and truckfill station location.

4. ROLES AND RESPONSIBILITIES

Table 1 lists the community and government departments, boards, agencies and organisations that have responsibilities associated with the Sachs Harbour community water supply system.

Agency or Department	Function
Hamlet of Sachs Harbour	1. Responsible for water delivery and minor maintenance of the water truck (such as cleaning). Water truck drivers do not enter the truckfill station itself, nor do they have any involvement in water treatment or water quality sampling.
÷	 Responsible for day to day operations including chlorine testing, maintaining proper chlorine dosage, water quality sampling and housekeeping.
	3. Responsible for maintenance of the infrastructure including generation of work orders for local staff, purchase of chemicals, PM inspections, and repairs.
Public Works and Services (PW&S)	Region & HQ provided project management and technical support, respectively, for infrastructure design and construction.
	2. Region & HQ continue to provide training and technical support for troubleshooting and optimization.
Municipal and Community Affairs (MACA)	 Holds ownership of the assets (truckfill, intake and water truck). Subsidizes the Community water delivery program through the Water and Sewer Subsidy Program (WSSP).
*	3. Provided program management for water supply system planning and funding for infrastructure construction.
Health and Social Services (H&SS)	1. As the main regulatory agency, H&SS administers the NWT Public Health Act, General Sanitation and Public Water Supply Regulations to ensure safe drinking water and adherence to the Guidelines for Canadian Drinking Water Quality (GCDWQ).
	2. Local Community Health Representative takes monthly bacteriological samples and may assist with other sampling. (Since the time of the review sampling is being done at Hamlet level, rather than CHR).
	3. All test results are sent to the Regional Environmental Health Officer (EHO) for review and action.
	Discussion needed to allow each community to use independent labs for water testing.
NWT Housing Corporation (HC)	1. Responsible for the cleaning of house water tanks in houses owned by the Housing Authority. (Private householders are responsible for cleaning their own tanks).
NWT Water Board (NWTWB), Indian and	 All play a role in environmental management of the watershed. NWTWB is responsible for issuing water licenses.
Northern Affairs Canada (INAC - Federal), Department of Fisheries and Ocean (DFO-Federal),	 INAC Regional staff inspect the water treatment facility annually for compliance with the water license and take raw water quality samples.
Resources Wildlife & Economic Development (RWED)	 DFO is responsible for fish habitat under the Fisheries Act. RWED monitors contaminant spills.

5. WATER SUPPLY SYSTEM COMPONENTS - DESCRIPTION

The Sachs Harbour water supply system consists of a 115 meter single insulated intake with a submersible pump and a truckfill facility with a chlorination system for disinfection. The intake and facility were built in 1978. It is one of the simplest, oldest systems running in the Northwest Territories.

5.1 Raw Water Source

Sachs Harbour is located on Banks Island. The raw water source for the community comes from Water Lake, located just northwest of the community.

5.2 Water Intake

The 116 meter permanent intake to the truckfill station consists of 200 mm insulated HDPE piping. The intake is a floating intake with a weight at the end of the piping, before the intake screen elbow, and a buoy to help keep it afloat. The buoy is red and can be seen in the water on a calm day. The intake end floats at about 6-7 m feet below the surface. The intake pipe has a heat trace cable for pipe freeze protection. There are no temperature controllers for the heat trace, just on/off. The intake screen at the end of the intake, preventing debris from entering the intake pipe, is a 200 mm Johnson Stainless Steel Screen with a 90° elbow at the end. The intake screen, pump, and discharge pipe are new, being installed in March 2002.

5.3 Truckfill Station

The truckfill station itself is a single room Bally freezer, with plywood flooring. In the original water supply system, this building was a pump access building. It was upgraded to a truckfill station when the original truckfill station was dismantled. The building foundation is below ground surface. Within the past year a plywood entrance-way has been built on the front of the building for added protection from the elements for workers. The plywood entrance is insulated with rigid board insulation.

5.3.1. Truckfill Sub-Systems

There is no flow switch, flow sensor or flow meter installed in the truckfill.

There is one pump located in the intake pipe. The new pump installed in early 2002 is a Franklin Electric (Crown), S6-150 2 stage submersible turbine pump c/w 5 HP 4" 230/1/60 submersible motor, motor 01L18-30-2420. The community has a spare pump (the same make) with motor number 01L18-30-0335, in storage near the community garage. Both pumps came with power cables and splice as well as 5 HP 230/1/60 Franklin control boxes. There is no means for backwashing the intake. However, the fire truck can be used for backwashing if necessary.

The truckfill arm is not a typical truckfill arm (though it will be called a truckfill arm for the purposes of this report). The Sachs Harbour truckfill has a hose attached to the end of the pipe bringing water out of the building. The operator must manoeuvre the hose into the water truck fill hole. The truckfill arm is not heat traced or insulated.

5.3.2. Mechanical and Electrical Systems

The electrical system generally consists of the main power supply, pump switch for the submersible truckfill pump and distribution panel. The main breaker is Panel D (600 volts) with on/off switch. It is an Amalgamated Electric power switch, max. amps. 30.

The pump switch is a single phase magnetic starter, Furnas Seris A, Volts 115/230, Max. Amps. 35, 600 VAC, size 1P, contact kit 75EF14, 1 Ph 35. The pump is a Franklin Electric, Model 2821138110, HP 5, Volts 230, HZ 60, PH 1, RPM 3450, Amp 23, S.F 1.15, S.F. max. amp. 27.5, Code F, Continuous Duty, Date 01E19.

The distribution Panel B is 120/240 volts, system 3W SN, Type ANLB, Amps. 225, Panelboard # 169940. The transformer inside of the truckfill building is by Polygon Industries Ltd., Style 6H1-10C-1, Serial 17949-7 Phase 1, Class H, Rated KVA 10, H.V. 600, L.V. 240/120.

Building heat is provided by a baseboard heater approximately 1.5 feet above floor base.

The pumphouse interior lighting is a single bulb. There is an exterior light next to the truckfill side of the building, which is likely photocell controlled.

One eyewash station is installed inside the truckfill.

5.3.3. Alarms

An auto dialer alarm used to be connected to the original truckfill station building, and was probably disconnected when the intake pumphouse was converted into the current truckfill station. There are currently alarms operating in the truckfill building.

5.4 Water Treatment

Water treatment consists of chlorine disinfection alone. The community, up until December 2001, was using powdered calcium hypochlorite. Due to operational problems the powdered calcium hypochlorite system was shut down and the community turned to batch clorination as their source of water disinfection. Batch chlorination was the process being used during the time of the review. After the review, however, the previous chlorination system was hooked back up. This disinfection system consists of a chlorine mixing tank, electric mixer, solution tank, and chlorine injection pump. There was also an electric mixer on the solution tank.

Both the chlorine mixing and solution tanks are 200L (45 imperial gallon) white plastic tanks, marked in 20L intervals (5 imperial gallon) with a white (painted) plywood tops. The mixers (agitators) on both tanks are by JL Wingert. The mixer on the mixing tank is Model, P-31 Code 1297 and mixer of the solution tank is P-11 Coce 0296. The metering pump (chlorine injection pump) is by Chempulse Electronic, Model 45-050K/KIM, Max GPH 5, Volts 115, S/N Au04655, · Max Psi - 100, and Amps 2.3. There is no spare metering pump. Chlorine solution is gravity fed from the mixing tank to the solution tank.

5.5 Water Distribution

Water distribution is accomplished via truck delivery. The community has two water trucks. The oldest truck an F700 Ford with a 1000 imperial gallon tank, purchased in 1990, is currently not in use, the tank has been removed for servicing. The newer truck, an F Series with a 1000 imperial gallon tank, purchased in 1997, is currently being used for water delivery in the community. Water truck delivery in Sachs Harbour is the responsibility of the Hamlet.

5.6 Household Water Tanks

There are about 120-130 people in Sachs Harbour, and about 37 residential houses in the community. About 20 of these homes belong to the Housing Corporation, leaving approximately 15 as private homes. The majority of the home water tanks are 325 imperial gallon upright white plastic tanks. The Co-op and a few homes have low profile tanks under the building in the crawlspace area. Some public buildings may have larger tanks, particularly the school and the Nursing Station. Schools generally require enough water for drinking and operation of the sprinkler fire protection system.

6. WATER SYSTEM REVIEW - INFRASTRUCTURE

6.1 Water Intake and Truckfill Station

- In March of 2002 the discharge pipe, intake screen and water pump were replaced after a pump break down episode as well as a building freeze up episode. The repair work ended up costing approximately \$90,000 for a water treatment facility that is over 20 years old. This was however, the only option at the time for getting the water treatment plant back on line. Although this facility is old and there are a number of items that are below standard there is no immediate public health risk. However, recommend a planning study and conceptual design project be initiated for the next 20 year life cycle.
- The access road to the truckfill is in reasonably good shape. The water truck, however, must back into position at the facility for filling, increasing the risk of hitting the building or backing into the lake. It would be more convenient to have a turnaround that allows the water truck to drive in and drive out when filling is complete. The current condition is likely due to the fact that the building was originally just a pumphouse, not a truckfill station. Recommend a proper turnaround be built for the new truckfill.
- The truckfill building is generally tidy. But it was poorly lit, cramped and the work station was not large enough to allow for proper testing or to wash the chlorine testing equipment. There was also no storage space for chemicals and supplies. The building is also poorly ventilated Recommend establishing a designated area for storage and testing, such as the Hamlet Garage.
- The truckfill building has been damaged in a number of places, as there are no bollards protecting the building from being hit. Also, the building is below ground surface and down gradient and floods up to a foot or more every spring. Recommend installing bollards in the new facility (when built in the future) and immediately redirecting drainage around building using berms or ditching.
- There is no fencing around the facility and there is no sign on the building labelling it as the water treatment facility. Recommend attaching a sign to the new building written in English and the local language.

6.1.1. Truckfill Sub-systems

- A new pump was installed in March 2002. Everything was connected properly but the pull cable was not attached for future removal of the pump. In order to remove the pump in the future the crew will have to pull on the discharge pipe (the pump screws into the discharge pipe). This may damage the discharge pipe, which would then have to be replaced again. Recommend the pull cable be attached when the pump is next removed.
- There is a new spare pump (same make as the current pump in use), with a power cord attached, in storage near the Hamlet maintenance garage.
- Some of the major sub-system problems are the lack of alarms, controls and backup power supplies to prevent freezing or alert operators to freezing conditions. Recommend these problems be addressed when a new project is undertaken. Details of some of the major concerns are listed below:
 - There are no thermistors (temperature sensors) on the intake line to regulate the intake heat trace cable or activate a low temperature alarm if the intake freezes. This means the intake heat trace is on all the time, which increases power costs.

- There is no back up building heat and no low or high building temperature alarms, nor any fire or smoke alarms.
- There is no back-up power supply nor any battery back-up to take over in the event of
 power failure. There were two power outages last year, which is not too frequent but
 is enough to be of concern.
- The building foundation is below grade and floods every spring, up to 1.5 feet deep. This can become a hazard if the water level comes in contact with an electrical unit. For example, the baseboard heater is less than 2 feet above the floor of the building. Recommend moving the baseboard heater up at least half a foot, if possible.
- Flow rate for the truckfill is below the standard 1000 L/min of flow required for fire protection purposes.
- There is no flow meter or flow totalizer on the truckfill process piping. Having a flow meter allows the operator to do regular checks on flow rate to confirm the intake screen has not become partially blocked or frozen. The flow totalizer helps as a check on total volume of water used.
- The chlorine injection port is bent, and the ports are welded instead of tapped, which makes them more difficult to fix. There is no flow switch to activate the chlorine injection pump.
- There is no connection available to allow regular backwashing of the intake.
- There is no storage space in building.

6.1.2. Mechanical and Electrical Systems

- Some of the electrical components are old and eventually will need to be replaced. However, they will likely suffice until a new truckfill is established.
- There is also some concern about pump power cable not being covered/protected (a potential danger).
- There is potential danger if spring run-off floods the building above some of the electrical components, such as the baseboard heater.

6.1.3. Alarms

• There is no alarm system in the truckfill at present. Recommend a complrehansive alarm system be installed when a project is undertaken to replace the truckfill. In the mean time consideration should be given to installation of a simple alarm system.

6.2 Water Treatment

- At the time of the review the operators were batch chlorinating, as their form of disinfecting, the
 water being delivered by the water truck. They had been batch chlorinating since the pump
 broke down in December. Since the review, however, the calcium hypochlorite disinfection
 system inside the truckfill building has been connected and is now being used.
- Expected revisions to the GCDWQ turbidity guidelines will likely require filtration for all surface water sources. This will have a significant impact on NWT water supply infrastructure in general, including that in Sachs Harbour. H&SS is working with the Federal-Provincial-Territorial Committee on Drinking Water Quality Guidelines on this issue, and with PW&S (through the NWT Drinking Water Committee), on a pilot plant study to test the viability of cartridge filtration for meeting the new requirement. Cartridge filtration systems are less expensive than traditional filtration systems, and simpler to operate and maintain. Recommend continued co-operation between PW&S and H&SS on the pilot study project, along with

- continued monitoring of the status of any guidelines changes, and further investigation of options for addressing the new requirements.
- If a decision is eventually made to build a new water treatment plant, consideration should be given to some type of filtration system. More comprehensive seasonal raw water quality data is required before treatment options can be properly identified and evaluated. Recommend planning work include sampling of raw water quality for physical, chemical and microbiological parameters (PW&S and H&SS to advise on sampling requirements). A minimum of three sample sets should be collected over the course of a year, one during spring runoff, one in the fall and one in the winter.

