



Final Design Report

Sachs Harbour Water Upgrades

Final Design Report

Sachs Harbour Water Upgrades PMIS # 3421 Contract # 339539

Prepared for:

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Government of the Northwest Territories
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February 2004

Project No. 70026

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February 20, 2004

Refer to File:

70026-03

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Attention:

Mr. John Bulmer, P.Eng.

Dear Sir:

Re:

Sachs Harbour Water Upgrades

Final Design Report -

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867-873-6316

Please find attached, two (2) copies of the Final Design Report for the above mentioned project. We have couriered the Final Design Report to the various parties listed below as per your request.

Facsimile

867-873-6407

We trust this is satisfactory and should you have any questions, please do not hesitate to contact the undersigned at (780) 453-0717.

Very truly yours,

EARTH TECH (CANADA) INC.

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GNWT- Department of Public Works and	Services
Sachs Harbour, NT, Water Upgrades	
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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.

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

1.2 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, NWT. 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. Buoys were tied to the end of the intake for identification purposes only. The intake is located in about 7 meters of water with the intake screen approximately 3.5 meters below the surface of Water Lake.

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 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. The design of the new truck fill station does not intend to reuse any of the existing equipment. The existing equipment will be stored as spares if required.

1.3 Pilot Testing

Recognizing the need to upgrade the Water Treatment system in Sachs Harbour with a simple easy to operate system, the GNWT has conducted pilot testing on the raw water source, Water Lake, in December 2003. This pilot testing concentrated on the use of cartridge filtration in Sachs Harbour and other similar small northern communities with excellent raw water characteristics. The pilot testing results will prove the suitability of cartridge filtration for meeting the Guidelines for Canadian Drinking Water Quality (GCDWQ) including the removal of Giardia and Cryptosporidium in Sachs Harbour. Although the results from the Pilot Testing have not yet been issued, this report assumes that the pilot testing results will be favorable towards cartridge filtration.

Previous pilot testing of cartridge filtration has been completed by the GNWT in the community of Colville Lake, NWT. Colville Lake, like Sachs Harbour, has a small population (100) and very good raw water characteristics. The pilot testing took place in July 2003. The purpose of the pilot testing was used to seek approval from regulatory authorities for the use of cartridge filtration for meeting all of the existing and proposed future guidelines as per the GCDWQ's. The results from this pilot test proved favourable for the suitability of cartridge filtration for Colville Lake and other similar small northern communities with similar raw water characteristics. The approval for the cartridge filtration system with chlorination from the regulatory authorities (NWT Chief Medical Heatlh Officer) was received in October 2003 (Refer to Appendix G for letter of approval from the NWT Health and Social Services). The approval letter states that the cartridge filtration treatment method, along with chlorination, meets the proposed new GCDWQ turbidity guideline and therefore is approved for treating pristine surface water sources.

2.0 DESIGN CRITERIA AND TREATED WATER OBJECTIVES

2.1 Water Quantity

Population data has been collected from the Bureau of Statistics for the NWT for Sachs Harbour and is presented below in **Table 2-1**. 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 2-1: 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 2-1 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 Hamlet of Sachs Harbour provided the actual water usage for the community for the months of July, November and December in 2003. The actual monthly water usage by the community during these months is shown below in **Table 2-2**:

Table 2-2: Actual Water Usage provided by Hamlet of Sachs Harbour

Month	Actual Water Usage
July 2003	312,372 L/month
November 2003	419,855 L/month
December 2003	451,844 L/month
AVERAGE of 3 months	394,690 L/month
	(13,156 L/day)

Based on the information provided in **Table 2-1**, the Sachs Harbour water use for 2004 by MACA guideline for 161 people is 15,027 L/day or 457,000 L/month. The Sachs Harbour actual water usage for 2003 based on the information provided in **Table 2-2** is 13,156 L/day or 394,690 L/month. The MACA water demand projection will be used, as it is a more conservative estimate.

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

The facility must be capable of filling water trucks and providing a fire flow of 1000 l/min, either from storage or, if the process capacity allows, directly from the process train.

2.2 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**, **Table 2.3** indicates Earth Tech's recommended water quality goals for the upgrade to the Sachs Harbour water treatment plant.

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Table 2-3
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	$MAC = 1.0 \text{ NTU}$ $AO \le 5.0 \text{ NTU}$	Conventional Treatment MAC = 0.3 NTU Membrane Treatment MAC = 0.1 NTU Cartridge Filtration = 1 NTU^3 AO $\leq 5.0 \text{ NTU}$	Conventional Treatment $MAC = 0.3 \text{ NTU}$ $Membrane Treatment$ $MAC = 0.1 \text{ NTU}$ $Cartridge Filtration = 1$ NTU^{3} $AO \leq 5.0 \text{ NTU}$
Trihalomethanes	IMAC = 100 ug/L	LRAA: 80 ugL	LRAA: 80 ugL
Haloacetic Acid	None	LRAA: 60 ug/L	LRAA: 60 ug/L
Giardia cysts	None	99.9% (log 3) removal or inactivation (currently under review)	99.9% (log 3) removal or inactivation
Viruses	None	99.99% (log 4) removal or inactivation (currently under review)	99.99% (log 4) removal or inactivation
Cryptosporidium oocysts	None	99.9% (log 3) removal or inactivation (currently under review)	99.9% (log 3) 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 less than
 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.
- 3. USEPA Turbidity Regulation for Approved Cartridge Filters

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2.3 Overview of Raw Water Quality

2.3.1 Raw Water Quality

It is imperative to analyze the raw water source prior to identifying the appropriate water treatment technology suitable for Sachs Harbour. Unfortunately, the extent of raw water quality monitoring in Sachs Harbour is limited. However, **Table 2-4** 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 2-3** with shaded boxes indicating values in excess of the goals. Individual raw water quality test results are contained within **Appendix D**.

Table 2-4 Summary of Water Treatment Goals and Average and Maximum Raw Water
Ouality

	Quai	ity	
特別。於	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	< 0.00005	< 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
	Conventional Treatment MAC = 0.3 NTU	Service Control of the Control of th	
Turbidity	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 2-4** 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.

Having identified the raw water parameters not meeting the required goals, the following sections discuss in further details each of those parameters.

2.3.2 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 also very important for health reasons. Turbidity can serve as a source of nutrients for waterbourne bacteria, viruses and protozoa, which can be trapped within particulate matter. In addition, effective disinfection can be hampered due to turbidity, as microorganisms can "hide" within particulate matter and not be fully exposed to the disinfection process.

2.3.3 Giardia and Cryptosporidium

It is Earth Tech's considered opinion 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.

However, goals have been set for their removal as Giardia or Cryptosporidium are particularly resistant to traditional disinfectants. Each has 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 indicate 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 a residual disinfectant, 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, as mentioned above, is ineffective for inactivation of Cryptosporidium. However, the contact time is sufficient to provided inactivation of viruses (required contact time is 12 minutes).

3.0 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 2.

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 3-1** 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 3-1
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	*	会会会	**	*	去去去去
Clarification- Filtration	* * *	***	***	* * *	****
Microfiltration Membranes	***	****	***	*	****
Ultrafiltration Membranes	* * * * *	****	***	女女女	***
Chlorination	***	**		***	
Ultraviolet(UV) Disinfection	***	****	长女女女女	***	-

Note:

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

2. No stars:

No removal

*:

Poor

**:

Mediocre

女女女:

Average

会会会会:

Good

会会会会会:

Excellent

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

3.1 Cartridge Filtration

Typically, cartridge filtration has been used to effectively filter Giardia and lower the solids content from surface water down to 1 micron. However, as mentioned previously, the GNWT pilot tested a 0.35 micron cartridge filter in Colville Lake and a similar system has been installed in Kugluktuk, Nunavut. Water is flushed through a cluster of replaceable polyester cartridge filters that are 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 size exclusion principle of MF or UF membranes (See Section 3.6) and 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, under US EPA regulations, using a 1 micron absolute pore size (as provided by companies such as Harmsco and Pall filtration) would enable a regulator to grant a 2-log removal credit for cyst size particles such as Giardia Lamblia cysts and Cryptosporidium oocycts. The cartridge filters from Harmsco are certified to ANSI-NSF61 and have met US EPA's challenge tests. The other applicable US standard to look for when considering cartridge filtration is NSF Standard 53 for cyst reduction.

As mentioned in Section 1, the GNWT has pilot tested a cartridge filtration system in Sachs Harbour in December 2003. The main objective of the pilot studies (Sachs Harbour and Colville Lake) was to arrive at an agreement with the Department of Health on the effectiveness of this technology for Sachs Harbour water treatment as well as other similar small water systems. As mentioned in Section 1, the GNWT Department of Health and Social Services approved the use of cartridge filtration with chlorination in Colville Lake for meeting all of the existing and proposed future guidelines as per the GCDWQ's. If the pilot test results for Sachs Harbour are positive for the cartridge filtration treatment method and meet the proposed new GCDWQ turbidity guideline, this technology would be suitable for Sachs Harbour.

3.2 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

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

pressure vessel containing anthracite and sand media. The filter media will remove sediment, turbidity and a level of pathogens. When operating properly 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.

3.3 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 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.

Log removal rate for this process are 2.5 for Giardia and 2.0 for Cryptosporidium.

3.4 Chlorination

Chlorination is commonly 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 and viruses, but is less effective against some other common pathogens of concern, including 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.

3.5 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% (3-log) 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 to prevent re-growth in the distribution system.

3.6 Micro/Ultra Membrane Filtration

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

Microfiltration (MF) and Ultrafiltration (UF) membranes work on the 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% (4-log) Giardia, 99.99% (4-log) Cryptosporidium

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

4.0 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. Each of these treatment process trains is described in more detail in the following sections. All options identified will include the provision of chlorination in order to achieve the required distribution residual.

4.1 Clarification-Filtration-UV (Future)-Chlorination

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 alone 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 a chemical sludge is produced by the coagulation process. 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 operator attention to ensure that the water chemistry is optimized to provide effective coagulation and filtration. Changes in raw water quality can sometimes require significant changes in chemical dosages to maintain effective treatment. Therefore, it may be difficult to contract someone within Sachs Harbour with the training required to operate this type of plant.

4.2 Cartridge Filtration-UV (Future)-Chlorination

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.

As shown in the Colville Lake Pilot Study and approved by the GNWT Health Authority, cartridge filtration can achieve a 2-log reduction of Giardia and a 2-log reduction of Cryptosporidium as well as exceed the USEPA turbidity objective of 1.0 NTU. 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. If an additional 0.5-log removal of Giardia is required using chlorination, a contact time of 61 minutes is required to maintain a residual of 1 mg/L in water that has a pH of 8.5 and a temperature of 0.5 degrees Celsius.

4.3 UF Membrane Filtration-Chlorination

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. (The exception to this is when the treatment process is required to remove dissolved organic material, in which case coagulation is required.) 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. 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.

As no chemicals are required and membrane systems are typically very automated, the level of operator attention is minimal. Since UF membranes can be granted a 99.99% (4-log) removal credit for Giardia, Cryptosporidium, and viruses, no additional disinfection would be required in theory for waters treated using this approach¹. However, as a chlorine residual is required under the NWT regulations and for the distribution system, chlorination is required as a secondary disinfectant.

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.

4.4 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 4-1**.

Table 4-1
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 for fire flow requirements
Cartridge Filtration-UV (Future)-Chlorination	 Simple to operate Simple to maintain No water storage required Low capital cost 	Cost of replacement cartridge filters 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 water generated is greater than other options High capital and maintenance cost Requires water to be stored within the plant for fire flow requirements

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 4-2 summarizes the financial requirements for each of the treatment trains presented. A breakdown of the order of magnitude costs for each treatment train, which were previously submitted as part of the Preliminary Design Report in September 2003, is presented in **Appendix F.**

Table 4-2 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

<u>Note</u>: The O&M costs for UF membranes are based upon an estimated membrane life, this can be difficult to predict without extensive pilot work and can vary greatly between manufacturers and Raw Water Sources. As such the costs could vary significantly from the estimate produced herein.

A further analysis of the advantages and disadvantages has been performed as illustrated in **Table 4-3** – 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 4-3 Decision Analysis Worksheet

	EVALUATE ALTERNATIVES						
	Clarification/Filtration/ UV (Future)/Chlorination			Filtration/UV (Future) Chlorination	UF Membranes-Chlorination		
MUST (Mandatory, Measurable, Realistic)	Information	Go/No Go	Information	Go/No Go	Informati	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 Dec 2003	8	80	Tulita	10	100
				9						
TOTAL WEIGHTED SCORE				292			340			240

4.5 Recommendation

In the review of Sachs Harbour's water system management and infrastructure report prepared by the Department of Public Works and Services GNWT (see **Appendix A**), it was recommended that a pilot study be conducted to determine the feasibility of using cartridge filtration for truck fill stations such as Sachs Harbour. As stated in Section 1, the cartridge filtration pilot study was conducted in December 2003 in Sachs Harbour. The pilot study results will determine the applicability of this treatment process in this location.

As mentioned in Section 1, the GNWT also did a pilot test on cartridge filters for a similar small northern community, Colville Lake, in July 2003. The results indicated that cartridge filtration with chlorination can achieve the log reduction of protozoa and viruses specified in the turbidity guideline. Therefore, the selection of using cartridge filtration with chlorination as the treatment process for Sachs Harbour Truck Fill Station is based on the anticipated positive results from the upcoming pilot test in Sachs Harbour as well as results from the pilot test done in Colville Lake.

The quality of the raw water drawn from Water Lake is considered very good with only the turbidity parameter exceeding the goals for Sachs Harbour. The turbidity parameter will need to be addressed with the chosen treatment process and achieve the USEPA turbidity goal for approved cartridge filters of 1.0 NTU.

As stated in section 4.2, cartridge filtration can achieve 2-log reduction of Giardia and Cryptosporidium and exceed the USEPA turbidity objective of 1.0 NTU. Therefore cartridge filtration would provide treatment greater than the current GCDWQ and will be capable of meeting the new turbidity guidelines.

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 of 3-log removal.

Considering that the Cartridge Filtration-UV (Future)-Chlorination process 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.

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.

5.0 WATER TREATMENT PROCESS

5.1 General

As stated previously, water treatment requirements depend heavily upon the raw water characteristics. The facility that will treat water from Water Lake needs to be able to address all of the parameters identified in Section 2.

5.2 Water Treatment Design Capacity

The facility must have sufficient production capacity to meet the peak daily demands for Sachs Harbour in the year 2025. The combination of production and pumping capacity must be capable of meeting both Sachs Harbour demands and the fire flow requirements.

Population and treated water demand estimates for the design period are presented in Section 2. Based on these figures, the water treatment peak demand estimate in the design year of 2025 is 37,890 L/day. The facility must be capable of filling water trucks and providing a fire flow of 1000 l/min, either from storage or, if the process capacity allows, directly from the process train.

5.3 Process Description

The recommended water treatment process is cartridge filtration with chlorination. This water treatment process would utilize cartridge filters as the primary disinfection stage to achieve turbidity removal and pathogen removal and utilize chlorination for a secondary (residual) disinfectant. This option would allow the treatment scheme to operate at the full fire flow rate of 1,000 L/min, eliminating the need for separate fire storage. Refer to Appendix H for drawings of the proposed water treatment method and layout.

5.3.1 Raw Water Supply

The raw water supply to the truck fill station will be pumped by a submersible turbine pump encased in an insulated high-density polyethylene carrier pipe (HDPE) that will transport water from Water Lake. The existing 200 mm HDPE DR21 carrier pipe that encases the raw water supply line to the existing truck fill station will be reused in this design. The 200 mm carrier pipe will be extended approximately 30 m to the west to supply raw water to the new truck fill station. Refer to **Appendix H** for the new truck fill station location drawing. The interior components of the existing raw water carrier pipe will be replaced entirely. This includes the existing 100 mm HDPE intake pipe, heat trace cable, submersible turbine pump and any components affiliated with these interior items.

The raw water pump will be sized to provide 1000 L/min at ~ 55 m of total dynamic head. There will be one duty pump and one shelf spare with an option in the tender documents to supply a third spare pump. The raw water supply pipe will consist of a 100 mm HDPE DR 11 supply line encased in a 200 mm HDPE DR 21 carrier pipe that will be insulated with 50 mm polyurethane and heat-traced. The raw water supply line is submersed in the lake at a depth of ~ 3 m and will then run underground with a minimum berm cover of 1 m to the building.

The raw water pump is activated by the Operator pressing the start button on the Truckfill Panel. The raw water is then discharged to the Truckfill via the raw water intake line as described above. Upon entering the Truckfill, the raw water intake pipe transitions to PVC –SCH 80 piping. Prior to the filters are the following items;

- Air/Vacuum Release Valve provides the function of eliminating air from the line upon pump start up and allowing air into the line upon draining. The raw water line must be drained between uses in order to allow the Operators to pull the 100 mm DR 11 HDPE intake pipe and the submersible turbine pump out for maintenance.
- Pressure Relief Valve The pressure relief valve will provide emergency pressure relief in
 the event that a valve is in the closed position thus blocking the flow from discharging to
 the truckfill arm.
- Actuated Control Valve The actuated control valve will slowly open once the flow has
 reached the Truckfill Station. The purpose of the control valve is to protect the basket
 strainer and cartridge filters from the initial surge that the raw water pump creates upon
 start-up. The concern is that the initial surge may force larger particles through the
 strainer and 10 MIC filter and clog up the smaller sized filters sooner than expected.
- Check Valve A check valve has been included prior to the filters in order to prevent reverse flow through the filters, which is considered undesirable for the filters.

A solenoid valve is located downstream of the filters, on a drain line which drains to the carrier pipe. The intent is for the solenoid valve to open once the pump stops in order to drain the truckfill arm for freeze protection. The solenoid valve is located such that it will also prevent reverse flow through the filters.

The raw water is then chlorinated prior to discharging into the filters.

5.3.2 Chlorination

Within Sachs Harbour, chlorination is the only method of treatment presently practiced. The existing truck fill station chlorinates using powdered calcium hypochlorite. The proposed

chlorination system for the new truck fill station will be very similar to the existing chlorination system. All of the chlorination equipment will be replaced and the existing equipment will be disposed of.

The new chlorination system will use calcium hypochlorite (tablet form) to make a 0.5 % chlorine solution. The chlorine dosage rate is dependant on many factors such as the raw water quality, the environmental conditions, seasonal changes, age of the dosing solution, the flow rate, etc. Therefore the dosing pumps have been sized for a maximum dose of 3 mg/L for the treated water flow of 1000 L/min. The chlorine solution will be prepared in a mixing tank equipped with an electric mixer. The batches should be made to last no more than two weeks to avoid chlorine decay problems. The mixed solution will then gravity feed into a solution tank.

The chlorine solution will be injected via a diaphragm-metering pump into the 100 mm raw water supply pipe prior to the filters. The intent of chlorinating prior to the filters is to minimize bacteriological growth on the filter cartridges. The design has allowed for a post filter chlorination injection point if, in the future, the Operations favor this location. However, there will only be the option of chlorinating at one location, pre or post filters not both. There will be two chlorine dosing pumps operating as duty/standby and one shelf spare. The chlorine dosing pumps will be manually controlled. The Operator will be required to test the chlorine residual to ensure that the chlorine dose is sufficient and adjust the dosage accordingly.