7. WATER SUPPLY REVIEW - OPERATIONS AND MAINTENANCE

7.1 Watershed and Raw Water Quality

- The Hamlet of Sachs Harbour has a Type "B" water license as required under the *NWT Waters Act*. This license allows them to withdraw 4,400 m³ of water per year. The license does not require raw water quality monitoring though Indian and Northern Affairs (INAC) completes an annual inspection in the fall of each year, which includes raw water quality testing. The current water license expires on June 30,2009. During the review the Hamlet still had not filled out the required annual report. Recommend completing this report as required.
- There are currently no noted concerns with the drinking water quality, in the community. As in various other communities, many members use ice from the lake or sea ice as sources of water, mainly for making tea. There was concern when approximately 7 years ago a plane when down into the lake. Community members were concerned about possible pollutants from the plane fuel, and they did not want to drink the water out of respect for those who passed away in the accident. However, since then the community has resumed using Water Lake (DOT Lake) as their drinking water source.
- Water samples collected from Water Lake during the time of the review, as well as previous
 water quality data, indicate that the quality of Water Lake is very good and there are currently
 no concerns with the quality. We do, however, recommend continuous sampling of water from
 Water Lake, following the sampling guidelines set out by the Department of Health and Social
 Services. Recommend contacting the Regional Environmental Health Officer for
 clarification on sampling frequency and procedures.

7.2 Water Intake

• The community has not had a problem with raw water supply but have over the past year had problems with pump failure and intake freeze-up (see Executive Summary for discussion). A major factor in this freeze up was the lack of alarm systems and proper training for pump removal and installation. During turn over of the facility to the Hamlet from Public Works and Services (in 1997) training was provided on pump removal and installation. That was many years ago, however, and information is easily forgotten after such a period of time. Recommend the Hamlet request a member of Public Works and Services to come into the community for a hands-on training update for the current system, including the chlorination system. The Works Foreman has recently completed a small systems course, held in Inuvik (November 2002), for operators and completed the course with ease, which is a great start to training upgrading. Ideally it is beneficial to have at least two people in a community trained for small system operations.

7.3 Truckfill Station

• An erosion channel has developed down gradient between the truckfill facility and the lake. Recommend the channel be filled in with a course granular to help drainage and minimize further erosion. Also a splash pad and drainage channel or culvert at the base of the truckfill under the spot where the truckfill arm drains should be installed. Further, the culvert that goes under the access road near the truckfill station should be cleared and the end pried open to allow run-off from the ditch to drain away from the truckfill.

- The water truck must back into position at the building in order to complete its fill. There is a potential for the truck to back into the lake. Recommend placing a log or similar truck stop on the ground behind the truckfill arm to reduce the possibility of backing into the lake.
- During the review spare parts were found resting on the floor. It was noted that the facility usually floods every spring; which could potentially damage any spare parts stored on the building floor. It also appeared that the baseboard heater could be within flooding limits of the building (although it was reported that the water in the building had never gotten as high as the heater). Recommend moving the spare parts off the floor, to another building, if necessary. The baseboard heater could also be raised a few inches to provide extra protection from flood damage.

7.3.1. Truckfill Sub-systems

The truckfill station logbook (daily checklist) has columns for daily recording of free available
chlorine, total available chlorine, date, time, operator. Recommend adding columns to the
checklist for recording changes to chlorine injection pump settings, dates of mixing
chlorine solutions, water quality changes, such as visual or measured changes in color or
tubidity and weather.

7.3.2. Mechanical and Electrical Systems

• There is potential danger from spring flooding of the truckfill building. Recommend establishing a berm or diversion channel around the building, to reduce flooding. Recommend keeping spare parts off the floor of the building and raising any electrical components higher up inside the building if possible.

7.3.3. Alarms

• There used to be an autodialer system installed in the original truckfill station, which is no longer connected. Recommend consideration be given to installing some sort of alarm system, to alert local staff to critical problems while still being simple to maintain, which might include (in addition to the current low building temperature alarm) low intake casing temperature. Cost and benefits of installing a more comprehensive system must be evaluated, however, considering the age of the building and the fact that a planning study may be initiated in the near future.

7.4 Water Treatment

- The community uses calcium hypochlorite granules (65% available chlorine). At the time of the review there were approximately ten 2 kilogram bags of the powdered chlorine in storage at the Hamlet Garage. When they are using the calcium hypochlorite disinfection system they usually mix up a solution once a month. 2/3 of a cup of powder are added to make up a 45 gallon solution of chlorine (which lasts about one month). Recommend mixing smaller batches of chlorine solution (approximately once every two weeks) in order to maintain chlorine solution strength, since the amount of chlorine in the solution slowly dissipates over time. Recommend posting updated instructions.
- The NWT Public Health Act requires you to have a spare chlorine injection pump. Recommend purchasing a spare chlorine injection pump.
- An agitator (mixer) is located on each of the tanks (both the mixing and solution tanks).
 Recommend removing the mixer for the solution tank and trying the system without it. A

mixer is needed on the mixing tank, but not generally on the solution tank. It is best if the binding agent in the powdered chlorine stays settled out on the bottom of the solution tank so it doesn't clog the foot valve on the chlorine injection pump.

• The tubing leading from the chlorine injection pump to the truckfill piping was black. Recommend switching to clear tubing so that the operator can visually check that the chlorine solution is pumping onto the system.

7.5 Water Quality Testing and Reporting

• Table 2 shows the frequency of water quality sampling being done, along with the sample location. Table 3 shows who takes the samples, who tests them, who sees the results.

Parameter	Frequen	cy of Testing	No. of	Location	Comments
T at afficier	Raw	Treated	Samples	Location	Comments
Bacteriological		Monthly	Three	Two public buildings (random), water truck, and private homes upon request	Treated water should be tested 4 times each month as per GCDWQ. Ideally, water should be tested once each week to allow for the required 4 tests per month. Test should be carried out from water obtained from water trucks by the Hamlet, as that is the municipal system.
Chemical	Annually	ıally			Incorporate into regular routine.
THMs and TOCs					THM and TOC should be tested for every six months by the Hamlet.
Water License	ter License Annually One		Truckfill station		
Free Available Chlorine		Daily (since review)	One	Water truck or truckfill arm	EHO would like to see tests three times a day.
Total Chlorine		Daily (since review)	I me		EHO would like to see tests three times a day.

Table 2 Sampling and Testing Procedures

Sampling/ Testing	Sampled by	Tested by	Distribution of Results	Comments
Bacteriological	Health Center Clerk or Local H&SS Representative (Since review has changed to Water treatement operator each week).	Inuvik Hospital	H&SS Rep. (Health Center) when necessary	EHO to report findings on a quarterly basis as a minimum.
Chemical	INAC Region – Scott Gallupe	Taiga Labs	INAC Region and SAO	Raw water sampling done in August 2002.
THMs and TOC				THM and TOC to be sampled by Hamlet/PWS and tested by an independent lab. Results to be forwarded to EHO.
Water License	INAC Region – Scott Gallupe	Taiga Labs	INAC Region and SAO	(Scott Gallupe is no longer with INAC – Replacement is unknown).
Free Available Chlorine	Works Foreman	Works Foreman	Truckfill log-book	
Total Chlorine	Works Foreman	Works Foreman	Truckfill log-book	Recommenced after review.

Table 3 Communication and Reporting

7.5.1. Chlorine Testing

- The truckfill station has one Hach Pocket Colorimete (tests free and total chlorine), which was purchased after the review. There is also a Hach Colour Disk, which was used prior to the purchase of the Hach Pocket Colorimeter, which had only one 10 ml vial to use for testing. Recommended buying (if not already done) extra 10 ml testing vials, brushes for cleaning the vials, Free Available Chlorine testing reagent, rubber gloves and a container for washing. Vials can be cleaned with a mixture of vinegar and water.
- When testing, recommend wiping test vial free of all excess moisture on outside, fill sample so bottom of meniscus is level with 10 ml line on vial, and hold the vial by the top so fingerprints do not interfere with the Colorimeter reading.
- Recommend three chlorine tests per day. Samples should be collected from the water truck, as water collected from the truckfill arm is not fully mixed and test results will not be accurate. The following tests are recommended:

- 1. The truckload that sits overnight for fire protection purposes should be tested first thing in the morning to ensure adequate free available chlorine level prior to delivery, and batch chlorinated to increase the free available chlorine if required. Additional test(s) may be required to confirm the batch chlorination results.
- 2. The first truckload filled in the morning should be tested, for free available chlorine and total available chlorine, 20 minutes after filling. This test ensures the chlorine injection pump is set properly for the day. Additional test(s) may be required to confirm FAC results due to pump adjustments.
- 3. A truckload in the afternoon, testing for free available chlorine only, to ensure that there is a minimum of 0.2 mg/L after 20 minutes.
- Remember to wait 20 minutes after the chlorine has been added to the water before testing for chlorine. This gives the chlorine sufficient time to react with (kill) the bacteria in the tank and leave available free chlorine.
- Recommend inserting extra columns into daily data log sheet in order to have room for the increased number of free and total chlorine readings.
- Currently in the truckfill station there is no good place for the operator to do the chlorine tests and clean the test equipment after use. The building is cramped and poorly lit with no place to rinse the equipment off, and the addition (built on to the main building) would be too cold in the winter. Recommend either buying a small tub or wash pail for the truckfill station, or allow the operator to do the tests somewhere else where there are better facilities for washing.

7.5.2. Bacteriological Testing

- Bacteriological sampling is done by the Health Centre Clerk or the local Community Health (H&SS) Representative. Ultimately the collection of water samples is the responsibility of the operator. However, in many communities it has become the responsibility of the CHR, though it is not part of their job description. EHO has recently, since the review, designated water operator for sampling. Recommend ensuring this change.
- The Community Health Representative takes about three samples each month. Generally, two are collected randomly from public buildings, one from the water truck. Samples are collected from a private home upon request. Bacteriological testing is done free of charge at the Inuvik Hospital and additional samples are recommended whenever there is a concern. EHO suggests the Hamlet be given the choice of labs to use.
- The Guidelines for Canadian Drinking Water Quality (GCDWQ) recommend four bacteriological samples per month for populations up to 5,000 people. All EHO's across the NWT recently adopted this standard and informed the communities of the change. (The NWT Public Health Act requires only two bacteria samples per month for communities of 501 to 2,500 people.) The Inuvik Region EHO has requested that communities take one sample per week, for a total of four per month. This helps level out time requirements for analysis of all regional samples and ensures more frequent monitoring of all community water supply systems. Recommend community staff (operator) take four bacteria samples per month (one per week). Samples should be collected from the public water system, including the water truck (2 or 3 per month) and public buildings (1 or 2 per month). Testing should focus on the water trucks. Samples should not be obtained from private homes when assessing public systems. month).
- MACA Region should work with the EHO to develop a Standard Operating Procedure (SOP) for bacteria sampling, and incorporate this into an SOPs binder for the truckfill station.

- Samples are normally taken from the kitchen or bathroom sink. Recommend the tap be sterilized with a lighter and the water run until temperature stabilizes before taking a sample.
- Test results are forwarded from the hospital lab to the EHO automatically. The EHO calls the Community Health Representative immediately if there is a problem. Recommend bacteriological test results be forwarded automatically from the EHO to the local water treatment plant operator, Community Health Representative, SAO, and PW&S HQ.

7.5.3. Chemical Sampling

- The community is not regularly testing their drinking water or raw source water for THMs (Trihalomethanes) and TOC/DOC (total and dissolved organic carbon). The Water Resources Officer (INAC) does water sample collection for chemical analysis during some of his visits to Northern communities. However, any water quality testing results obtained by PW&S for this review do not show any THM or TOC/DOC analyses. THMs are part of the set of disinfection by-products compounds formed by the interaction of chlorine with organic material naturally present in the raw water supply (such as decaying leaves). As such, THM samples are generally collected after chlorination, usually from the water truck or the tap of a public building. Recommend developing routine sampling procedures for THMs and TOC/DOC and that samples be collected biannually.
- Recommend MACA work with the Community and Regional EHO to clarify operator responsibilities with respect to sampling and help the community integrate sampling into their regular routine.
- As sampling for chemical and physical parameters had not yet become routine, there was no
 protocol for distribution of sample results. Recommend the Regional EHO ensure sample
 test results and/or deficiencies in sample collection are forwarded to the local Operator,
 SAO and Council. Test results should come complete with Guidelines for Canadian
 Drinking Water Quality (GCDWQ) maximum acceptable concentration (MAC), interim
 maximum acceptable concentration (IMAC), or Aesthetic Objectives (AO) values for
 comparison and/or a brief interpretive letter explaining the significance of the results.
- Recommend MACA clarify sampling requirements with the EHO and incorporate them into the regular operational routine. In general, H&SS requires sampling of treated water for chemical parameters once a year at spring freshet and sampling for THMs twice a year in spring and fall. Additional sampling for TOCs is recommended to coincide with THM sampling. Recommend MACA Region work with Taiga Environmental Laboratory and the Regional EHO to develop a set of standard operating procedures (SOPs) for annual sampling of chemical and physical parameters and biannual sampling of THMs, and incorporate the procedures into a SOPs binder for the truckfill.
- Sampling should be co-ordinated between MACA, the Community, the EHO and INAC
 to minimize costs, and ensure all parameters are covered and samples are collected
 properly.

7.5.4. Sampling and Testing for Water License

Even though the current water license does not require raw water quality testing, INAC does
an annual inspection complete with raw water quality sampling at the truckfill intake for a
number of physical, chemical and biological parameters. The annual INAC inspection report
complete with sampling results is sent to the SAO and other government departments as

requested. H&SS has been relying on this data for the last three years, even though it has been collected in the fall and not under worst-case conditions. Currently there is no Water Resources Officer at INAC in Inuvik (previously Scott Gallupe). Recommend sampling be co-ordinated with H&SS and done at spring freshet and that all necessary parameters are covered.

7.5.5. Reporting - General

- The operator never sees the results of any testing except the chlorine testing he does himself. Recommend H&SS forward all sample results to PW&S HQ for entry into the new Water Quality Database (which can be found at the GNWT Public Works and Services website).
- The public does not receive any information on their drinking water. An attempt should be made to educate the public on water quality issues. This could take the form of a poster in the Hamlet Office describing the water quality system, summarizing water quality test results and providing a contact number for concerns.

7.6 Community Operations

 Table 4 lists community and GNWT staff with operational responsibilities relating to the water supply system.

Name	Level of Certification	Years of Experience	Education Requirement	Reports To	Comments (hr./day on site)
Floyd Lennie (Works Foreman)	Small Systems (re-certified after Review)	16	Met	SAO	10 min/day testing chlorine levels and a couple of hours every month for mixing chlorine.
Joseph Carpenter	Trained – Not certified	3	Met	Works Foreman	1-2 hours/3 days – water truck driver
Tim Bettger	Mechanic			Works Foreman	Maintenance on water trucks
Margaret Lennie	Trained – Not Certified			Works Foreman	Sewage truck driver

Table 4 Community Water System Operational Staff and Related Training

• The Community Works Foreman, Floyd Lennie, is responsible for day-to-day truckfill station operations including chlorine testing, adjusting the chlorine injection rate, and general housekeeping. During the Review, however, Joseph Cerpenter was performing much of the day-to-day operations (at that time the chlorine system was not hooked up and there was no testing being performed).

- Joseph Carpenter, the water truck driver, is interested in the day-to-day operations in the truckfill station and had attended a small systems course in January/February of 2002. Margaret Lennie the sewage truck driver also attended the course. It is important that there be at least two trained workers; one or more for backup if the regular operator(s) is not available. Recommend further training.
- There was no O&M Manual at the truckfill station. MACA Region should confirm whether there is an O&M manual in the community and have a copy remain in the truckfill station or at the maintenance garage so it can be referred to when necessary.
- Recommend MACA Region work with the operators and the Regional EHO to prepare a simple set of standard operating procedures (SOPs) (or consider having SOPs as part of the O&M manual for the future truckfill station), for items such as (but not limited to):
 - · chlorine test procedures;
 - process control (adjusting the chlorine injection pump and batch chlorinating);
 - · summary of sampling requirements for regulatory compliance and water tanks;
 - · sampling procedures for bacteria, THMs, TOCs and chemical parameters; and
 - a summary of roles of various agencies/departments with respect to water supply along with contact names and numbers.

7.7 Training Requirements

• Recommend MACA organize continued practical, "hands-on" field training for all operations staff.

7.8 Workplace Safety

- Material Safety Data Sheets (MSDS) should be clearly displayed for all chemicals used in the truckfill station and included in the SOPs.
- The truckfill station has some of the required safety equipment including goggles, eyewash station, first aid kit and first aid booklet. Gloves and dust masks are stored at the maintenance garage. Most of the staff has WHMIS. Recommend purchasing appropriate gloves and aprons to be used when mixing chlorine solution.
- · Recommend spare eyewash bottles be provided.

7.9 Maintenance Management Systems

• The community does not refer to the Operations and Maintenance (O&M) Manual. There was no O&M Manual in the truckfill station. Recommend MACA Region assist the community with preparation of regular (daily, weekly, monthly, and annual) PM checklists with specific action triggers and responses. An old copy of the Water Pumphouse Maintenance Schedule (developed by PWS) can be found at the Sachs Harbour Hamlet Office, which can be used as a basis for the development of an up to date and suitable checklist. It is also strongly recommended that operator(s)' responsibilities are clarified so that each worker knows what role they play with respect to truckfill operations. There appears, in past records, to be some confusion about operators' roles and responsibilities.

• The Works Foreman does not use the MMOS system. Recommend training on the MMOS system.

7.10 Inventory/Spares

Spare parts should include (but not be limited to) a chlorine injection pump, two or three
pump repair kits, flexible tubing, a foot valve, powdered chlorine and chlorine test reagent.

7.11 Water Distribution

- The Bureau of Statistics estimates there were 153 people living in Sachs Harbour in the year 2000, and 40 occupied dwellings with an average of 3.3 people per dwelling in 1996. Population is expected to grow to 169 in 2009 and 185 in 2019. Local staff estimated there are about 20 public houses and approximately 15 residential units in the community.
- The water license allows the Community to draw a maximum of 4,400 m³ from Water Lake each year.
- The water truck driver delivers water to all buildings three times a week (Monday, Wednesday, and Friday). Monday and Friday are the busiest days. Local staff estimated the water truck delivers approximately 10 loads of water per day. The water truck generally works 9 to 5 on delivery days.
- Recommend establishing cleaning the water truck with a chlorine bleach solution at least once a year or as recommended by the Environmental Health Officer, and incorporate into the water delivery contract.
- The nozzle on the water truck hose does not have a trigger, camlock or other means for shutting off the flow of water. Therefore water is spilled on the stairway or driveway creating icey conditions in the winter-time. Also the reel, to reel up the hose on the new water truck, does not work. Recommend replacing the nozzle with a trigger nozzle (like used for pumping gas at a gas station. (Note: This may have already been done since time of review). Also recommend fixing hose reel.
- The reverse option on the water truck did not work during the time of the review. In order to back up the truck had to be driven to a high point and allowed to roll back wards. Recommend water truck be serviced and repaired as soon as possible.

7.12 Household Water Tanks

- The Housing Corporation cleans its managed residential units once a year. A notice is also put up in the community during that time to notify/remind homeowners that water tank cleaning should be done. Private homeowners are responsible for cleaning their own tanks. Recommend the Community discuss public education with the Regional EHO and MACA to encourage local residents to clean their water tanks regularly. The Band should consider organizing a regular (annual) community wide household water tank cleaning program, building upon what is already done annually in the community.
- Although only a few homes have crawl space water tanks and it was not mentioned whether
 people had to enter the water tanks for cleaning it is a common occurrence in communities.
 However, no one should be entering water tanks (or any other confined space) without
 proper equipment. Recommend the EHO provide the band with updated instructions for
 cleaning water tanks (and possibly some training) and ensure they are posted at the Band
 Office and Health Centre. Recommend H&SS take the lead in discussions with the
 Housing Corporation to develop a preferred method (including equipment specifications if

necessary) for cleaning of household water tanks, and an improved water tank design that facilitates easy identification of dirty tanks and cleaning.

8. GAP ANALYSIS

The gap analysis shown in Table 5 highlights some of the deficiencies in the existing water supply system. It is the intention of the GNWT to review and undate the gap analysis annually.

ystem. It is the intention of the GNWT to review and update the gap analysis annually.		
COMPONENT	ANALYSIS	
Roles and Responsibilities	Works Foreman responsibilities relating to preventative maintenance inspections and sampling should be clarified.	
	H&SS and Clinic staff relied on the majority of the time to do bacteriological sampling.	
Infrastructure Review	• Infrastructure is ageing past its expected design life. Planning for the next 20-year life cycle is required.	
	Some deficiencies noted during the Review include:	
	No system alarms	
	No back-up power	
	Flow rate below GNWT standard	
	Chlorine system not working (during review)	
	No gauges, flow meters	
	Inadequate chlorine testing space and no storage space	
	No complete truckfill turnaround	
	Poorly lit building	
	No ventilation system	
Operations and	No certified back-up staff (although there are trained staff).	
Maintenance Review	Water quality sampling not done during worst case conditions.	
	Concerns identified relating to chlorine mixing, testing and process control.	
02	Operations and Maintenance Manual not made available.	
	Missing some required laboratory and test equipment.	
	Responsible staff are not getting all water quality test information.	
	Residents are not getting any information on drinking water quality.	
	No simple standard operation procedures available for all activities.	
	No standard chemical and physical water sampling procedures.	
	No preventative maintenance checklists available for operator.	
	Material Safety Data sheets not readily available.	
	The operator is not alerted of an alarm situation automatically.	
	Lack of GNWT support.	

9. RECOMMENDED COMMUNITY ACTION PLAN

Table 6 suggests a recommended action plan for the community. Items are listed in priority order. Note that "time frame" is a general reference to the expected time to implementation, and not necessarily a reflection of priority. GNWT assistance maybe required in some cases, and a lead contact is specified where applicable.

#	RECOMMENDED COMMUNITY ACTION PLAN	PRIORITY	TIME FRAME	LEAD
1	Ensure a minimum free available chlorine (FAC) residual of 0.2 mg/L after 20 minutes contact time for all water delivered. Recommend a minimum of three FAC tests on each delivery day, one on the truck that sits full overnight for fire protection, one on the first truckload filled each morning, and one in the afternoon to confirm pump settings	High	Immediate and on- going	Hamlet
2	Recommend Community staff assist H&SS staff with bacteria sampling to ensure at least four samples are taken each month (one per week). At least one sample should be taken from the water truck and one or two from public buildings. Water should not be tested from private homes when assessing public systems. Complaints from private owners should contact EHO and discuss solutions/testing. Sampling requirements should be confirmed with the Regional EHO.	High	Short term and on- going	Hamlet H&SS
3	Recommend the Community ensure staff in charge of day-to-day operations have Small Systems Certification and maintain their certification status by providing regular opportunities to attend training events and conferences for continuing education credit. Recommend two people be trained (1 for back-up).	High	Short- term and on-going	Hamlet MACA
4	Recommend staff begin batch chlorinating the water truck if it does not have a minimum FAC residual of 0.2 mg/L after 20 minutes.	High	Immediate and on- going	Hamlet
5	Recommend chlorine solution be mixed every two weeks in order to maintain solution strength.	High	On-going	Hamlet
6	Recommend improving the workstation area in the building for testing, washing, etc. or establish a suitable area elsewhere for testing, record keeping and washing test equipment.	High	Medium term and on-going	Hamlet
7	Purchase a spare chlorine injection pump.	High	Short term and on- going	Hamlet
8	Remove agitator from solution tank.	High	Short term and on- going	Hamlet
9	Recommend Material Safety Data Sheets (MSDS) for all chemicals used be posted in the truckfill so they are readily available at all times for emergency response.	High	Short term and on- going	Hamlet
10	Appropriate safety equipment (including solution for the eyewash station, gloves and an apron) must be available at the truckfill station at all times.	High	Short term and on- going	Hamlet

11	Recommend annual water quality sampling for chemical parameters and THMs. Confirm sampling requirements with the Regional EHO.	High	Short term and on- going	Hamlet H&SS
12	Recommend the Community implement daily, weekly, monthly and annual operations and preventative maintenance checklists for the water supply system. MACA Region to take the lead in assisting with preparation of O&PM checklists. Improve daily chlorine checklist.	High	Medium term and on-going	Hamlet MACA
13	Recommend filling in the erosion channel on the lake side of the truckfill station with a course granular material to help drainage and minimize further erosion. It is also recommended to install a splash pad and drainage channel or culvert at the base of the truckfill under the spot where the truckfill drains and repair the culvert that is currently present under the access road near the truckfill station (which would only require clearing it out and straightening out the pipe).	High	Medium term and on-going	Hamlet
14	Complete annual report as required by water license.	High	Short term and on- going	Hamlet
15	Fix reverse on water truck.	High	Short term	Hamlet
16	Change tubing on chlorine injection line from black to clear	High/Medium	Short term and on- going	Hamlet
17	Recommend storing a fire extinguisher in the truckfill building and that it be checked monthly and serviced annually.	Medium	Medium term and on-going	Hamlet
18	Recommend installing a simple ventilation system or keep door open when mixing chlorine solution.	Medium	Short term and on- going	Hamlet
19	Recommend cleaning water truck once a year. Work with MACA or H&SS to develop a regular preventative maintenance program for water truck.	Medium	Short term and on- going	Hamlet MACA
20	Recommend continued discussions with the EHO on public education and appropriate cleaning methods for household water tanks. Ensure updated instruction for cleaning household tanks are posted at the Band Office and Health Centre. Consider a regular (annual) community based water tank cleaning program.	Medium	Medium term and on-going	Hamlet H&SS
21	Recommend formal reporting to Council to facilitate planning, budgeting and continual improvement. The SAO (in co-ordination with operating staff) should submit brief Annual Operating Reports and quarterly updates to the Community Council on the status of the water supply system. Operating Reports should include summaries of water quality test results, maintenance work, operating issues/concerns, expenses and training. Reports should be forwarded to MACA Region to assist MACA in identifying training, technical or financial support requirements. MACA Region will co-ordinate with Community staff, PW&S and the EHO to assist with preparation of the first Annual Operating Report in 2003.	Medium	Medium term and on-going	Hamlet MACA

23	Recommend purchasing extra chlorine test vials, as well as a small tub and cleaning brushes to facilitate cleaning of laboratory equipment.	Medium	Medium term and on-going	Hamlet
24	Recommend placing a log or similar truck stop on the ground behind the truckfill arm to reduce the possibility of the water truck backing into the lake.	Medium	Medium term and on-going	Hamlet
25	Track inventory of chlorine test reagent to ensure sufficient supply at all times.	Medium	On-going	Hamlet
26	Move spare parts off the floor (store elsewhere if necessary). Recommend moving baseboard heater up in order to ensure protection from spring flooding.	Medium	Short term	Hamlet
27	Fix nozzle on water truck (prevent from leaking when water flow stops).	Medium/Low	Short term	Hamlet
28	Recommend Community work with PW&S and MACA to determine the feasibility installing an alarm system and determine whether it is worthwhile considering the age of the facility and the potential for new infrastructure planning.	Low	Medium term	Hamlet MACA PW&S
29	Recommend the back-up water truck be stored full every night if possible to assist with fire protection.	Low	Short term and on- going	Hamlet
30	Recommend advance preparation of mechanical and electrical deficiency lists prior to each annual inspection to facilitate faster repairs at minimal cost. MACA Region to assist as required.	Low	Medium term and on-going	Hamlet MACA

Table 6 Recommended Community Action Plan

10. RECOMMENDED GNWT ACTION PLAN

Table 7 suggests a recommended action plan for the GNWT to help improve the overall water supply system efficiency. Items are listed in priority order. "Time frame" is a general reference to the expected time to implementation, and not necessarily a reflection of priority.