The contact time of 20 minutes, required by GNWT Health regulations, with a minimum free available chlorine residual of 0.2 mg/L will be achieved in the water truck tank prior to delivery to the community.

There will be a one-year supply of calcium hypochlorite on-site, which will be approximately 25 kilograms. The expected average available chlorine decay rate of the calcium hypochlorite tablets is 5% per year. However, in order to minimize the decomposition of available chlorine, the tablets must be stored in a cool and dry area.

The chlorinated water is then discharged into the filters.

5.3.3 Cartridge Filtration

The recommended filtration system would consist of a series of three cartridge filters preceded by a coarse pre-filter to remove larger objects. The series of cartridge filters will consist of a 10 MIC nominal, a 1 MIC (absolute) and a 0.35 MIC nominal pore size filter. The 10 MIC (nominal) filter is a polyester filter that will remove the particles 10 MIC or larger in size from the raw water. The 1 MIC is an absolute rated polypropylene filter that will remove cyst size particles (Giardia and Cryptosporidium) from the raw water. The absolute rating of the filter is

granted a 2-log removal for cyst size particles by the USEPA regulations. Although the 1 MIC absolute is sufficient to meet the water quality goals outlined in Section 2, the 0.35 MIC (nominal) filter has been included as a safety measure to provide additional removal of pathogens and viruses if required. The 0.35 MIC (nominal) filter will also remove the finer particles such as clays and silts from the raw water.

The pilot tests in Sachs Harbour in December 2003 tested the same train of filter sizes.

As stated above, the cartridge filters will be preceded by a 75 MIC (200 MESH) coarse pre-filter basket strainer to remove the larger particles in the raw water (i.e. blood worms, cold water shrimp, etc.) This pre-filter basket strainer is stainless steel encased in a stainless steel housing. The pre-filter basket strainer is washable and therefore does not require replacement. There will be two on-site spare baskets for change out during maintenance cleaning and will serve as a stand-bys.

The raw water will be discharged through the cartridge filters under pressure. The series of filters can filter a maximum flow of 1135 L/min. The raw water pump is sized such that it can pump the raw water through the series of filters (including the pre-filter) in both a clean and dirty state. A clean state is defined as all four filters in newly installed condition. The cartridge filters will have a pressure drop of 5 PSI and the basket strainer will have a pressure drop of 0.7 PSI in a clean state. In a clean state, the pump will supply a flow of approximately 1135 L/min at approximately 35 m of head in the system. A dirty state is defined as one filter clogged (pressure drop =15 PSI) and the other 3 filters in between a dirty and a clean state (pressure drop =10 PSI). The pump will supply a flow of approximately 915 L/min at approximately 55 m of head in the system in a dirty state. Each filter canister and the basket strainer will be provided with a pressure differential gauge (PDG) that will allow the Operator to determine if the filters or the strainer require cleaning or replacement. There will be an alarm associated with each PDG, which will activate at a pre-determined maximum pressure differential of 15 PSI. This will indicate to the Operator that the filter or strainer must be cleaned or replaced.

Each of the filter canisters contains twenty-five (25) triple filters (3X the length of a single cartridge). These cartridge filters are replaced individually. The 10 MIC (nominal) filter can be washed with a low pressure nozzle up to a maximum of four (4) times before it will require replacement. It will require washing once the pressure drop across them reaches a maximum of 15 PSI. The 1 MIC (absolute) and the 0.35 MIC (nominal), however, cannot be washed. These filters will require replacement once the pressure drop across the filters has reached the maximum allowable pressure drop (15 PSI). It is difficult to estimate how often the Operator will be required to clean/replace the filters. However, based on the pilot testing in December

2003, the GNWT estimated the following volumes that could be passed through each size of filter tested before failure:

- 10 micron 18,000 litres
- 1.0 micron 12,000 litres
- 0.35 micron 36,000 litres

Each Canister contains 25 triple length cartridge filters. Therefore the above numbers scaled up to reflect the triple length (3) and the number of cartridges (25) is as follows:

- 10 micron 1,350,000 litres
- 1.0 micron 900,000 litres
- 0.35 micron 2,700,000 litres

As stated above, the 10 micron are washable up to four (4) times or can filter 5,400,000 litres before they require replacement. As stated in Section 2, the Sachs Harbour water use for 2004 by MACA guideline for 161 people is 15,027 L/day or 457,000 L/month. Therefore the estimated number of filters required for a two year on-site storage supply including the initial fill is as follows:

- 10 micron 3 changes (75 filters)
- 1.0 micron 13 changes (325 filters)
- 0.35 micron 5 changes (125 filters)

The above numbers are an estimate. The actual on-site filter requirements will not be known until the facility has operated through a full season. It is anticipated that summer operation will require more frequent changes/washing. Due to the uncertainty in the required number of filters, the following recommended minimum initial order for a 2-year on-site storage supply, which is 50 % higher than the above estimate, is listed below.

- 10 micron 5 cases = 120 filters = 4 changes (100 filters) with 20 left over
- 1.0 micron 20 cases=480 filters = 19 changes (475 filters) with 5 left over
- 0.35 micron 9 cases = 216 filters = 8 changes (200 filters) with 16 left over.

It should be noted that the cartridge filters are supplied as twenty-four (24) to a box although the canister requires 25 filters. There are two shelves dedicated to storage of the cartridge filters; one is located inside the Truckfill and one is located on the exterior for the building enclosed in a metal shed. The filter manufacturer stated that the cold climate would not affect the performance for the filters. However, it is recommended that the Operator use the spare filters inside for replacement as they are at room temperature. Refer to **Appendix H** for filter storage location.

The pre-basket strainer can be washed on a regular basis by taking out the stainless steel basket and rinsing it with the low-pressure nozzle. The frequency of washing will be determined by the pressure drop across the pre-basket strainer. The pressure drop should not exceed 15 PSI for optimal flow through the system.

The water supply for washing the cartridge filters and the pre-basket strainer will be accomplished utilizing a low-pressure nozzle located on the utility sink. The Operator will be required to clean the 10 MIC (nominal) filter and the pre-basket strainer when the pressure drop across either of these filters reaches 15 PSI. The wash water will be discharged to the nozzle from the on-site water tank. The water is filtered and chlorinated prior to discharging into the water tank. The wastewater from the cleaning of the filters will be discharged to a floor trench, which drains to a sump. The sump contains a pump that will send the wastewater to an on-site wastewater tank. The wastewater tank will be pumped out on an as-needed basis. Refer to Appendix H for the location of the water and wastewater systems on the general layout drawing. Refer to Section 7 for more mechanical details on the water and wastewater system.

Each filter canister and the basket strainer housing contain a drain. In order to minimize slime growth on the filters and the strainer, the Operator will manually drain the canisters and strainer housing once per week. The frequency of draining the filter and strainer housings will be revised accordingly once the system has been in operation for a period of time. The canisters and the strainer housing will be drained by attaching a rubber hose to the drain connection and draining the water to the floor trench. The drain water will be sent to the wastewater tank as described in the above paragraph.

There is by-pass piping around each of the filters and the basket strainer that allows the Operator to isolate one or more of the filter canisters if required for maintenance. It is not anticipated that this will be required often given the infrequency of the truck fills per day. It is anticipated that any maintenance can be done in between truck fills.

5.3.4 Future Disinfection

As mentioned in section 4.2, UV disinfection is not included in the design at this point. We have allowed for sufficient floor space to install a UV disinfection unit if required in order to meet future regulations.

5.3.5 Water Truck Fill Operation

After the raw water is chlorinated and filtered, the treated water will be discharged into the water truck, which has a capacity of 4,500 L. Given an average flow rate of 1000 L/min, it will take

approximately 5 minutes to fill the water truck. The water truck will then deliver the treated water to the community of Sachs Harbour.

5.3.6 Fire Flow

In the event of a fire, the Operator can select the fire start button at the Truckfill arm rather than the normal fill start button. The fire start button automatically bypasses the flow around the filters by means of an actuated control valve. Refer to **Appendix H** for the location and instrumentation associated with the fire bypass control valve. The raw water pump will provide a fire flow of 1300 L/min at approximately 22 m of head in the system. The fire flow will be chlorinated prior to discharging into the water truck.

5.4 Process Equipment Selection and Sizing

This section describes the process equipment and sizing of the major equipment for the water treatment process.