Table 7 Recommended GNWT Action Plan

#	RECOMMENDED GNWT ACTION PLAN	PRIORITY	TIME FRAME	LEAD
1	The Sachs Harbour truckfill is old and a number of repairs are required to bring it up to standard. Recommend a planning study be added to MACAs Capital Plan as soon as possible.	High	Long term	MACA
2	Increase operational assistance to the community to facilitate continual improvement. EHO will continue to visit community twice a year, and will review log book and chlorine levels/test procedures on each visit. PW&S HQ will work with EHO to provide regular practical hand-on operations training and troubleshooting assistance.	High	On-going	PW&S H&SS
3	PW&S HQ will continue to review truckfill station operations and maintenance annually. On each visit, PW&S will review the log-book and maintenance checklists, test chlorine levels in the water truck, and confirm accurate chlorine test and batch chlorination procedures, provide technical services and hands-on training.	High	Short term and on- going	PW&S
4	Recommend MACA work with Community to install backup building heat and alarm system. However, the cost and benefits of installing these systems should first be evaluated against the long-term cost and benefits of a new system in the planning study.	High	Medium term	MACA
5	Improve community and interdepartmental reporting on water quality testing. As of 2003, H&SS will forward all test results with GCDWQ values for comparison and/or a brief interpretative letter to the Band Manager and Council. H&SS will copy all test results and notices regarding sampling requirements to PW&S HQ for input into the water quality database.	High	Short term and on- going	H&SS
6	PW&S HQ will conduct a pilot study (in Colville Lake) to determine the feasibility of using cartridge filtration for truckfill stations typical of the NWT. Study to be completed in FY 2003/04.	Medium	Long term	PW&S
7	INAC Region and EHO Region to ensure all sample results are forwarded to PW&S HQ for input into Database as soon as possible.	Medium	Long term	INAC EHO

8	Recommend MACA Region work with the Community, PW&S, the Regional EHO, Taiga Environmental Laboratories, and INAC or the NWT Water Board, as required, to prepare a set of standard operating procedures (SOPs) for the Truckfill Station Operator. SOPs will be finalized by mid 2003 and should be included in O&M manual for new truckfill station.	Medium	Medium term	MACA
9	Recommend MACA Region co-ordinate with Community staff, PW&S and the EHO to assist with preparation of Annual Community Operating Reports. MACA Region should forward Community Operating Reports to PW&S and the IHO to ensure all departments are aware of any deficiencies or concerns. First Operating Report to be prepared by 2004/2005 FY.	Medium	Medium term and on-going	MACA
10	Recommend MACA Region take the lead in assisting the Community with budgeting for water supply system O&M at the Community's request. This would include clarification of funding sources, identification of annual operating requirements (sampling, training, etc.), and possibly an annual review to identify major maintenance requirements (inventory deficiencies, electrical/mechanical deficiencies, etc.). Planned for 2004.	Medium	Long term and on- going	MACA Hamlet
11	Recommend H&SS HQ take the lead in discussions with the Housing Corporation (NWTHC) to improve water tank design and develop a preferred tank cleaning methodology. PW&S will provide technical support as required. Discussions to be initiated in 2003.	Medium	Medium term	H&SS
12	Recommend MACA Region take the lead in working with the Community, Regional EHO and INAC or the Sahtu Land and Water Board, to co-ordinate annual sampling of chemical and physical parameters and THMs with annual sampling for water license requirements where possible and to arrange for sampling of chemical parameters including, turbidity, THMs and TOCs in raw and treated water every year during spring freshet starting in May 2003.	Medium	Medium term and on-going	MACA
13	Recommend H&SS take the lead on improving communications between federal and territorial departments on issues related to the water supply system. This would include establishing links to facilitate input on watershed development, planning studies and projects, and circulate information won water quality sampling, water license reporting, community O&M reporting and community concerns. H&SS to initiate discussions in early 2003.	Medium	Long term and on- going	H&SS
14	Establish a reporting structure to alert the GNWT to watershed issues that may affect raw water supply. H&SS HQ, through the Drinking Water Committee, will invite Federal and Territorial Departments responsible for watershed management to a round table discussion on reporting links.	Medium	Medium term	H&SS
15	Recommend H&SS develop a standard poster that can be customized for each community to educate/inform residents of their water supply system and water quality.	Medium	Medium term	H&SS

, , , , , , , , , , , , , , , , , , , ,				Short term	
	16	MACA to help community revise daily chlorine checklist	Medium/Low	and on- going	MACA

Table 7 Recommended GNWT Action Plan (continued)

11. APPENDIX A (PHOTOGRAPHS)

11.1 Raw Water Source

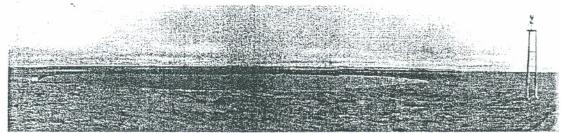


Photo 1. Sachs Harbour truckfill station (white building in picture left), located on the shoreline of Water Lake.

11.2 Truckfill Station Building, Site and Water Truck

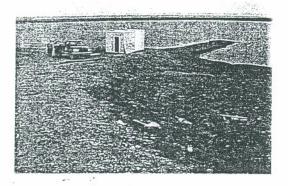


Photo 2. Sachs Harbour truckfill station.

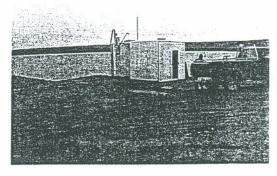


Photo 3. Water truck pull-up area of truckfill station.

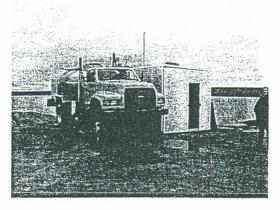


Photo 4. Water truck must back into position in order to fill with water.

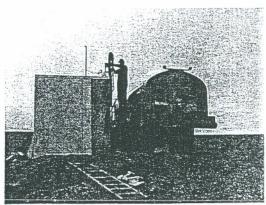


Photo 5. Water truck driver initiating truck fill. Truck is being batch chlorinated.

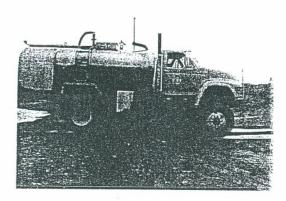


Photo 6. Sachs Harbour water truck.

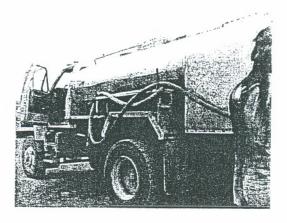


Photo 7. Water truck distribution hose.

11.3 Electrical, Mechanical, Process Piping, and Disinfection System

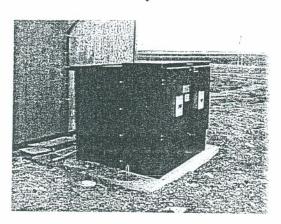


Photo 8. Transformer, uphill from truckfill station, which supplies power to the building.

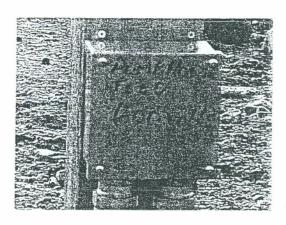


Photo 9. Power is transferred from the transformer (Photo 8) to this pump house feed which used to supply power to the old village truckfill building. Power is relayed from this location to the current truckfill station.

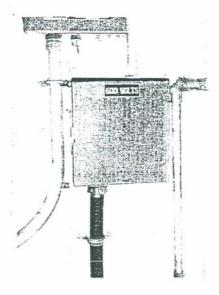


Photo 10. Power from the pump house feed (Photo 9) enters the truckfill station into this power box at 600 volts.



Photo 11. Main Panel D is the buildings power on/off switch.

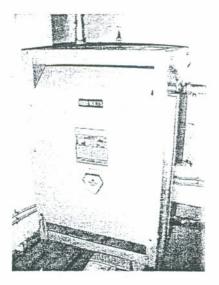


Photo 12. Power the power is then transformed in this transformer to lower voltage and is transferred to the distribution panel.

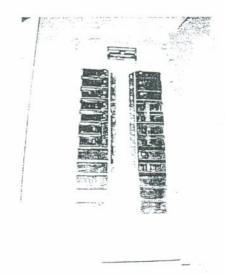


Photo 13. Distribution panel.

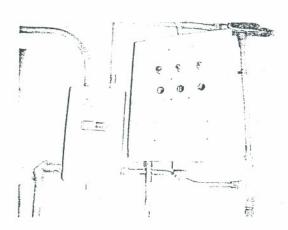


Photo 14. Pump on/off switch on left and control panel on right (not currently operating).

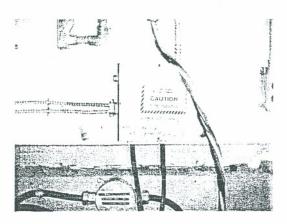


Photo 16. Heat trace power supply box. Heat trace tapes are the grey lines coming out of the bottom of the box.

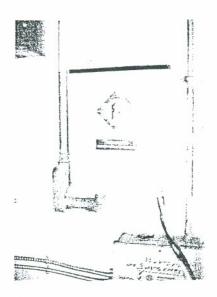


Photo 15. Pump power supply box. Note power cord (red, green, black, yellow) leading to pump.

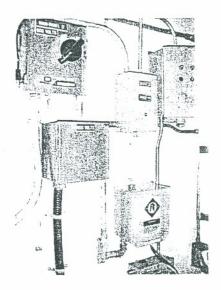


Photo 17. Electrical panels.

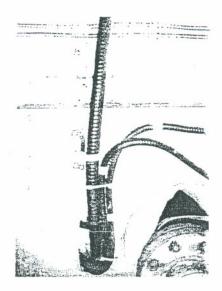


Photo 18. Left is where power enters building from underground power cable. Bottom right is where the water intake line enters building.

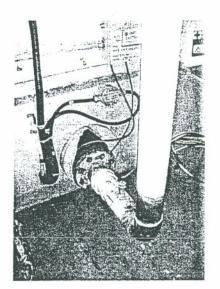


Photo 19. Raw water intake line into building.

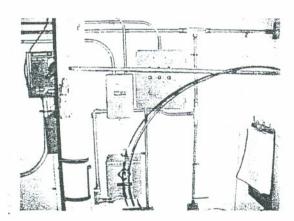


Photo 20. Water distribution piping (white). The domestic water supply is the copper pipe leading from the white pipe to the chlorine solution mixing tank (out of picture). The chlorine injection point is located just below where the copper piping enters the distribution pipe. Note that, in this picture, the black tube (used to transfer chlorine solution to water) is not connected.

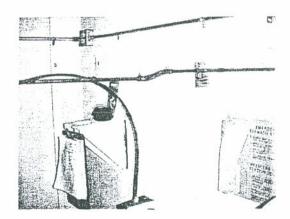


Photo 21. The hanging clipboard is where chlorine levels are recorded. Also observed are the eyewash station, the black tubing leading from the chlorine injector, and the copper tubing leading to the mixing tank.

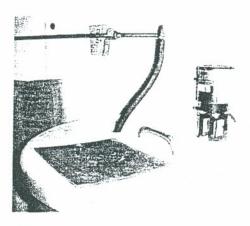


Photo 22. Copper piping (the domestic water supply) leading to mixing tank. Mixer is located on the tank.

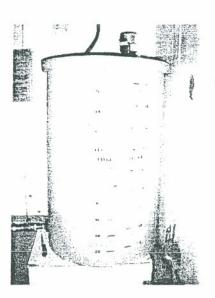


Photo 23. Chlorine solution mixing tank.

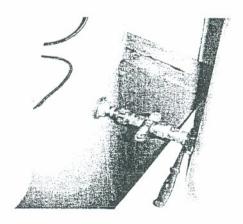


Photo 24. Connection between chlorine mixing tank (right) and chlorine solution tank (left); solution is gravity fed from the mixing tank to the solution tank via this connection.

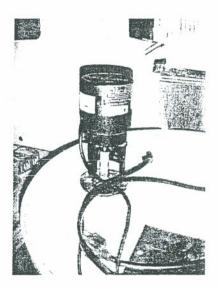


Photo 25. Mixer (agitator) on chlorine solution tank.

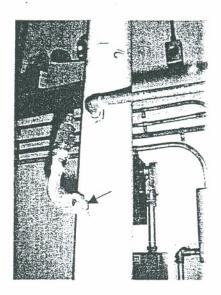


Photo 26. There is a bend in the chlorine injection pipe (indicated by arrow).

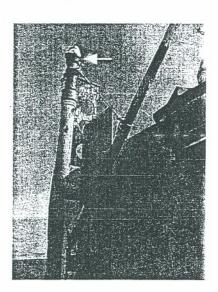


Photo 28. A camlock hose is attached to the top of the piping (indicated by white arrow) in order to fill water truck.



Photo 27. Water is carried out of the building at this point (white pipe near ceiling) to the truckfill pipe.

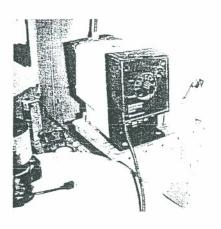


Photo 29. Chlorine injection pump.

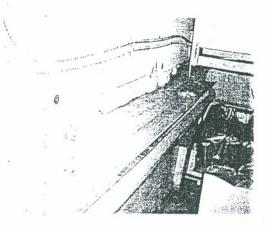


Photo 30. Baseboard heater. Only building heat source.

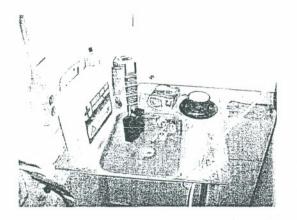


Photo 32. Workstation in truckfill building (pumphouse).

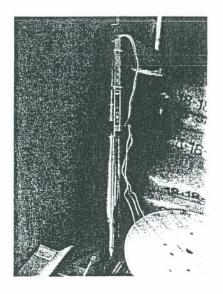


Photo 34. Spare pump connected to power cord.

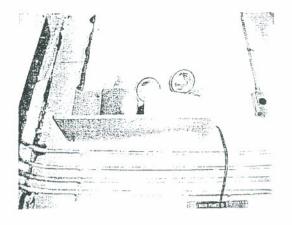


Photo 31. Emergency lighting and spare eyewash fluid.

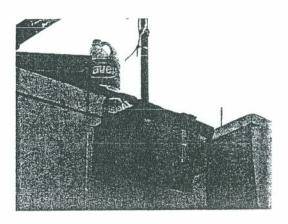


Photo 33. Outside lighting on truck fill side of building. Note the javex used for batch chlorination.

APPENDIX B S GLOSSARY OF TERMS

Glossary of Terms

Technical Term	Definition				
activated carbon	A highly adsorptive material used to remove organic substances from water. (See <i>adsorption.</i>)				
activated silica	A coagulant aid used to form a denser, stronger floc.				
activation	The process of producing a highly porous structure in carbon by exposing carbon to high temperatures in the presence of steam.				
adhesion	A condition in which particles stick together.				
adsorbent	Any material, such as activated carbon, used to adsorb substances from water.				
adsorption	The water treatment process used primarily to remove organic contaminants from water. Adsorption involves the adhesion of the contaminants to an adsorbent such as activated carbon.				
aeration	The process of bringing water and air into close contact to remove or modify constituents in the water.				
alum	The most common chemical used for coagulation. It is also called aluminium sulphate.				
aluminium sulphate	See alum.				
anionic	Having a negative ionic charge.				
backwash	The reversal of flow through a filter to remove the ma trapped on and between the grains of filter media.				
bed life	The time it takes for a bed of adsorbent to lose its adsorptive capacity. Whithis occurs, the bed must be replaced with fresh adsorbent.				
breakpoint	The point at which the chlorine dosage has satisfied the chlorine demand				
breakthrough	The point in a filtering cycle at which turbidity-causing material starts to pass through the filter.				
calcium carbonate (CaCO3)	carbonate (CaCO ₃) The principal hardness- and scale-causing compound in water.				
calcium hardness	The portion of total hardness caused by calcium compounds such as calcium carbonate and calcium sulphate.				
carbon dioxide (CO ₂)	A common gas in the atmosphere that is very soluble in water. High				
	concentrations in water can cause the water to be corrosive. Carbon dioxide is added to water after the lime-softening process to lower the pH in order to reduce calcium carbonate scale formation. This process is known as recarbonation.				
carbonate hardness Hardness caused primarily by compounds containing carbo as calcium carbonate and magnesium carbonate.					
carcinogen	A chemical compound that can cause cancer in animals or humans.				
chlorination	The process of adding chlorine to water to kill disease-causing organisms or to act as an oxidizing agent.				
chlorinator	Any device that is used to add chlorine to water.				
clarification	Any process or combination of processes that reduces the amount of suspended matter in water.				
clarifier	See sedimentation basin.				
coagulant	A chemical used in water treatment for coagulation. C examples are aluminium sulphate and ferric sulphate.				

Technical Term	Definition
coagulation	The water treatment process that causes very small suspended particles to attract one another and form larger particles. This is accomplished by the addition of a chemical, called a coagulant, that neutralizes the electrostatic charges on the particles that cause them repel each other.
coagulation-flocculation	The water treatment process that converts particles of suspended solids into larger, more settleable dumps.
combined chlorine residual	The chlorine residual produced by the reaction of chlorine with substances in the water. Because the chlorine is "combined," it is not as effective a disinfectant as free chlorine residual.
conventional filtration	A term that describes the treatment process used by most surface water systems, consisting of the steps of coagulation, flocculation, sedimentation, and filtration.
Cryptosporidium Parvum	A protozoan pothogen which forms oocysts when released to the environment which are highly resistant to the most commonly used disinfectants
disinfectant residual	An excess of chlorine left in water after presence of residuals indicates that an adequate amount of been added at the treatment stage to ensure completion of all reactions with some chlorine remaining.
disinfection	The water treatment process that kills disease-causing organisms in water, usually by the addition of chlorine.
disinfection by-products (DBPs)	Chemical compounds formed by the reaction of disinfectants with organic or inorganic compounds in water. At elevated concentrations, many disinfection by-products are considered a danger to human health.
dissolved air flotation (DAF)	A clarification process in which gas generated in a basin so that they will attach to solid particles to cause them to rise to the surface. The sludge that accumulates on the surface is then periodically removed by flooding or mechanical scraping.
dissolved solid	Any material that is dissolved in water and can be recovered by evaporating the water after filtering the suspended material.
dual-media filtration	A filtration method designed to operate at a higher rate by using two different types of filter media, usually sand and finely granulated anthracite.
empty bed contact time (EBCT)	The volume of the tank holding an activated carbon bed, divided by the flow rate of water. The EBCT is expressed in minutes and corresponds to the detention time in a sedimentation basin.
filtration	The water treatment process involving the removal of suspended matter by passing the water through a porous medium such as sand.
flash mixing	See rapid mixing
floc	Collections of smaller particles (such as silt, organic matter, and micro- organism) that have come together (agglomerated) into large more settleable particles as a result of the coagulation-flocculation process.
flocculation	The water treatment process, following coagulation, that uses gentle stirring to bring suspended particles together so that they form larger, more settleable clumps called floc.
free chlorine residual	The residual formed once all the chlorine demand has been satisfied. The chlorine is not combined with other constituents in the water and is free to kill micro-organisms.
fulvic acids	Organic acids which result from the decay of natural organic matter (NOM) in the environment
GCDWQ	Guidelines for Canadian Drinking Water Quality

Technical Term	Definition	
galvanic series	A listing of metals and alloys according to their corrosion potential.	
Giardia Lamblia	A protozoan pothogen which forms cysts when released to the environm which are quite resistant to the most commonly used disinfectants	
granular activated carbon (GAC)	Activated carbon in a granular form, which is used in a bed, much like a conventional filter, to adsorb organic substances from water.	
GNWT	Government of the Northwest Territories	
haloacetic acids	A family of halogenated disinfection by-products believed to cause cancer in humans	
iron	An abundant element found naturally in the earth. As a result, dissolved iron is found in most water supplies. When the concentration of iron exceeds 0.3mg/L, it causes red stains on plumbing fixtures and other items in contact with the water. Dissolved iron can also be present in water as a result of corrosion of cast-iron or steel pipes. This is usually the cause of red-water problems.	
LRAA	locational running annual average method. This means that for every sample location, quarterly samples will be averaged versus averaging all samples from all locations.	
manganese	An abundant element found naturally in the earth. Dissolved manganese is found in many water supplies. At concentrations above 0.05 mg/L, it causes black stains on plumbing fixtures, laundry, and other items in contact with the water.	
maximum contaminant level (MCL)	The maximum allowable concentration of a contaminant in drinking water established by state and/or federal regulations. Primary MCLs are health related and mandatory. Secondary MCLs are related to the aesthetics of water and are highly recommended but not required.	
membrane processes	Water treatment processes in which relatively pure water passes through a porous membrane while particles, molecules, or ions of unwanted matter cexcluded.	
nanofiltration	Membrane filtration capable of removing material in the molecular and ionic range	
nephelometric turbidity unit (NTU)	The amount of turbidity in a water sample as measured by a nephelometric turbidimeter.	
NTU	See nephelometric turbidity unit.	
organic substance (organic)	A chemical substance of animal or vegetable origin, having carbon in its molecular structure.	
oxidation	(1) The chemical reaction in which the valence of an element increases because of the loss of electrons from that element. (2) The conversion of organic substances to simpler, more stable forms by either chemical or biological means.	
oxidize	To chemically combine with oxygen.	
ozonation	The process of applying ozone to water for the purposes of disinfection, or oxidation	
ozone generator	A device that produces ozone by passing an electrical current through air or oxygen.	
pathogen	A disease-causing organism.	
point-of-use (POU) treatment	A water treatment device used by a water customer to treat water at only on point, such as at a kitchen sink. The term is also sometimes used interchangeably with POE to cover all treatment installed on customer services.	
sedimentation	The water treatment process that involves reducing the velocity of water in basins so that the suspended material can settle out by gravity	

Technical Term	Definition		
sedimentation basin	A basin or tank in which water is retained to allow settleable matter, such as floc, to settle by gravity. Also called a settling basin, settling tank, or sedimentation tank.		
sludge	The accumulated solids separated from water during treatment.		
total organic carbon (TOC)	The amount of carbon bound in organic compounds in a water sample determined by a standard laboratory test.		
trihalomethane (THM)	A compound formed when natural organic substances from decaying vegetation and soil (such as humic and fulvic acids) react with chlorine.		
turbidity	A physical characteristic of water making the water appear cloudy The condition is caused by the presence of suspended matter.		
UV disinfection	Disinfection using ultraviolet light.		

APPENDIX C S GUIDELINE SUMMARY

Water Treatment Goals

Earth Tech Canada has reviewed legislation pertaining to drinking water quality requirements for the Northwest Territories (NWT) as set out in the Public Water Supply Regulations (1990) under the Public Health Act. These NWT requirements follow the Guidelines for Canadian Drinking Water Quality (GCDWQ, 6th Edition). However, given the heightened awareness of water quality regulations due to outbreaks of waterborne disease in the past few years, it is pertinent, when considering the design of any new water treatment facility, that water quality goals be set based on existing and anticipated regulations across North America wherever practical and cost effective.

Unfortunately for purveyors of water, drinking water regulations tend to be a "moving target", and are continually evolving as a greater understanding of the health effects of contaminants in drinking water is developed. Historically, drinking water regulations in Canada have a history of mimicking, drinking water regulations developed by the United States Environmental Protection Agency (USEPA). Therefore, before we can establish a reasonable set of water quality objectives for Sachs Harbour to serve into the future, it is prudent not only to summarize the present NWT and Canadian Federal regulations and guidelines, but also the USEPA regulations of relevance to the Community.

Existing NWT Regulations

The body of law governing water supply in the NWT is straight forward, as far as drinking water quality is concerned. The Public Water Supply Regulations (1990) under the Public Health Act dictates the water quality requirements in the NWT. Upon inspection of the Public Water Supply Regulations it is clear that these mimic the GCDWQ and therefore we will discuss both regulations together.

Guidelines for Canadian Drinking Water Quality

The Guidelines for Canadian Drinking Water Quality (GCDWQ) were published most recently in the 6th edition in 1996¹. In order to keep interested parties informed of changes to the Guidelines, a summary table is updated and published every spring on Health Canada's Web site, the most recent update being in April, 2002². The Guidelines were prepared by the Federal-Provincial-Territorial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environmental and Occupational Health, and the Guidelines were published by authority of the Minister of Health. The guidelines include limits for a variety of drinking water parameters, and sub-classify those parameters into 3 sub-groups:

¹ Health Canada – "Guidelines for Canadian Drinking Water Quality", 6th Edition, 1996.

² The update are available on the Internet at: http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/summary.pdf

- Those which have a known or suspected health effect, based upon epidemiological and toxicological study. These parameters have been granted a Maximum Acceptable Concentration, or MAC beyond which these health effects may occur, based upon lifelong consumption of drinking water containing the substance at that concentration. Common drinking water parameters for which a MAC is specified in the GCDWQ include: mercury, cyanide, and turbidity. It is of note that the MAC for turbidity is specified not due to direct health effects, but rather due to the fact that elevated turbidity can lead to indirect health effects by hindering effective disinfection.
- Those parameters for which there is believed to be a health effect, but for which insufficient toxicological data has been collected at present. For these parameters, an Interim MAC (or IMAC) is specified, based upon what is believed to be the MAC, but with an increased factor of safety included to compensate for the lack of available data. IMAC's by definition are subject to amendment as further data becomes available. Common drinking water parameters which have been granted an IMAC in the 6th Edition include arsenic, and total trihalomethanes
- Those parameters which may adversely affect the palatability of the water to consumers. An aesthetic objective, or AO, has been specified for these parameters. Common drinking water parameters governed by aesthetic objectives include iron, manganese, turbidity (direct effect only), true colour, taste and odour, and pH.

Table 2 presents a list of some of the most common drinking water parameters of concern, and includes the MAC, IMAC, or AO for each of these parameters. It is to be noted that the parameters listed in Table 2 focus primarily upon chemical or physical properties of the water, and none of the parameters in the table are microbiological in nature. The GCDWQ do provide guidelines for the microbiological quality of the drinking water, but the focus is on total and faecal coliform bacteria. Section 3.4 of the Guidelines stipulates a sampling frequency that must be followed, and Section 3.2 specifies a MAC for total coliform bacteria. Heterotrophic plate counts (HPC) can also be used to estimate background colony counts. The MAC for coliforms published in the Guidelines is zero organisms detectable per 100 mL. However, the Guidelines also present an alternative list of conditions by which drinking water may detect coliforms occasionally but still be considered in compliance with the MAC for coliform bacteria. These conditions consist of:

- No sample should contain more than 10 total coliforms per 100 mL, none of which should be faecal
- No consecutive sample from the same site should show the presence of coliform organisms
- For a community drinking water system, no more than one set of samples taken from the community on a given day should show the presence of coliform organisms, and not more than 10% of the samples based upon a minimum of 10 samples should show the presence of coliform bacteria.

• Recommended minimum sampling frequency for a community the size of Tsiigehtchic are 4 samples per month.