5.4.1 Raw Water Supply

The raw water supply system will consist of the components listed in the table below:

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Table 5-1 Raw Water Supply Equipment

Equipment	Type	Size	Make/Model #
Raw Water Pump (1 duty and 1 shelf spare with option to provide 3 rd spare pump)	- Submersible Centrifugal Pump	- 1000 L/min @ 55 m TDH - 4 Stage - 100 mm discharge - 11.25 kW motor - 150 mm O.D. motor - 575V/3phase/60Hz - Length = 1.42 m (incl. Motor)	- Crown Pump with a Franklin motor (same make as existing) - # S6-230-4
Raw Water Insulated, heat traced Carrier Pipe	 HDPE carrier Polyurethane insulation HDPE jacket Heat Trace Copper tubing 	 200 mm I.D. DR21 L₂₀₀~ 30 m 50 mm of insulation 20 mm copper pipe 	- Sclairpipe (HDPE) - Urecon (Insulation)
Raw Water Supply Pipe (exterior)	- HDPE	- 100 mm - DR11 - L ₁₀₀ ~ 145 m	- Sclairpipe
Raw/Treated Water Supply Pipe (interior)	- PVC	- SCH 80 - 100 mm	- IPEX

5.4.2 Cartridge Filtration

The following table outlines the components of the filtration system:

Table 5-2 Filtration Equipment

Equipment	Туре	Size	Make/Model #
Pre-Filter (2 on-site spare baskets)	- Stainless Steel Basket and housing Simplex Strainer	- 75 MIC (200 MESH) - 100 mm inlet/outlet	- Hayward Industrial Products - Simplex Strainer #72 ST072400R2C
Cartridge Filter #1	- Polyester-Plus Filters - Stainless Steel Canister	 10 MIC (nominal) Triple cartridges per filter 75 mm inlet/outlet (NPT) 38 mm drain (NPT) 	- Harmsco 801 Series –HIF75 - # 931-10
Cartridge Filter #2	- Polyester-Plus Filters - Stainless Steel Canister	- 0.35 MIC (nominal) - Triple cartridges per filter - 75 mm inlet/outlet (NPT) - 38 mm drain(NPT)	- Harmsco 801 Series –HIF75 - # 931-0.35
Cartridge Filter #3	 Poly-Pleat absolute rated Filters Stainless Steel Canister 	 1 MIC (Absolute) Triple cartridges per filter 75 mm inlet/outlet (NPT) 38 mm drain (NPT) 	- Harmsco-HIF75 - # PP-T-1

5.4.3 Chlorination System

The following table outlines the components of the chlorination system:

Table 5-3 Chlorination Equipment

Equipment	Туре	Size	Make/Model #
Chlorine Dosing Pumps (2 duty/stby and 1 shelf spare)	Motor driven metering pumps Manual adjustment	- Max flow = 42 L/hr @ 145 PSI - 115 V/1 Phase/60 Hz - 0.09 kW	- Prominent Sigma Series - #1BaHM12035P VT
Chlorine Mix/Solution Tanks (2)	- HDPE	- 250 L	- Prominent - # 931-20
Mixer (1)	- High speed Electric - Epoxy coated	- 1/20 Hp - 1725 rpm - 115 V/1 phase/60Hz	- Prominent

6.0 ARCHITECTURAL/STRUCTURAL/SITEWORKS

6.1 New Building

It is proposed to replace the existing Water Truck Fill Facility with a new insulated structure. The building will be approximately 13.0m x 4.05m (52.65 m²) and have a minimum clear inside height of 3.2m.

The proposed structure will comprise of self-framing insulated steel-clad wall and roof panels supported by a rigid skid based floor.

The building will be divided into two main areas, a water process room and a generator room. Mounted to one corner of the building will be a steel framed truck fill arm, sized to accommodate the local water service provider's equipment.

6.2 Foundation

The intent of the foundation is such that, it will be pre-assembled and shipped to site complete. The foundation will be constructed from metal skids and channel framing, placed directly on a prepared and level granular base (pit-run gravel). Optionally, the skid rails may be supported by a series of timber blocs to allow for adjustments over the building life.

The metal framing would support galvanized metal deck over which a concrete topping will be cast. The topping will allow for integral curbing, drainage slopes and also provide a substrate for a sealer membrane to control water.

The nature of the process is such that a substantial amount of water may be spilled on to the floor at various times. Therefore, the floor slab will have localized slopes to a floor trench and continuous concrete curbs around the perimeter of the building. The floor trench will flow in to a small sump. The sump will be pumped into the wastewater storage tank.

It is anticipated that during shipping and placement of the building on site some cracking of the floor slab will occur. It is recommended that the application of a flowable membrane sealer be applied to the concrete surface once the building is in place.

6.3 Walls and Roof

The walls and roof will be constructed of self-supporting steel-clad insulated metal sandwich panels. (Roof minimum - R40, Walls minimum - R30) and be weather tight at all joints and

intersections. The sandwich panels will be reinforced at specific locations to accommodate concentrated loads as may occur at the attachment of the filler boom.

Passage doors will be included to meet the specific need of the building operations.

6.4 Siteworks

The civil/siteworks portion of the design is limited to a new truckfill turnaround for the water truck, a building pad for the truck fill facility and construction of a berm over the raw water intake pipe. The new location for the Truck Fill facility and turnaround will be approximately 30 m west of the existing truck fill facility. Refer to **Appendix H** for location plan. The purpose of relocating the truck fill facility is to avoid having the access to the facility on the steep slope leading down to the lake. The turnaround and berm will be compacted pit run gravel.

6.5 Site Requirements

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

Earth Tech obtained selected 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 design of the access road; however, the construction contract will be set-up to accommodate and provide any additional information required. The expense to perform a survey is not recommended at this time.

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.

7.0 MECHANICAL

7.1 General

This report will address mechanical strategies for heating, ventilation, and miscellaneous mechanical systems. The recommended components will meet all applicable codes, the intended function of the facility and will be selected to meet the project budget while retaining the standards of quality and reliability required for this remote facility. Refer to **Appendix H** for mechanical drawings.

7.2 Codes and Standards

The following list of codes and standards have been utilized in the preparation of this report:

- National Building Code 1995
- National Plumbing Code 1995.
- National Fire Code 1995.
- CAN/CSA B-139 Oil Burning Equipment Code.
- Public Health Act General Sanitation Regulations
- Northwest Territories Public Works and Services Good Building Practice for Northern Facilities Manual

7.3 Heating

The primary source of heat for the building will be an oil fired forced air furnace located in the Treatment Room. Heated air will be distributed through the space and ducted to the adjacent Generator Room. A transfer grille with fire damper will be provided to allow return air back to the furnace. The furnace will run on a call for heat from the local thermostat located in the Treatment Room.

Electric infrared heaters will be provided for back-up heat in the event of furnace failure. Local thermostats, set slightly above critical temperature, will be provided in both the Treatment Room and the Generator Room to control the heaters. Refer to Section 8 for electrical requirements.

7.4 Ventilation

Summer ventilation will be provided to meet occupancy requirements. A wall mounted exhaust fan coupled with wall mounted intake damper will be provided. The system will be enabled via a manual switch. Once enabled the fan and damper will be energized on a call for cooling from the local thermostat.

Ventilation will be provided for the standby generator. Outside air, relief and recirculation dampers will be modulated to maintain the room temperature set point.

7.5 Plumbing

Domestic water and wastewater storage will be provided for the facility to meet user requirements. Domestic water will be stored in a local 1500 L tank with manual fill valve from the discharge side of the process train. A small booster pump and pressure tank will be provided to ensure adequate pressure at the hose bibs and sinks. Domestic hot water will be provided via a small electric heater located under the sink.

Wastewater from the sinks and floor will be collected in a shallow grated trench drain sloped to a sump. A submersible pump, actuated via float switch will pump the wastewater to a 2250 L storage tank located inside the building. The wastewater tank will be pumped out as required by the Sachs Harbour Sewer Truck.

7.6 Fuel Oil System

A fuel oil system will be provided for the furnace and the emergency standby generator. The system will consist of a 1,135 L single walled oval steel storage tank, level gauge, interconnecting piping, warming tube and all necessary peripherals to meet code and user requirements. The tank size will provide fourteen (14) days of continuous furnace run time at full load plus 48 hours of continuous generator run time based on rated load.

Fuel lines to the engine will be specified as flexible metal. Rubber hose shall not be allowed.

8.0 ELECTRICAL

8.1 General

This section of the report is intended to provide a consolidated outline of the electrical systems design for the New Truckfill Station in Sachs Harbour, N.W.T. Refer to **Appendix H** for preliminary electrical drawings. The report will cover the following items:

- Power Distribution Systems
- Standby Power Generation and Distribution
- Building Wiring
- Lighting and Emergency Lighting Systems
- Power for Mechanical Equipment
- Building Electrical Heat
- Heat Trace Systems for the Intake Piping and the Truckfill Arm
- Control Systems are discussed in Chapter 9 of this report

This report is intended to define the scope, material and quality of installation and provide sufficient information to enable the Project Team to establish a realistic estimate of probable cost for the project.

The electrical design and installation will conform to the following codes, regulations and standards:

- National Building Code (1995 Edition)
- Canadian Electrical Code (2002 Edition)
- Northwest Territories Power Corporation Utility Requirements

8.2 Site Services

At present, the power service for the Sachs Harbour Truckfill Station is provided underground from the adjacent unoccupied Transport Canada site, and provides a 600 volt, 30Amp incoming service breaker. The new facility will have an increased electrical load, largely due to the addition of increased pumping requirements and the lighting/heating needs of a larger building.

Discussions with the Northwest Territories Power Corporation are underway to co-ordinate the installation of an upgraded power service to the site to meet the requirements of the new facility. At this time we are anticipating a connected load of approximately 32 kW, with a running load of approximately 24kW. (Connected load is the power required to simultaneously operate all electrical devices at 100%. Running load is the power to operate the facility under normal conditions.) It is our intent to service the new facility at 600volts and 100Amps.

At the time of this report Earth Tech Canada is in the process of investigating the feasibility of installing Northwest Tel service into the facility. Should the cost of this installation be acceptable the project would proceed with this installation. However should this prove too costly the telecommunications requirements for this facility can be provided using a Globalstar fixed, satellite based telephone.

Either the Northwest Tel line or the Globalstar phone will be used to dial out alarm conditions via an automated alarm dialer, as well as providing external voice communications for the facility operator. (Refer to Chapter 9 for further information on the alarm dialer.)

8.3 Power Distribution

Building power distribution is to be configured as indicated on the attached Single Line Diagram shown on project drawing 70026-E01, with the power distribution components laid out on the north wall of the generator room as shown on project drawing 70026-E02.

Our intent is to specify Cuttler Hammer as the standard of acceptance manufacturer for the power distribution, the pump motor starter and pump ground fault detection equipment.

8.4 Standby Power System

The facility will be equipped with a diésel powered standby generator unit to provide standby power to all facility loads. In the event of utility power loss, under voltage or loss of a single phase, the Automatic Transfer Switch will detect the utility problem and start the generator. Once up to temperature and operating voltage the Automatic Transfer Switch will transfer all facility loads onto the generator.

The Automatic Transfer Switch will also sense the resumption of utility power and monitor the utility for stability. Once the utility power is proven stable for an adjustable amount of time (0-30min) the transfer switch will re-transfer the load back to the utility and initiate the generator cool down/stop sequence. Re-transfer time would be set in the 15 to 20 min range. Our intent is

to specify Cummins Onan as the standard of acceptance manufacturer for both the generator and the contactor type transfer switch.

8.5 Mechanical Equipment Connection

The facility's major motor load is the lake source pump (P-100). The lake source pump starter is to be fed at 600 volts from the main splitter. The motor will be controlled by a Cuttler Hammer line voltage starter. This starter will be fitted with monitoring by a ground fault detection fault relay. This assembly will be provided in a single enclosure and be mounted on the north wall of the generator room. The reduced voltage starter has been included to prevent the occurrence of water hammer when the discharge of the lake pump first arrives at the truck fill building. Should this issue be addressed in another manner the pump can be started using a conventional magnetic starter, resulting in the installed cost being reduced by one half.

Power will be provided by 120 volt branch circuits fed from panel A, for mechanical equipment such as the summer ventilation fan (EF-1), facility furnace (FU-1), sump pump (P-1), water pressure pump (P-2). Also the generator mechanical controls, and the boiler controls will be powered by panel A.

8.6 Branch Circuit Wiring

All conductors will be copper, RW-90 insulation, minimum size # 12 AWG and a corresponding minimum conduit size of 19mm. Wiring methods will be as follows:

- Rigid Galvanized Conduit Exposed conduit subject to mechanical injury.
- EMT Conduit General concealed and surface runs.
- Liquid Seal Conduit Connections to mechanical equipment and transformers.
- Teck Cable Connections to mechanical equipment, exterior devices.

Electrical devices installed throughout the facility will be surface mounted and shall be attached to plywood back boards wherever the weight of the electrical equipment is not compatible with mounting the device directly to the wall construction.

Generally, building utilization voltages will be as follows:

120 volts Small motors .373 kW or less (EF-1, FU-1, P-1, P-2), duplex receptacles, lighting.

240 volts Electric building heat, heat trace and domestic water heater.

600 volts Lake pump (P-100).

8.7 Lighting

New interior lighting fixtures be installed with T-8 lamps and electronic ballast's. The new fixture will be totally enclosed and gasketed which will prohibit the entrance of environmental contaminants.

New exterior lighting fixtures are to be provided on the west wall to illuminate the building entries and the truck fill driving lane, and the fuel storage area to the south of the building. A single exterior fixture will be mounted on the fill arm. Exterior lighting will be provided by surface mounted High Pressure Sodium fixtures with lexan shields to deter vandalism.

To ensure an energy efficient installation that meets the functional requirements of the facility, the following light sources will be used:

Lamp Source	Areas of Utilization
HID-High Pressure Sodium	Exterior lighting
Fluorescent-Standard T-8 lamp	Throughout the building interior

Lighting control will be as follows:

Exterior:	Photocell, cabinet	hand-off-auto	exterior	lighting,	contactor
Interior:	Line voltag	ge switches			

8.8 Emergency Lighting Units

Emergency lighting units are provided to ensure the required coverage when the electrical service is interrupted and the generator has not yet transferred into use, or in event of a generator failure. New battery packs and additional remote heads will be installed to ensure proper coverage throughout the building.

Emergency lighting will be provided by self contained, battery operated emergency lighting units to illuminate access to exits.

8.9 Exit Signs

Exit signs will operate from the power supply of the emergency lighting battery packs in order to ensure that the exit signs are illuminated normally and in event of a power failure.

Illuminated exit signs will be provided at all exit doors and as required by the National Building Code. Exit signs will be constructed of extruded aluminum and utilize LED type lamps.

8.10 Building Heat

Both the process and generator rooms are to be heated using both the facility furnace and electric infrared radiant heaters. The facility furnace will be sized to heat the entire facility. Electric heaters will be used as backup in the event of a furnace failure. The electric heaters are sized to allow a number of heaters to be used to meet the heating requirements of each space. Two electric heaters will be mounted in the process room and one electric heater will be mounted in the generator room. As infrared only heats the surface contacted by the beam, heaters will be configured to provide heat to the concrete floor which will in turn radiate heat warming the building interior.

Our intent is to specify Chrolomox KRR series wide beam as the standard of acceptance manufacturer for the electric Infrared Radiant heaters. The furnace standard of acceptance is discussed in Chapter 7 of this report.

8.11 Heat Tracing

The intake pipe is to be heat traced using a self limiting heat trace cable enclosed in a copper heat trace carrier tube which is strapped to the intake pump discharge line. Heat trace cable is to be the rated at 6 watts per foot. This installation arrangement is provided twice in order to have a redundant system in the event of a heat trace cable failure.

The truckfill arm delivery pipe is to be heat traced using a self limiting heat trace cable. The heat trace cable is to be the rated at 6 watts per foot. This installation arrangement is provided once in order to ensure against freezing in the event that the truckfill delivery pipe does not drain back to the lake.

Our intent is to specify Raychem self limiting heat trace cable and the corresponding Digitrace controller the standard of acceptance manufacturer for the intake heat trace system.

9.0 CONTROLS

9.1 Control Scheme

The control scheme for the New Truckfill Facility is to be implemented executed by the field instruments and control devices as shown on the attached Piping and Instrument Diagram (P&ID's). Refer to **Appendix H** for controls drawings. The written description that follows should be read in conjunction with this drawing and drawing 70026-E03. The proposed station is relatively simple in function; as such control panels will be simple relay based rather than a more complex computer or PLC based control.

9.2 Treated Water Flow

Production of treated water for delivery to the truck fill arm is initiated when the driver presses start button. Start/stop station pushbuttons will be located at both the fill arm and at the truck fill control panel mounted at ground level. The run time of the treatment process will be limited for each delivery, by a driver adjustable timer located in the truck fill control panel. This timer also ensures that, should vandals manage to start the pump, it will only run for the period set by the timer. Once the start button is depressed the intake pump will start and lift water to the inlet of the filter train. The truck fill piping is monitored by a flow switch that confirms the flow of water is established through the facility within a preset period of time after the pump start is initiated. If the flow switch does not prove, an Intake Failed to Flow alarm will occur. The Intake Failed to Flow alarm will then shut down the pump to ensure the pump does not run deadheaded for extended periods of time. Once flow is established the raw water is routed through a series of filters. Each filter is monitored by a differential pressure switch. Should the differential pressure across any of the filter elements exceed a preset value, a filter high differential alarm for that filter will be displayed on the alarm panel, and common Filter Requires Service alarm lamp will be displayed on the truck fill panel.

Treated water exiting the filter train is metered by the treated water flow meter. This meter will indicate the flow rate, totalize the volume delivered to the trucks with a resettable totalizer. The meter will also indicate flow rate in the exterior operators panel and totalize the volume on a non-resettable totalizer. Detection of treated water flow will operate the chlorine dosing pumps. Chlorine addition starts upon the detection of flow and is stopped when the flow stops.

Once the truck fill stop pushbutton is pressed or the fill timer has elapsed the lake intake pump will stop, flow will stop and the chlorine dosing will also stop. When the truck fill stop pushbutton is pressed or the fill timer has elapsed a solenoid valve will open allowing the truck fill arm and the pump discharge piping to drain back to the lake. Line drainage will provide freeze protection to both of these pipes. The solenoid valve is also located such that there will be no reverse flow through the filters, which is considered undesirable for the filters. During the line drainage time the pump start signal will be locked out. This allows the pump to completely stop reverse flow before it is restarted. This lockout protects the pump and its starter components from being operated while the pump may be turning in a reverse direction.

9.3 Fire Water Flow

Production of fire water for delivery to the truck fill arm is initiated when the driver presses the fire water start button. The fire water start/stop pushbuttons will be located at the fill arm. The run time of the treatment process will be controlled by the stop pushbutton. Once the fire water start button is depressed the fire flow bypass valve will be opened before the inlet of the filter train and the intake pump will start and lift water from the lake. The truck fill piping is monitored by a paddle style flow switch that confirms the flow of water is established through the facility within a preset period of time after the pump start is initiated. If the flow switch does not prove, an Intake Failed to Flow alarm will occur. The Intake Failed to Flow alarm will then shut down the pump to ensure the pump does not run deadheaded for extended periods of time. Once flow is established the raw water is routed through the filter bypass to the truck fill arm.

Fire flow water is routed around the filter train to ensure the minimum fire flow rate of 1000 L/min is always exceeded. The fire flow will be separately metered. This meter will indicate the flow rate, totalize the volume delivered to the trucks with a non-re-settable totalizer mounted in the alarm panel. Detection of fire water flow will operate the chlorine dosing pumps. Chlorine addition starts upon the detection of flow and is stopped when the flow stops.

Once the fire water stop pushbutton is pressed the lake intake pump will stop, flow will stop, the chlorine dosing will also stop and the filter bypass valve will close. When the fire water stop pushbutton is pressed a solenoid valve will open allowing the truck fill arm and the pump discharge piping to drain back to the lake. Line drainage will provide freeze protection to both of these pipes. During the line drainage time the pump start signal will be locked out. This allows the pump to completely stop reverse flow before it is restarted. This lockout protects the pump and its starter components from being operated while the pump may be turning in a reverse direction.