Currently limited guidance is provided on other pathogens, particularly Giardia and viruses, but also Cryptosporidium. The GCDWQ recommends that "it is desirable, however, that no viruses or protozoa (e.g. Giardia) be detected. A water treatment system that provides effective filtration and disinfection and maintains an adequate disinfectant residual should produce water of an acceptable quality in this regard". Essentially, the GCDWQ advocates finished water devoid of viruses or protozoa, without providing concrete guidelines for meeting this objective.

Table 2
Some Common Drinking Water Parameters included in the GCDWO

Parameter	MAC, mg/L (unless otherwise noted)	IMAC, mg/L (unless otherwise noted)	AO, mg/L (unless otherwise noted)
Arsenic		0.025	paluunin kun kan kan kan kan kan kan kan kan kan ka
Barium	1.0	0.020	
Cadmium	0.005		
Chloramines (total)	3.0		
Chloride			≤ 250
Chromium	0.05		
True Colour			≤ 15 TCU ¹
Copper			≤ 1.0
Cyanide	0.2		
Fluoride	1.5		
Iron			≤ 0.3
Lead	0.01		
Manganese			≤ 0.05
Mercury	0.001		
Nitrate	45		
Odour			Inoffensive
pН			6.5 - 8.5
Sodium			≤ 200
Sulphate			≤ 500
Taste			Inoffensive
Temperature			≤ 15 °C
Total Dissolved Solids			≤ 500
Trihalomethanes (total)		0.1	
Turbidity (see note 3 below)	1 NTU ²		≤ 5 NTU, at the point of consumption

Notes:

- 1. TCU: True Colour units. Denotes the use of a colorimetric colour analysis to determine colour of the water against a standard (blank) sample. The true colour test involves pre-filtration of the source water to eliminate interference effects due to turbidity.
- 2. NTU: Nephelometric Turbidity Units.
- 3. The GCDWQ specify two discrete limits for turbidity; An MAC of 1 NTU leaving the plant, to ensure that disinfection is not compromised by the masking of micro-organisms within particles, and an AO of 5 NTU at the point of consumption, to ensure that the cloudiness of the water does not reach unpalatable levels to the consumer.

If any of the above criteria are exceeded, corrective action should be taken immediately. The most common immediate actions include re-sampling to confirm positive results. If the presence of coliforms is confirmed, the cause should be determined if possible, and corrective action taken as appropriate.

Table 2 indicates the current turbidity guidelines under the GCDWQ, however, the Federal-Provincial-Territorial Subcommittee on Drinking Water has issued a document "Turbidity in Drinking Water" for public comment until October, 2002. This document provides proposed new guidelines that will be adopted under the GCDWQ in the near future. The proposed guidelines are technology based and a summary is as follows:

- Chemically assisted filtration filtered water less than 0.3 NTU and never greater than 1.0 NTU when the source water turbidity is greater than 1.5 NTU on a monthly average.
- Chemically assisted filtration filtered water less than 0.2 NTU and never greater than 1.0 NTU when the source water turbidity is less than 1.5 NTU on a monthly average.
- Slow sand or diatomaceous earth filtration filtered water less than 1.0 NTU and never greater than 3.0 NTU.
- Membrane filtration filtered water less than 0.1 NTU and never greater than 0.3 NTU.
- The aesthetic objective for turbidity in the water at the point of consumption should be less than or equal to 5.0 NTU.

Therefore, it is clear that the turbidity goals for the Community should be set greater than the current GCDWQ in anticipation of the changes outlined above.

Current U.S. Drinking Water Regulations

The Safe Drinking Water Act (SDWA) was enacted by the United States Congress and signed into law in 1974. Through the SDWA, the federal government gave the United States Environmental Protection Agency (the USEPA) the authority to set standards for contaminants in drinking water supplies.

In 1986 and 1996, U.S. Congress passed two sets of amendments to the SDWA. The provisions of these amendments currently govern the process through which the USEPA develops drinking water regulations and sets compliance dates. Under these provisions, the USEPA has published a Drinking Water Contaminant Candidate List (CCL). The contaminants on this list are not currently regulated and every five years, the USEPA is charged to select five contaminants from this list to determine whether or not to regulate their concentration in drinking water.

³ Federal-Provincial-Territorial Subcommittee on Drinking Water – "<u>Turbidity in Drinking Water</u>", November 2001

Current Federal Regulations

In accordance with the SDWA and its amendments, the USEPA has established a number of drinking water regulations and the major ones are discussed below. For the sake of brevity, only those regulations which may one day have impact on the Community by forming a benchmark for future Canadian Federal or Provincial regulations are discussed herein.

National Primary Drinking Water Regulations (Finalized in 1975)

This included standards for 22 compounds that were originally adopted by the USEPA under the SDWA. These contaminants have since been updated or replaced by subsequent regulations. See **Table 3** for a list of current maximum contaminant levels.

Secondary Drinking Water Regulations (Finalized in 1979, 1991)

Standards for compounds established under these regulations are advisory in nature from the USEPA and are applied as determined by each State. These standards generally address aesthetic issues related to drinking water.

Surface Water Treatment Rule (Finalized in 1989)

The Surface Water Treatment Rule (SWTR) was promulgated to control the levels of turbidity, Giardia lamblia, Legionella, viruses, and heterotrophic plate count bacteria in drinking waters. Filtration is required for all surface water supplies and groundwater supplies under the influence of surface waters. Exemptions to filtration are given only when the utility has control of the source watershed and the watershed produces a pristine water supply that meet rigid water quality standards.

The turbidity requirements established in the SWTR for conventional filtration plants include:

- a. "...the turbidity of representative samples of a system's filtered water must be less than or equal to 0.5 NTU in at least 95 percent of the measurements taken each month..."
- b. "The turbidity level of representative samples of a system's filtered water must at no time exceed 5 NTU..."

The disinfection requirements for systems that filter include:

- a. "The disinfection treatment must be sufficient to ensure that the total treatment processes of that system achieve at least 99.9 percent (3-log) inactivation and/or removal of Giardia lamblia cysts and at least 99.99 percent (4-log) inactivation and/or removal of viruses, as determined by the State."
- b. "The residual disinfectant concentration in the water entering the distribution system...cannot be less than 0.2 mg/L for more than 4 hours."

c. "The residual disinfectant concentration in the distribution system cannot be undetectable in more than 5 percent of the samples each month. Water in the distribution system with a heterotrophic bacteria concentration less than or equal to 500/mL, is deemed to have a detectable disinfectant residual for purposes of determining compliance with this requirement."

A conventional water treatment plant meeting SWTR requirements is given 99.7% removal credit for Giardia and 99% removal credit for viruses. The remaining required log removal is met through disinfection with sufficient contact times as determined in the USEPA Guidance Manual to the SWTR.

Interim Enhanced Surface Water Treatment Rule (1998)

This rule amended the existing SWTR and added requirements for inactivation of Cryptosporidium. This rule was promulgated along with the Stage 1 D/DBP rule (see below) to address risk trade-offs with disinfection by-products. Under this rule, systems must continue to meet existing requirements for Giardia lamblia and viruses plus meet the following:

- 99% Cryptosporidium removal requirements for systems that filter
- Strengthened combined filter effluent turbidity performance standards
- Individual filter turbidity monitoring provisions
- Requirements for covers on new finished water reservoirs

In addition, the rule includes disinfection profiling and benchmarking provisions to assure continued levels of microbial protection while facilities take the necessary steps to comply with new DBP standards. Conventional and direct filtration plants that meet the strengthened turbidity performance standards are granted 99% Cryptosporidium removal credit. Utilities must have been in compliance with this rule by January 1, 2002.

Stage 1 D/DBP Rule (Finalized 1998)

This rule revised the maximum contaminant level for trihalomethanes to 80 ug/L. It also sets maximum contaminant levels for haloacetic acid (5) at 60 ug/L, chlorite at 1 mg/L and bromate at 10 ug/L. In addition, the rule sets maximum residual disinfectant level for chlorine and chloramine at 4 mg/L (as Cl₂) and for chlorine dioxide at 0.8 mg/L (as ClO₂). Furthermore, conventional treatment plants whose source water is a surface supply must reduce total organic carbon through the use of enhanced coagulation. Utilities must have been in compliance with this rule by January 1, 2002.

Long Term 1 Enhanced Surface Water Treatment Rule (Finalized Jan 2002)

This rule extends the requirements (with some modifications) of the Interim Enhanced Surface Water Treatment Rule to smaller water systems (i.e. systems serving less than 10,000 people). Compliance date for most of the rule requirements will be in 2005.

Table 3
U.S. Primary Drinking Water Standards

Parameter	Value
Disinfectants & Disinfection By-products	MCL (mg/L)
Bromate	0.01
Chloramines (as C12)	MRDL=4.0
Chlorine (as Cl2)	MRDL=4.0
Chlorine dioxide (as ClO2)	MRDL=0.8
Chlorite	1
Haloacetic acids (HAA5)	0.06
Total Trihalomethanes (TTHM's)	0.08
Inorganic Chemicals	MCL (mg/L)
Antimony	0.006
Arsenic	0.05
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium (total)	0.1
Copper	Action Level=1.3
Cyanide (as free cyanide)	0.2
Fluoride	4
Lead	Action Level=0.015
Mercury (inorganic)	0.002
Nitrate (measured as Nitrogen)	10
Nitrite (measured as Nitrogen)	1
Selenium	0.05
Thallium	0.002

Notes:

- 1. MRDL: Maximum Residual Disinfectant Level
- 2. MCL: Maximum Concentration Limit, equivalent to the MAC, or Maximum Acceptable Concentration in the GCDWQ
- 3. Action Level: The point at which a purveyor of water must take action to mitigate levels of contaminant in the water supply

Anticipated Future U.S. Federal Regulations

In addition to the current regulations, the USEPA is developing a number of new regulations to safeguard public drinking water. Some of these regulations have been officially proposed and have gone through the public comment period. Others are still being developed by the USEPA with input from various advisory panels. These anticipated regulations are briefly described below. It is important to note that these descriptions reflect the general understanding of the direction that the USEPA may take with these regulations as of January 2003. Until these regulations are finalized, the content of the regulations remain subject to change.

Anticipated Stage 2 D/DBP Rule

In December 2000, the Federal Advisory Committee signed an Agreement in Principle that will guide the USEPA in preparing a proposal for the anticipated Stage 2 D/DBP Rule. A pre-proposal draft of the preamble and regulatory language of this rule was released in 2001. The proposed rule is expected to keep the maximum contaminant levels established for THM's, HAA5, bromate and chlorite the same as those established in the Stage 1 D/DBP Rule; however, the methods for determining compliance are expected to change.

To determine compliance, the running averages of four quarterly samples will be reported for each sample location and will not be averaged across locations. This method of locational averaging instead of the system-wide averaging may be more difficult for utilities to be in compliance, due to areas where DBP levels are much higher than system average. To transition from the system-wide averaging to the locational averaging methods, the Stage 2 Rule will include interim maximum contaminant levels. Beginning with three years after promulgation of the Stage 2 Rule, the maximum contaminant level for THM and HAA5 using the new locational running annual average (LRAA) method will be 120 ug/L and 100 ug/L, respectively. During this period, utilities must continue to meet the requirements of Stage 1 D/DBP rule. This interim standard will last for three years before compliance with 80 ug/L of THM and 60 ug/L of HAA5 is expected using the new locational averaging method.

Anticipated LT2 Enhanced Surface Water Treatment Rule

In December 2000, the Federal Advisory Committee signed an Agreement in Principle that will guide the USEPA in preparing a proposal for the anticipated Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The USEPA released the preproposal draft of this rule in 2001 and the draft in 2003. The anticipated LT2ESWTR will classify water systems into categories of additional Cryptosporidium removal requirements based on results from 24 months of monitoring. If the system's source water is classified in the lowest bin, no additional Cryptosporidium inactivation will be required. The bin classifications are as follows (where "C" is the annual average Cryptosporidium oocyst counts per Litre (**Table 4**).

Table 4
Cryptosporidium Bin Definitions under the Proposed U.S. the USEPA LT2ESWTR

Cryptosporidium Average Concentration	Overall Cryptosporidium Objective
(oocysts per L)	
$C < 0.075/L \ (Bin \#1)$	99.9% (3-log removal or inactivation)
0.075 < C < 1.0 counts/L (Bin #2)	99.99% (4-log removal or inactivation)
1.0 < C < 3.0 counts/L (Bin #3)	99.999% (5-log removal or inactivation)
C ≥ 3.0 counts/L (Bin #4)	99.9997% (5.5-log removal or inactivation)

Systems in the highest bin will require 99.7% log of additional Cryptosporidium inactivation in addition to the requirements of the Interim Enhanced Surface Water Treatment Rule. The proposed rule is expected to provide a "toolbox" of options to meet the treatment requirements. The rule will also address uncovered finished water reservoirs. The reservoirs must either be covered, be treated at the outlet to achieve 99.99% virus inactivation, or be deemed by the state as having adequate risk mitigation in the areas of physical access, surface water run-off, animal and bird waste, and on-going water quality assessment. The Stage 2 DBP Rule was expected to be proposed by third quarter 2002 and finalized by third quarter 2003.

APPENDIX D RAW WATER QUALITY TEST RESULTS

Raw Water Test Results

Parameter	Units	15-Aug-02	25-Jul-03
Alkalinity	mg/L	132	129
Arsenic	mg/L	< 0.001	
Calcium	mg/L	44.6	46.6
Chloride	mg/L	62.4	66.2
Colour	TCU	5	<5
Cyanide	mg/L	< 0.003	
Fluoride	mg/L	0.06	0.02
Iron	mg/L	0.068	
Magnesium	mg/L	29.8	24.8
Mercury	mg/L	<0.00005	
Nitrate	mg/L	<0.008	
рН		8.32	8.18
Potassium		1.48	1.37
Sodium	mg/L	13.3	11.4
Sulphate	mg/L	36	34.1
Total Dissolved Solids	mg/L	336	330
Total Suspended Solids	mg/L		4
Total Hardness	mg/L as CaCo3	234	218
Total Organic Carbon	mg/L	2.8	
Turbidity	NTU	0.8	3.3

APPENDIX E

SUMMARY OF GUIDELINES FOR CANADIAN DRINKING WATER QUALITY

Summary of Guidelines for Canadian Drinking Water Quality

Prepared by the

Federal Provincial Territorial Committee on Drinking Water
of the

Federal Provincial Territorial Committee
on Environmental and Occupational Health

April 2003

The Guidelines for Canadian Drinking Water Quality are published by Health Canada. In order to keep interested parties informed of changes to the Guidelines between publication of new editions, this summary table is updated and published every spring on Health Canada⊠ website (www.hc-sc.gc.ca/waterquality). The April 2003 "Summary of Guidelines for Canadian Drinking Water Quality □supercedes all previous versions, including that contained in the published booklet.

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Healthy Environments and Consumer Safety Branch)

Mr. David Green

New, Revised and Reaffirmed Guidelines

New, revised and reaffirmed guidelines for chemical, physical and microbiological parameters are presented in Table 1.

Table 1
New, Revised and Reaffirmed Guidelines* for Chemical, Physical and Microbiological Parameters since the Publication of the Sixth Edition of the Guidelines for Canadian Drinking Water Quality

Parameter	Guideline (mg/L)	Previous guideline (mg/L)	Year approved
Chemical and Physical Paramet	ers		
Aluminum	0.1**	None	1998
Antimony	IMAC 0.006	None	1997
Bromate	IMAC 0.01	None	1998
Cyanobacterial toxins (as Microcystin-LR)	0.0015	None	2002
Fluoride	MAC 1.5	MAC 1.5	1996
Formaldehyde	None required ☐see Table 3	None	1997
Uranium	IMAC 0.02	MAC 0.1	1999
Microbiological Parameters			
Bacteria	***		Ongoing
Protozoa	***	The state of the s	Ongoing
Viruses	***		Ongoing

^{*} MAC = maximum acceptable concentration; IMAC = interim maximum acceptable concentration.

Summary of Guidelines for Microbiological Parameters

Bacteria (Under Review)

The maximum acceptable concentration (MAC) for bacteriological quality of public, semi-public, and private drinking water systems is no coliforms detectable per 100 mL. However, because coliforms are not uniformly distributed in water and are subject to considerable variation in public health significance, drinking water that fulfills the following conditions is considered to conform to this MAC:

Public Drinking Water Systems

1. No sample should contain *Escherichia coli*. *E. coli* indicates recent faecal contamination and the possible presence of enteric pathogens that may adversly affect human health. If *E. coli* is confirmed, the appropriate agencies should be notified, a boil water advisory should be issued, and corrective actions taken.

^{**} Refer to note 1 in Table 2.

^{***} Refer to section on Summary of Guidelines for Microbiological Parameters.

2. No consecutive samples from the same site or not more than 10% of samples from the distribution system in a given calendar month should show the presence of total coliform bacteria. The ability of total coliforms to indicate the presence of faecal pollution is less reliable than E. coli. However, this group of bacteria is a good indicator of quality control. The presence of total coliforms does not necessarily require the issuance of a boil water advisory but corrective actions should be taken.

Semi-public and Private Drinking Water Supply Systems

- 1. No sample should contain *E. coli*. As stated above, the presence of *E. coli* indicates faecal contamination and the possible presence of enteric pathogens; therefore the water is unsafe to drink. If *E. coli* is detected, a boil water advisory should be issued and corrective actions taken.
- 2. No sample should contain total coliform bacteria. In non-disinfected well water, the presence of total coliform bacteria in the absence of E. coli indicates the well is prone to surface water infiltration and therefore at risk of faecal contamination. In disinfected water systems, the presence of total coliform bacteria indicates a failure in the disinfection process. In both disinfected and non-disinfected systems, total coliform detection may also indicate the presence of biofilm in the well or plumbing system. The degree of response to the presence of total coliform bacteria, in the absence of E. coli, may be site specific and can vary between jurisdictions.

Protozoa (Under Review)

Numerical guidelines for the protozoa *Giardia* and *Cryptosporidium* are not proposed at this time. Routine methods available for the detection of protozoan cysts and oocysts suffer from low recovery rates and do not provide any information on their viability or human infectivity. Nevertheless, until better monitoring data and information on the viability and infectivity of cysts and oocysts present in drinking water are available, measures to reduce the risk of illness as much as possible should be implemented. If viable, human-infectious cysts or oocysts are present or suspected to be present in source waters or if *Giardia* or *Cryptosporidium* has been responsible for past waterborne outbreaks in a community, a treatment regime and a watershed or wellhead protection plan (where feasible) or other measures known to reduce the risk of illness should be implemented.

Viruses (Under Review)

Numerical guidelines for human enteric viruses are not proposed at this time. There are more than 120 types of human enteric viruses, many of which are non-culturable. Testing is complicated, expensive, not available for all viruses, and beyond the capabilities of most laboratories involved in routine water quality monitoring. The best means of safeguarding against the presence of human enteric viruses are based upon the application of adequate treatment and the absence of faecal indicator organisms, such as *Escherichia coli*.

Boil Water Advisories

General guidance on the issuing and rescinding of boil water advisories is provided. In the event of an advisory, a rolling boil for 1 minute is considered adequate.

Summary of Guidelines for Chemical and Physical Parameters

Parameters with Guidelines

Guidelines for all chemical and physical parameters, including all new, revised and reaffirmed maximum acceptable concentrations (MACs), interim maximum acceptable concentrations (IMACs) and aesthetic objectives (AOs), are listed in Table 2. For more information on the drinking water guideline for any particular compound, please refer to the Supporting Documentation for the parameter of concern.

Table 2 Summary of Guidelines for Chemical and Physical Parameters

_	MAC	IMAC	AO
Parameter	(mg/L)	(mg/L)	(mg/L)
aldicarb	0.009		
aldrin + dieldrin	0.0007		
aluminum ¹			
antimony		0.006 2	
arsenic		0.025	
atrazine + metabolites		0.005	
azinphos-methyl	0.02		
barium	1.0		
bendiocarb	0.04		- Color - Manual Color - Color
benzene	0.005		
penzo[a]pyrene	0.00001		
boron	The second secon	5	1000
bromate		0.01	
bromoxynil		0.005	
cadmium	0.005		
carbaryl	0.09		
carbofuran	0.09		
carbon tetrachloride	0.005		
chloramines (total)	3.0		
chloride			≤250
chlorpyrifos	0.09		
chromium	0.05		
colour			≤15 TCU ⁴
copper ²			≤1.0
cyanazine		0.01	
cyanide	0.2		
cyanobacterial toxins (as microcystin	n-LR) 3 0.0015		
diazinon	0.02		
dicamba	0.12		
dichlorobenzene, 1,2-5	0.20		≤0.003
dichlorobenzene, 1,4-5	0.005		≤0.001
dichloroethane, 1,2-	***************************************	0.005	
dichloroethylene, 1,1-	0.014		
dichloromethane	0.05		
dichlorophenol, 2,4-	0.9		≤0.0003
dichlorophenoxyacetic acid, 2,4- (2,		0.1	30.0003
diclofop-methyl	0.009	V.1	
limethoate		0.02	
dinoseb	0.01	0.02	
diquat	0.07		
diuron	0.15		
ethylbenzene	V-10		<0.0024
fluoride 6	1.5		≤0.0024
	1/		

D	MAC	IMAC	AO
Parameter	(mg/L)	(mg/L)	(mg/L)
iron			≤0.3
lead ²	0.010		
malathion	0.19		
manganese			≤0.05
mercury	0.001		
methoxychlor	0.9		
metolachlor		0.05	
metribuzin	0.08	ALL STATE OF THE S	
monochlorobenzene	0.08		≤0.03
nitrate 7	45		
nitrilotriacetic acid (NTA)	0.4		
odour			Inoffensive
paraquat (as dichloride)		0.01 8	
parathion	0.05		
pentachlorophenol	0.06		≤0.030
pH			6.5 🗆 8.5 9
phorate	0.002		
picloram		0.19	
selenium	0.01		
simazine	100 000	0.01	
sodium 10			≤200
sulphate 11			≤500
sulphide (as H ₂ S)			≤0.05
taste			Inoffensive
temperature			≤15°C
terbufos		0.001	
tetrachloroethylene	0.03		
tetrachlorophenol, 2,3,4,6-	0.1		≤ 0.001
toluene			≤0.024
total dissolved solids (TDS)			≤500
trichloroethylene	0.05		
trichlorophenol, 2,4,6-	0.005		≤0.002
trifluralin		0.045	
trihalomethanes (total) 12		0.1	
turbidity	1 NTU 13		≤5 NTU 13,14
uranium		0.02	
vinyl chloride	0.002		
xylenes (total)			≤0.3
zinc ²			≤5.0
The second control of			20.0

Notes:

- A health-based guideline for aluminum in drinking water has not been established. However, water treatment plants using
 aluminum-based coagulants should optimize their operations to reduce residual aluminum levels in treated water to the lowest
 extent possible as a precautionary measure. Operational guidance values of less than 100 μg/L total aluminum for conventional
 treatment plants and less than 200 μg/L total aluminum for other types of treatment systems are recommended. Any attempt to
 minimize aluminum residuals must not compromise the effectiveness of disinfection processes or interfere with the removal of
 disinfection by-product precursors.
- Because first-drawn water may contain higher concentrations of metals than are found in running water after flushing, faucets should be thoroughly flushed before water is taken for consumption or analysis.
- The guideline is considered protective of human health against exposure to other microcystins (total microcystins) that may also be present.
- 4. TCU = true colour unit.
- In cases where total dichlorobenzenes are measured and concentrations exceed the most stringent value (0.005 mg/L), the
 concentrations of the individual isomers should be established.
- It is recommended, however, that the concentration of fluoride be adjusted to 0.8 □.0 mg/L, which is the optimum range for the control of dental caries.
- Equivalent to 10 mg/L as nitrate introgen. Where nitrate and nitrite are determined separately, levels of nitrite should not exceed 3.2 mg/L.
- 8. Equivalent to 0.007 mg/L for paraquat ion.
- 9. No units.
- 10. It is recommended that sodium be included in routine monitoring programmes, as levels may be of interest to authorities who wish to prescribe sodium-restricted diets for their patients.
- 11. There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L.
- 12. The IMAC for trihalomethanes is expressed as a running annual average. It is based on the risk associated with chloroform, the trihalomethane most often present and in greatest concentration in drinking water. The guideline is designated as interim until such time as the risks from other disinfection by-products are ascertained. The preferred method of controlling disinfection by-products is precursor removal; however, any method of control employed must not compromise the effectiveness of water disinfection.
- 13. NTU = nephelometric turbidity unit.
- 14. At the point of consumption.

Parameters without Guidelines

Since 1978, some chemical and physical parameters have been identified as not requiring a numerical guideline. Table 3 lists these parameters.

The reasons for parameters having no numerical guideline include the following:

- currently available data indicate no health risk or aesthetic problem (e.g., calcium);
- data indicate the compound, which may be harmful, is not registered for use in Canada (e.g., 2,4,5-TP) or is not likely to occur in drinking water at levels that present a health risk (e.g., silver); or
- the parameter is composed of several compounds for which individual guidelines may be required (e.g., pesticides [total]).

Table 3
Summary List of Parameters without Guidelines

Parameter	Parameter
ammonia	
asbestos	phenols
calcium	phthalic acid esters (PAE)
chlordane (total isomers)	polycyclic aromatic hydrocarbons (PAH) ²
dichlorodiphenyltrichloroethane (DDT) + metabolites	radon
endrin	resin acids
formaldehyde	silver
gasoline	tannin
hardness 1	temephos
heptachlor + heptachlor epoxide	total organic carbon
lignin	toxaphene
lindane	triallate
magnesium	trichlorophenoxyacetic acid, 2,4,5- (2,4,5-T)
methyl-parathion	trichlorophenoxypropionic acid, 2,4,5- (2,4,5-TP)
mirex	

Notes

Public acceptance of hardness varies considerably. Generally, hardness levels between 80 and 100 mg/L (as CaCO₃) are considered acceptable; levels greater than 200 mg/L are considered poor but can be tolerated; those in excess of 500 mg/L are normally considered unacceptable. Where water is softened by sodium ion exchange, it is recommended that a separate, unsoftened supply be retained for culinary and drinking purposes.

2. Other than benzo[a]pyrene.

Summary of Guidelines for Radiological Parameters

In setting dose guidelines for radionuclides in drinking water, it is recognized that water consumption contributes only a portion of the total radiation dose and that some radionuclides present are natural in origin and therefore cannot be excluded. Consequently, maximum acceptable concentrations (MACs) for radionuclides in drinking water have been derived based on a committed effective dose of 0.1 mSv* from one years consumption of drinking water. This dose represents less than 5% of the average annual dose attributable to natural background radiation.

To facilitate the monitoring of radionuclides in drinking water, the reference level of dose is expressed as an activity concentration, which can be derived for each radionuclide from published radiological data. The National Radiological Protection Board has calculated dose conversion factors (DCFs) for radionuclides based on metabolic and dosimetric models for adults and children. Each DCF provides an estimate of the 50-year committed effective dose resulting from a single intake of 1 Bq** of a given radionuclide.