9.4 Control Components

The facility control scheme will be implemented using two control panels. The first is the truck fill control panel, which is accessible by the truck driver. The second panel will be the facility control and alarm panel located inside the process room door.

The truck fill panel will contain the start/stop pushbuttons, the fill timer, a re-settable flow meter display and the filter requires service indicator lamp.

The facility control/ alarm panel will contain the pump control logic relays and timers, the non-re-settable flow meter indicator/totalizer, the chlorine pump control logic relays, all alarm indicator lamps and the facility auto dialer.

Control and alarm signals within cabinets will be hardwired using relays, for logic functions. Panel indicators lamps are to be LED type with the push to test function.

9.5 Field Instruments

The following itemized list gives the names of the standard of acceptance products of each instrument type.

Туре	Acceptable Product
Differential pressure switches	ITT Neo-Dyn Series 164
Flow switches	McDonnell & Miller
Room Thermostats	Honeywell
Building Low Temperature switches	Honeywell
Flow metering	GF Signet Paddle wheel insertion type
Fuel Tank level Switches	GEMS LS800 CSA

9.6 Alarm Handling

Facility alarm signals will be hard wired to the facility control/alarm panel, and each alarm condition will be indicated with an individual indicator lamp. Upon the initiation of any given alarm condition the alarm lamp will illuminate. Should the alarm condition resolve within two minutes the lamp will turn off. (Alarms will self reset in the first two minutes.) Should the alarm stay in for greater than two minutes the panel indicator lamp will remain on. The following table lists the process and facility alarms, alarm descriptions and the forms of annunciation. Refer to drawing 70026-E03 for further alarm information.

Alarm Panel

Alarm Tag	Alarm Description	Annunciation
DPS-300	Change in pressure over 75 MIC strainer.	Alarm Panel
DPS-301	Change in pressure over 20 MIC filter.	Alarm Panel
DPS-302	Change in pressure over 5 MIC filter.	Alarm Panel
DPS-303	Change in pressure over 1 MIC filter.	Alarm Panel
DPS-304	Clean filters indicator light.	Truckfill Panel.
LAL-400	Fuel low warning.	Alarm Panel.
LALL-400	Fuel low alarm	Alarm Panel and Plant Dial Out.
TAL-400	Process room low temperature	Alarm Panel and Plant Dial

	temperature.	Out.
TAL-401	Generator room low temperature.	Alarm Panel and Plant Dial Out.
YA-100	Intake heat trace failure.	Alarm Panel and Plant Dial Out.
YA-300	Truckfill arm heat trace failure.	Alarm Panel and Plant Dial Out.
YA-402	Generator contact failure.	Alarm Panel and Plant Dial Out.

All alarms sent to the auto dialer will also be indicated by a common alarm beacon located above the building roof line and the facility alarm panel buzzer will sound.

10.0 COST ESTIMATE

For the purpose of this report, a capital and operation and maintenance cost has been estimated for the design. Refer to **Appendix I** for a breakdown of the capital and operation and maintenance cost estimate.

The capital cost estimate is \$1,171,000, which includes allowances for engineering and contingencies (GST not included). This has been done for budget purposes. **Table 10-1** outlines the suggested allowances:

Table 10-1: Capital Cost Estimate

Capital Cost Cost Estimate	\$816,955
General Contractor Requirements (5%)	\$40,848
Contingency at (20%)	\$163,391
Engineering	\$150,000
Total Estimated Project Capital Cost	\$1,171,000

The operation and maintenance net present value over 20 years at 8% is \$1,043,654. **Table 10-2** outlines the annual and net present value operation and maintenance cost estimate:

Table 10-2: Operation and Maintenance Cost Estimate

Operation and Maintenance Annual Cost Estimate (includes labour cost)	\$98,425
Interest Rate	8%
Operation and Maintenance NPV Estimate (20 years)	\$1,043,654

11.0 PROJECT DOCUMENTATION

11.1 Record Drawings

Full record drawings of the project will be prepared and submitted in both hard copy (mylar) and electronic form. Such drawings are essential for operations use as well as future plant upgrades.

11.2 Operations and Maintenance Manuals

To assist in plant operations, all of the renovations, procedures, standards and safety standards will be documented and included in a new set of complete operating and maintenance manuals. All disciplines will be represented in these manuals in an organized fashion. There will be six (6) copies of the Operation and Maintenance Manual supplied each complete with one (1) full size and one (1) reduced size paper drawing set. The GNWT Operations and Maintenance Manual specifications will be used for writing the operations and maintenance manuals for Sachs Harbour.

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

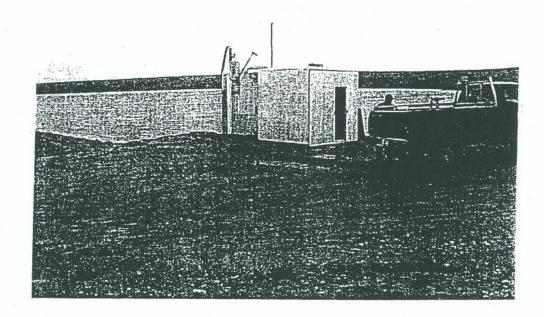
Safe Water



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 &



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 Comp	oletion Dates
Report Phase	Date
Field Work	August 12-16, 2002
Report Issue	April 2003

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ACKNOWLEDGMENTS

PW&S Technical Services Section would like to acknowledge the local community staff who gave of their time to assist with this evaluation, including Philip Moon Ho Son, SAO, Floyd Lennie, Works Foreman and Joseph Carpenter, Water Truck Driver. Also, Margaret Carpenter, the Clerk at the Sachs Harbour Health Center, and John Bulmer of PWS, Chris Beveridge, EHO (H&SS), and Ron Rusnell of MACA, all of whom provided valuable information.

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.

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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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- b) shall under any circumstances be under any liability whatsoever to any person for any loss, damage or expenses of whatever nature or kind arising or resulting directly or indirectly, whether in contract or tort, from reliance on the accuracy or completeness of the information contained in the Review report.

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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 community water supply system consists of a single intake, truckfill station and water delivery truck. 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.

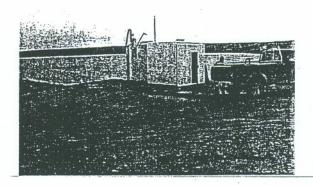
There were a number of O&M issues identified during the review, which are discussed throughout this report. Also, some community representatives expressed concern that there was a lack of general government support for the community.

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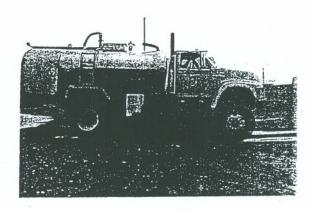
2. WATER SUPPLY SYSTEM

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.

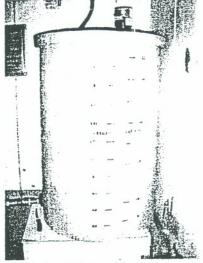


Truckfill Building



Water Delivery Truck

Chlorine System



Chlorine Mixing Tank

3. SYSTEM LAYOUT

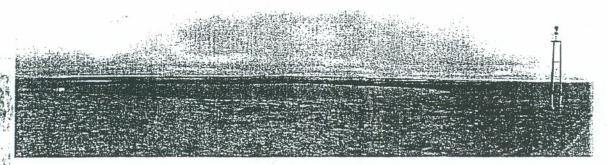


Figure 1. Panorama of Water Lake and Truckfill (white building in picture left).

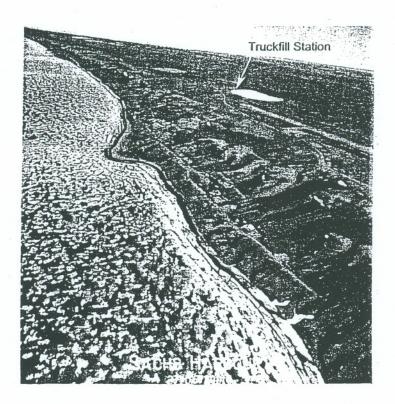


Figure 2. Aerial view of community and truckfill station location.

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)	1. Holds ownership of the assets (truckfill, intake and water truck).
	Subsidizes the Community water delivery program through the Water and Sewer Subsidy Program (WSSP).
	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)	 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 Northern Affairs Canada (INAC - Federal), Department of Fisheries and Ocean (DFO-Federal), Resources Wildlife & Economic Development (RWED)	 All play a role in environmental management of the watershed. NWTWB is responsible for issuing water licenses. INAC Regional staff inspect the water treatment facility annually
	for compliance with the water license and take raw water quality samples. • 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

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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

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 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

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• 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

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• 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
rarameter	Raw	Treated	Samples	Location	Comments
Bacteriological		Monthly	Three	Two public buildings (random), water truck, and private homes upon request	Treated water should be tested 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				Incorporate into regular routine.
THMs and TOCs					THM and TOC should be tested for every six months by the Hamlet.
Water 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)	One	Water truck or truckfill arm	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

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- 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

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 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.
15	Joseph Carpenter	Trained – Not certified	3	Met	Works Foreman	1-2 hours/3 days – water truck driver
L	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

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- 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 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.
	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

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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

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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

16	MACA to help community revise daily chlorine checklist	Medium/Low	Short term and on- going	MACA	_
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Table 7 Recommended GNWT Action Plan (continued)

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11. APPENDIX A (PHOTOGRAPHS)

11.1 Raw Water Source

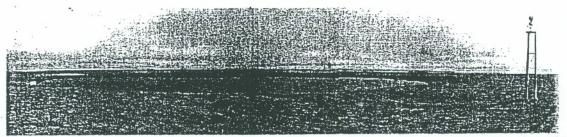


Photo 1. Sachs Harbour truckfill station (white building in picture left), located on the shoreline of Water Lake.

11.2 Truckfill Station Building, Site and Water Truck

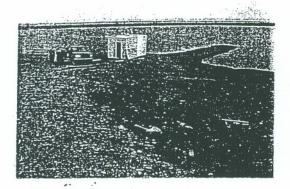


Photo 2. Sachs Harbour truckfill station.

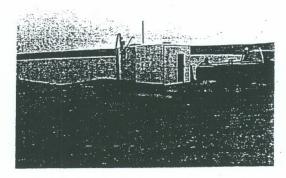


Photo 3. Water truck pull-up area of truckfill station.

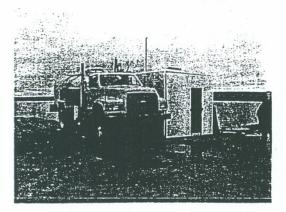


Photo 4. Water truck must back into position in order to fill with water.

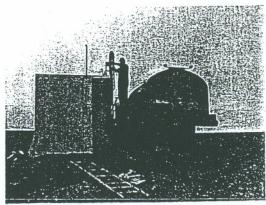


Photo 5. Water truck driver initiating truck fill. Truck is being batch chlorinated.

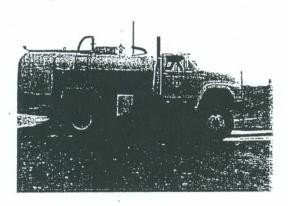
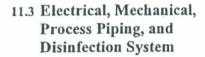


Photo 6. Sachs Harbour water truck.



Photo 7. Water truck distribution hose.



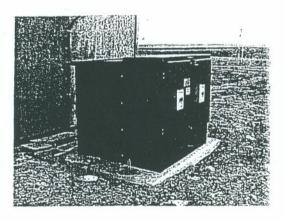


Photo 8. Transformer, uphill from truckfill station, which supplies power to the building.

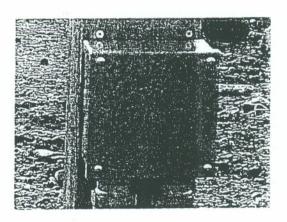


Photo 9. Power is transferred from the transformer (Photo 8) to this pump house feed which used to supply power to the old village truckfill building. Power is relayed from this location to the current truckfill station.

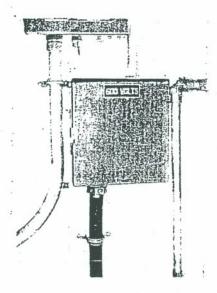


Photo 10. Power from the pump house feed (Photo 9) enters the truckfill station into this power box at 600 volts.



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

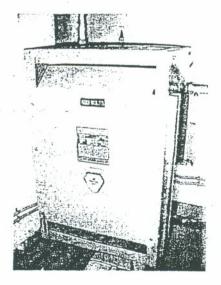


Photo 12. Power the power is then transformed in this transformer to lower voltage and is transferred to the distribution panel.

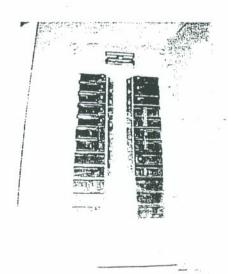


Photo 13. Distribution panel.

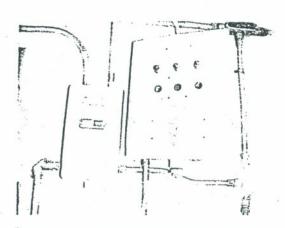


Photo 14. Pump on/off switch on left and control panel on right (not currently operating).

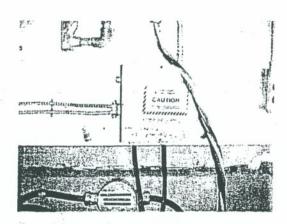


Photo 16. Heat trace power supply box. Heat trace tapes are the grey lines coming out of the bottom of the box.

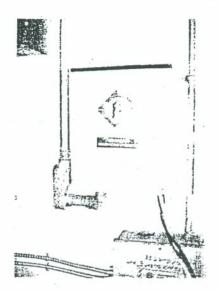


Photo 15. Pump power supply box. Note power cord (red, green, black, yellow) leading to pump.

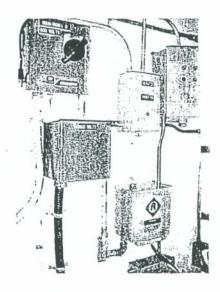


Photo 17. Electrical panels.

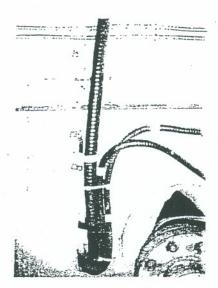


Photo 18. Left is where power enters building from underground power cable. Bottom right is where the water intake line enters building.

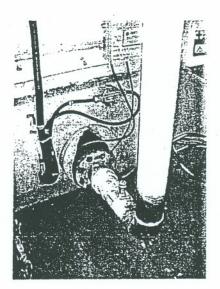


Photo 19. Raw water intake line into building.

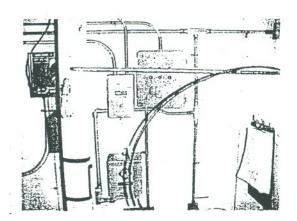


Photo 20. Water distribution piping (white). The domestic water supply is the copper pipe leading from the white pipe to the chlorine solution mixing tank (out of picture). The chlorine injection point is located just below where the copper piping enters the distribution pipe. Note that, in this picture,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

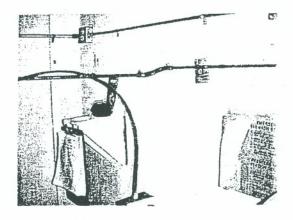


Photo 21. The hanging clipboard is where chlorine levels are recorded. Also observed are the eyewash station, the black tubing leading from the chlorine injector, and the copper tubing leading to the mixing tank.

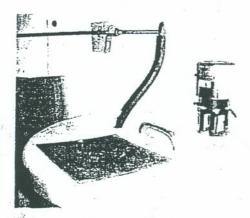


Photo 22. Copper piping (the domestic water supply) leading to mixing tank. Mixer is located on the tank.

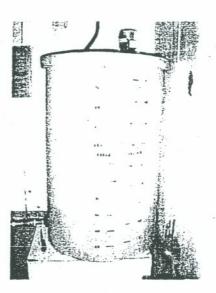


Photo 23. Chlorine solution mixing tank.

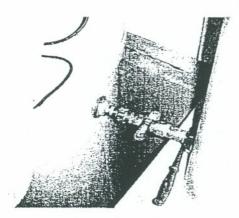


Photo 24. Connection between chlorine mixing tank (right) and chlorine solution tank (left); solution is gravity fed from the mixing tank to the solution tank via this connection.

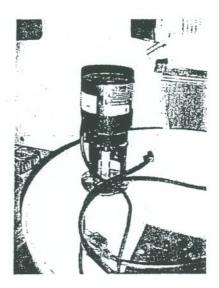


Photo 25. Mixer (agitator) on chlorine solution tank.

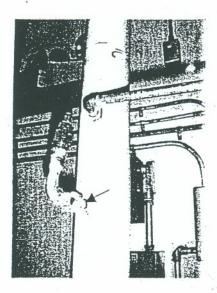


Photo 26. There is a bend in the chlorine injection pipe (indicated by arrow).



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.

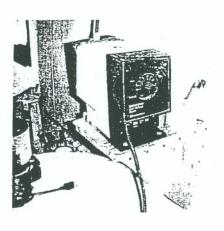


Photo 29. Chlorine injection pump.

1.33

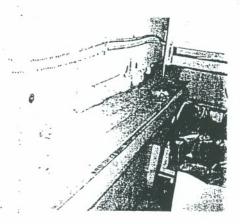


Photo 30. Baseboard heater. Only building heat source.

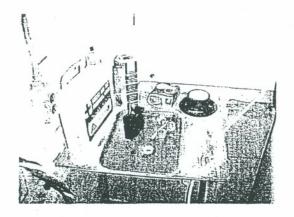


Photo 32. Workstation in truckfill building (pumphouse).

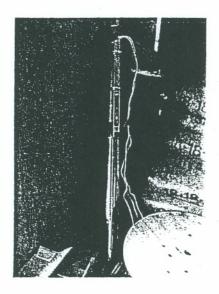


Photo 34. Spare pump connected to power cord.

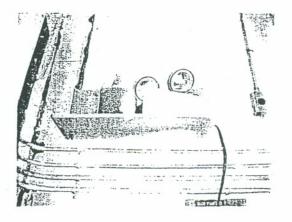


Photo 31. Emergency lighting and spare eyewash fluid.

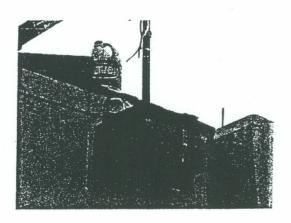


Photo 33. Outside lighting on truck fill side of building. Note the javex used for batch chlorination.

APPENDIX B © GLOSSARY OF TERMS

Table B-1: Glossary of Terms

Technical Term	Definition
activated carbon	A highly adsorptive material used to remove organic substances from water. (See adsorption.)
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 the 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. When this 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)	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 carbonate (CO ₃ ²) such 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.
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.