The MACs of radionuclides in public water supplies are derived from adult DCFs, assuming a daily water intake of 2 L, or 730 L/year, and a maximum committed effective dose of 0.1 mSv, or 10% of the International Commission on Radiological Protection limit on public exposure:

MAC (Bq/L) =
$$\frac{1 \times 10^{-4} \text{ (Sv/year)}}{730 \text{ (L/year)} \times \text{DCF (Sv/Bq)}}$$

* Sievert (Sv) is the unit of radiation dose. It replaces the old unit, rem (1 rem = 0.01 Sv).

** Becquerel (Bq) is the unit of activity of a radioactive substance, or the rate at which transformations occur in the substance. One becquerel is equal to one transformation per second and is approximately equal to 27 picocuries (pCi).

When two or more radionuclides are found in drinking water, the following relationship should be satisfied:

$$\frac{C_1}{\mathsf{MAC}_1} \ + \quad \frac{c_2}{\mathsf{MAC}_2} \ + \quad ... \qquad \frac{c_i}{\mathsf{MAC}_i} \quad \leq l$$

where c_i and MAC_i are the observed and maximum acceptable concentrations, respectively, for each contributing radionuclide.

MACs for radionuclides that should be monitored in water samples are listed in Table 4. If a sample is analysed by gamma-spectroscopy, additional screening for radionuclides that may be present under certain conditions can be performed. MACs for these radionuclides are given in Table 5. MACs for a number of additional radionuclides, both natural and artificial, can be found in the sixth edition of the guidelines booklet.

Water samples may be initially screened for radioactivity using techniques for gross alpha and gross beta activity determinations. Compliance with the guidelines may be inferred if the measurements for gross alpha and gross beta activity are less than 0.1 Bq/L and 1 Bq/L, respectively, as these are lower than the strictest MACs. Sampling and analyses should be carried out often enough to accurately characterize the annual exposure. If the source of the activity is known, or expected, to be changing rapidly with time, then the sampling frequency should reflect this factor. If there is no reason to suppose that the source varies with time, then the sampling may be done annually. If measured concentrations are consistent and well below the reference levels, this would be an argument for reducing the sampling frequency. On the other hand, the sampling frequency should be maintained, or even increased, if concentrations are approaching the reference levels. In such a case, the specific radionuclides should be identified and individual activity concentrations measured.

Table 4
Primary List of Radionuclides □Maximum Acceptable Concentrations

Radionuclide		Half-life t _{1/2}	DCF (Sv/Bq)	MAC (Bq/L)
Natural Radionuclides				
Lead-210	210Pb	22.3 years	1.3×10^{-6}	0.1
Radium-224	224Ra	3.66 days	8.0×10^{-8}	2
Radium-226	226Ra	1600 years	2.2×10^{-7}	0.6
Radium-228	228Ra	5.76 years	2.7×10^{-7}	0.5
Thorium-228	228Th	1.91 years	6.7×10^{-8}	2
Thorium-230	230Th	7.54×10^4 years	3.5×10^{-7}	0.4
Thorium-232	232Th	$1.40 \times 10^{10} \text{ years}$	1.8×10^{-6}	0.1
Thorium-234	234Th	24.1 days	5.7×10^{-9}	20
Uranium-234	234U	$2.45 \times 10^{5} \text{ years}$	3.9×10^{-8}	4*
Uranium-235	235U	$7.04 \times 10^{8} \text{ years}$	3.8×10^{-8}	4*
Uranium-238	238⋃	$4.47 \times 10^{9} \text{ years}$	3.6×10^{-8}	4*
Artificial Radionuclides				
Cesium-134	134Cs	2.07 years	1.9×10^{-8}	7
Cesium-137	137Cs	30.2 years	1.3×10^{-8}	10
Iodine-125	125I	59.9 days	1.5×10^{-8}	10
Iodine-131	131I	8.04 days	2.2×10^{-8}	6
Molybdenum-99	⁹⁹ Mo	65.9 hours	1.9×10^{-9}	70
Strontium-90	90Sr	29 years	2.8×10^{-8}	5
Tritium**	3H	12.3 years	1.8×10^{-11}	7000

^{*} The activity concentration of natural uranium corresponding to the chemical guideline of 0.02 mg/L is about 0.5 Bq/L.

** Tritium is also produced naturally in the atmosphere in significant quantities.

Table 5 Secondary List of Radionuclides

Maximum Acceptable Concentrations (MACs)

Radionuclide		Half-life t _{1/2}	DCF (Sv/Bq)	MAC (Bq/L)
Natural Radionuclides				
Beryllium-7	⁷ Be	53.3 days	3.3×10^{-11}	4000
Bismurh-210	210Bi	5.01 days	2.1×10^{-9}	70
Polonium-210	210Po	138.4 days	6.2×10^{-7}	0.2
Artificial Radionuclides	**			
Americium-241	241 Am	432 years	5.7 × 10-7	0.2
Antimony-122	122Sb	2.71 days	2.8×10^{-9}	50
Antimony-124	124Sb	60.2 days	3.6×10^{-9}	40
Antimony-125	125Sb	2.76 years	9.8×10^{-10}	100
Barium-140	140Ba	12.8 days	3.7×10^{-9}	40
Bromine-82	$82\mathrm{Br}$	35.3 hours	4.8×10^{-10}	300
Calcium-45	45Ca	165 days	8.9 × 10-10	200
Calcium-47	⁴⁷ Ca	4.54 days	2.2×10^{-9}	60
Carbon-14	14C	5730 years	5.6×10^{-10}	200
Cerium-141	141Ce	32.5 days	1.2×10^{-9}	100
Cerium-144	144Ce	284.4 days	8.8×10^{-9}	20
Cesium-131	131Cs	9.69 days	6.6×10^{-11}	2000
Cesium-136	136Cs	13.1 days	3.0×10^{-9}	50
Chromium-51	51Cr	27.7 days	5.3×10^{-11}	3000
Cobalt-57	57Co	271.8 days	3.5×10^{-9}	40
Cobalt-58	58Co	70.9 days	6.8×10^{-9}	20
Cobalt-60	60Co	5.27 years	9.2×10^{-8}	2
Gallium-67	67Ga	78.3 hours	2.6×10^{-10}	500
Gold-198	198Au	2.69 days	1.6×10^{-9}	90
Indium-111	111In	2.81 days	3.9×10^{-10}	400
Iodine-129	129 _I	1.60×10^7 years	1.1×10^{-7}	1
Iron-55	55Fe	2.68 years	4.0×10^{-10}	300
Iron-59	⁵⁹ Fe	44.5 days	3.1×10^{-9}	40
Manganese-54	54Mn	312.2 days	7.3×10^{-10}	200
Mercury-197	197Hg	64.1 hours	3.3×10^{-10}	400
Mercury-203	203 Hg	46.6 days	1.8×10^{-9}	80
Neptunium-239	239Np	2.35 days	1.2×10^{-9}	100
Niobium-95	95Nb	35.0 days	7.7×10^{-10}	200
Phosphorus-32	32P	14.3 days	2.6×10^{-9}	50
Plutonium-238	238Pu	87.7 years	5.1×10^{-7}	0.3
Plutonium-239	239Pu	2.41×10^4 years	5.6×10^{-7}	0.2
Plutonium-240	240Pu	6560 years	5.6×10^{-7}	0.2
Plutonium-241	241Pu	14.4 years	1.1×10^{-8}	10

The activity concentration of natural uranium corresponding to the chemical guideline of 0.1~mg/L (see separate criteria summary on uranium in the Supporting Documentation) is about 2.6~Bq/L.

Tritium and ^{14}C are also produced naturally in the atmosphere in significant quantities.

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Tab	e 5	(cont d)	١

Radionuclide		Half-life t _½	DCF (Sv/Bq)	MAC (Bq/L)
Rhodium-105	105Rh	35.4 hours	5.4×10^{-10}	300
Rubidium-81	⁸¹ Rb	4.58 hours	5.3×10^{-11}	3000
Rubidium-86	86Rb	18.6 days	2.5×10^{-9}	50
Ruthenium-103	103Ru	39.2 days	1.1×10^{-9}	100
Ruthenium-106	106Ru	372.6 days	1.1×10^{-8}	10
Selenium-75	75Se	119.8 days	2.1×10^{-9}	70
Silver-108m	108mAg	127 years	2.1×10^{-9}	70
Silver-110m	110mAg	249.8 days	3.0×10^{-9}	50
Silver-111	111Ag	7.47 days	2.0×10^{-9}	70
Sodium-22	²² Na	2.61 years	3.0×10^{-9}	50
Strontium-85	85Sr	64.8 days	5.3×10^{-10}	300
Strontium-89	89Sr	50.5 days	3.8×10^{-9}	40
Sulphur-35	35S	87.2 days	3.0×10^{-10}	500
Technetium-99	99Tc	2.13×10^5 years	6.7×10^{-10}	200
Technetium-99m	99mTc	6.01 hours	2.1×10^{-11}	7000
Tellurium-129m	129mTe	33.4 days	3.9×10^{-9}	40
Tellurium-131m	131mTe	32.4 hours	3.4×10^{-9}	40
Tellurium-132	132Te	78.2 hours	3.5×10^{-9}	40
Thallium-201	201T1	3.04 days	7.4×10^{-11}	2000
Ytterbium-169	169Yb	32.0 days	1.1×10^{-9}	100
Yttrium-90	90Y	64 hours	4.2×10^{-9}	30
Yttrium-91	91Y	58.5 days	4.0×10^{-9}	30
Zinc-65	65Zn	243.8 days	3.8×10^{-9}	40
Zirconium-95	95Zr	64.0 days	1.3×10^{-9}	100

Sachs Harbour Clarification-Filters-UV Membranes Order of Magnitude Cost

Design Horizon Population Plant Production (hrs/day)		192 22
Design Water Demands		
Average Day Demand Based (L/day) Peaking Factor Maximum Day Demand Based (L/day) Plant Production including Wastes (L/day) assumes 10% Plant Production Rate (L/min) Operating Storage (Max Day less 8 hours production)		18043 2.1 37890 41680 32 26320
WTP Estimated Capital Co	sts	
Clarification-Filter Skid Process Piping Treated Water Pumps Treated Water Storage Sludge Storage New Raw Water Pump/Intake Pumping Building (120m²) Mechanical Electrical/Instrumentation (with generator) Siteworks Mobilization Sub Total Contingency (20%) Grand Total	\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	125,000 40,000 12,500 40,000 10,000 190,000 380,000 125,000 45,000 45,000 68,000 1,230,500 246,100 1,476,600
Estimated Yearly WTP Operating	ng Costs	
Labour Materials Contract Services Utilities Subtotal Admin Fee (6%) GST (7%)	\$ \$ \$ \$ \$ \$	40,000 10,000 5,000 70,000 125,000 7,500 9,275
Grand Total	\$	141,775
Interest Rate NPV of O&M Costs (20 year life cycle)	\$	8% 1,503,325

Sachs Harbour Ultrafitration Membranes Order of Magnitude Cost

Design Horizon Population Plant Production (hrs/day)		192 22				
Flant Froduction (mis/day)		22				
Design Water Demands	;					
Average Day Demand Based (L/day) Peaking Factor		18043 2.1				
Maximum Day Demand Based (L/day) Plant Production including Wastes (L/day) assumes 10% Plant Production Rate (L/min)		37890 41680 32				
Operating Storage (Max Day less 8 hours production)		26320				
WTP Estimated Capital Costs						
UF Membrane Skid	\$	150,000				
Process Piping		40,000				
Treated Water Pumps	\$ \$ \$ \$	12,500				
Treated Water Storage	\$	40,000				
Sludge Disposal (Pipe to Water Lake)	\$	150,000				
New Raw Water Pump/Intake Pumping	\$	190,000				
Building (120m ²)		380,000				
Mechanical	\$	125,000				
Electrical/Instrumentation (with generator)	\$	195,000				
Siteworks	\$	45,000				
Mobilization	\$ \$ \$ \$ \$	68,000				
Sub Total	\$	1,395,500				
Contingency (20%)		279,100				
Sub Total	\$	1,674,600				
Contractor (20%)	\$	334,920				
Grand Total	\$	2,009,520				
Estimated Yearly WTP Operation	na Costs					
Labour	\$	35,000				
Materials (Membrane replacement every 5 years)	\$	15,000				
Contract Services	\$	5,000				
Utilities	\$	70,000				
Subtotal	\$	125,000				
Admin Fee (6%)	\$	7,500				
GST (7%)	\$ \$	9,275				
551 (1.75)	Ψ	0,210				
Grand Total	\$	141,775				
Interest Rate		8%				
NPV of O&M Costs (20 year life cycle)	\$	1,503,325				

Sachs Harbour Cartridge Filtration-UV Future-Chlorination Membranes Order of Magnitude Cost

Design Horizon		
Population Plant Production (hrs/day)		192
Fiant Floduction (nis/day)		22
Design Water Demand	s	
Average Day Demand Based (L/day)		18043
Peaking Factor		2.1
Maximum Day Demand Based (L/day)		37890
Plant Production Rate (L/min)		1000
WTP Estimated Capital Co	osts	
Cartridge Filters	\$	85,000
Process Piping	\$	30,000
New Raw Water Pump/Intake Pumping	\$	190,000
Building (50m ²)	\$	410,000
Mechanical	\$ \$	119,000
Electrical/Instrumentation (with generator)	\$	130,000
Siteworks	\$	45,000
Mobilization	\$ \$	68,000
Sub Total	\$	1,077,000
Contingency (20%)	\$	215,400
Grand Total	\$	1,292,400
Estimated Yearly WTP Operati	ng Costs	
Labour	\$	25,000
Materials (Based on changing one train of filters per mor		36,000
Contract Services	\$	5,000
Utilities	\$	50,000
Subtotal	\$	116,000
Admin Fee (6%) GST (7%)	\$ \$	6,960
GST (7%)	Ф	8,607
Grand Total	\$	131,567
Interest Rate		8%
NPV of O&M Costs (20 year life cycle)	\$	1,395,086