Technical Term	Definition
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
Пос	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
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 environment
granular activated carbon (GAC)	which are quite resistant to the most commonly used disinfectants Activated carbon in a granular form, which is used in a bed, much like a conventional filter, to adsorb organic substances from water.
GNWT	
OITHI	Government of the Northwest Territories

Technical Term	Definition		
haloacetic acids	A family of halogenated disinfection by-products believed to cause cancer 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 0.3 mg/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 cas 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 foun 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, as established by state and/or federal regulations. Primary MCLs are health related and mandatory. Secondary MCLs are related to the aesthetics of the water and are highly recommended but not required.		
membrane processes	Water treatment processes in which relatively pure water passes through a poror membrane while particles, molecules, or ions of unwanted matter are excluded.		
nanofiltration	Membrane filtration capable of removing material in the molecular and ionic		
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 one point, such as at a kitchen sink. The term is also sometimes used interchangeabl 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		
sedimentation basin	A basin or tank in which water is retained to allow settleable matter, such as floot to settle by gravity. Also called a settling basin, settling tank, or sedimentation tank.		
sludge	The accumulated solids separated from water during treatment.		

Technical Term	The amount of carbon bound in organic compounds in a water sample as determined by a standard laboratory test.		
total organic carbon (TOC)			
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 (GCDWO, 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	
Barium	1.0		
Cadmium	0.005		
Chloramines (total)	3.0		
Chloride			≤ 250
Chromium	0.05		
True Colour			≤ 15 TCU¹
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
pH			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)	I 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 GCDWO, 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 - "*Turbidity in Drinking Water*", 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 Cl2)	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 GCDWO
- 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

APPENDIX D Sachs Harbour 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 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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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 Parameters			
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	***		Ongoing
Viruses	***		Ongoing

- MAC = maximum acceptable concentration; IMAC = interim maximum acceptable concentration.
- ** Refer to note 1 in Table 2.
- *** Refer to section on Summary of Guidelines for Microbiological Parameters.

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.

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

- 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 I			
antimony		0.006 2	
arsenic		0.025	
atrazine + metabolites		0.005	
azinphos-methyl	0.02		
barium	1.0		
bendiocarb	0.04		
benzene	0.005		
benzo[a]pyrene	0.00001		
boron		5	
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		ALLE TO THE PROPERTY OF THE PR
chromium	0.05		The state of the s
colour			≤15 TCU ⁴
copper 2			≤1.0
cyanazine		0.01	51.0
cyanide	0.2	0.01	
cyanobacterial toxins (as microcystin-			
diazinon	0.02	T TANK DE LA COLUMN DE LA COLUM	
dicamba	0.12		
dichlorobenzene, 1,2-5	0.20		≤0.003
dichlorobenzene, 1,4-5	0.005		
dichloroethane, 1,2-	0.003	0.005	≤0.001
dichloroethylene, 1,1-	0.014	0.003	
dichloromethane	THE RESIDENCE AND ADDRESS OF THE PERSON NAMED IN COLUMN 2 IS NOT THE OWNER, THE PERSON NAMED IN COLUMN 2 IS NOT THE OWNER, AND ADDRESS OF THE OWNER,	The state of the s	
	0.05		
dichlorophenol, 2,4-	0.9		≤0.0003
dichlorophenoxyacetic acid, 2,4- (2,4-		0.1	
diclofop-methyl	0.009		
dimethoate		0.02	
dinoseb	0.01		
diquat	0.07	The second secon	
diuron	0.15		
ethylbenzene			≤0.0024
fluoride 6	1.5		
glyphosate		0.28	

	MAC	IMAC	AO
Parameter	(mg/L)	(mg/L)	(mg/L)
iron			≤0.3
lead ²	0.010	1	
malathion	0.19		
manganese			≤0.05
mercury	0.001		
methoxychlor	0.9		
metolachlor		0.05	
metribuzin	0.08		
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
pН			6.5□8.5 ⁹
phorate	0.002		
picloram		0.19	
selenium	0.01		
simazine		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		And the second s
tetrachlorophenol, 2,3,4,6-	0.1		≤0.001
toluene		The second secon	≤0.024
total dissolved solids (TDS)		AMERICA CALLANDA DE MOTO A MATERIA MATERIA DE CONTRACTOR DE COMPANSA DE CONTRACTOR DE	≤500
trichloroethylene	0.05		
trichlorophenol, 2,4,6-	0.005		≤0.002
trifluralin	0.003	0.045	20.002
trihalomethanes (total) 12		0.1	
turbidity	1 NTU 13	V.1	≤5 NTU 13,14
uranium	1110.5	0.02	221410 1311
Minimum Advisor of the Control of th	0.002	0.02	
vinyl chloride	0.002	To select securities a loss day in addition of all boths and advantagements in the	<0.2
xylenes (total)	AND REST DESCRIPTION OF THE REST OF THE RE	THE PLANT OF THE RESIDENCE OF THE PARTY OF T	≤0.3
zinc ²			≤5.0

Notes:

- 1. 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.
- 6. It is recommended, however, that the concentration of fluoride be adjusted to 0.8 \(\tau\).0 mg/L, which is the optimum range for the control of dental caries.
- Equivalent to 10 mg/L as nitrate [hitrogen. 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:

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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.

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:

$$\frac{C_1}{MAC_1} + \frac{c_2}{MAC_2} + \dots \frac{c_i}{MAC_i} \le 1$$

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 _½	DCF (Sv/Bq)	MAC (Bq/L)
Natural Radionuclides				
Lead-210	210РЬ	22.3 years	1.3×10^{-6}	1.0
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	2.45×10^5 years	3.9×10^{-8}	4*
Uranium-235	235U	7.04×10^8 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	125[59.9 days	1.5×10^{-8}	10
Iodine-131	131[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**	311	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 _½	DCF (Sv/Bq)	MAC (Bq/L)
Natural Radionucli	ides				
Beryllium-7		7Be	53.3 days	3.3×10^{-11}	4000
Bismurh-210		210Bi	5.01 days	2.1×10^{-9}	70
Polonium-210	357	210Po	138.4 days	6.2×10^{-7}	0.2
Artificial Radionuc	lides**				
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	· (C	140Ba	12.8 days	3.7×10^{-9}	40
Bromine-82	9	82Br	35.3 hours	4.8×10^{-10}	300
Calcium-45		45Ca	165 days	8.9×10^{-10}	200
Calcium-47	1	47Ca	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[1.60×10^7 years	1.1×10^{-7}	1
Iron-55		55Fe	2.68 years	4.0×10^{-10}	300
Iron-59		59Fe	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		203Hg	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	$2.41 \times 10^{4} \text{ years}$	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 ¹⁴C are also produced naturally in the atmosphere in significant quantities.

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Radionuclide		Half-life t _½	DCF (Sv/Bq)	MAC (Bq/L)
Rhodium-105	105Rh	35.4 hours	5.4 × 10-10	300
Rubidium-81	81Rb	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	IIIAg	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

APPENDIX F ORDER OF MAGNITUDE COSTS

APPENDIX F PRELIMINARY ORDER OF MAGNITUDE COSTS

Sachs Harbour Clarification-Filters-UV Membranes September 2003

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

APPENDIX F PRELIMINARY ORDER OF MAGNITUDE COSTS

Sachs Harbour Ultrafitration Membranes September 2003

Design Horizon Population Plant Production (hrs/day)		192 22
Design Water Demands		
Average Day Demand Based (L/day)		18043
Peaking Factor		2.1
Maximum Day Demand Based (L/day)		37890
Plant Production including Wastes (L/day) assumes 10%		41680
Plant Production Rate (L/min)		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 Operating C	osts	
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
Grand Total	\$	141,775
Interest Rate		8%
NPV of O&M Costs (20 year life cycle)	\$	1,503,325

APPENDIX F PRELIMINARY ORDER OF MAGNITUDE COSTS

Sachs Harbour Cartridge Filtration-UV Future-Chlorination Membranes September 2003

Design Horizon Population		192
Plant Production (hrs/day)		22
Design Water Demands		
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 Costs		
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 Operating Co	osts	
Labour	\$	25,000
Materials (Based on changing one train of filters per month)	\$	36,000
Contract Services	\$	5,000
Utilities	\$	50,000
Subtotal	\$	116,000
Admin Fee (6%)	\$ \$ \$.	6,960
GST (7%)		8,607
Grand Total	\$	131,567
Interest Rate		8%
NPV of O&M Costs (20 year life cycle)	\$	1,395,086

APPENDIX G



LETTER OF ACCEPTANCE OF CARTRIDGE FILTERS TECHNOLOGY GNWT – OCTOBER 2003 PAUL GUY, MANAGER WATER & SANITATION DEPARTMENT OF PUBLIC WORKS & SERVICES GOVERNMENT OF THE NORTHWEST TERRITORIES

Acceptance of Cartridge Filtration Technology

This email is in response to a request from the Water and Sanitation Section, Public Works and Services, regarding regulatory approval in principal for cartridge filtration and acceptance of this filtration technology as meeting the intent of the proposed new *Guideline for Canadian Drinking Water Quality* (GCDWQ) turbidity guideline.

Public works and Services have submitted two documents for consideration on this topic, titled *Colville Lake Pilot Study* and *DISCUSSION PAPER: CARTRIDGE FILTRATION.* This documentation includes product specific challenge testing information which indicates that cartridge filtration with chlorination can achieve the log reduction of protozoa and viruses specified in the proposed turbidity guideline. It is the view of this office that this treatment method does meet the intent of the proposed new GCDWQ turbidity guideline. Therefore the Office of Chief Medical Health Officer, as the regulator for drinking water safety in the NWT, is prepared to approve cartridge filtration systems for treating pristine surface water sources. Please note that detailed applications for specific projects will still have to be made to the department.

Duane Fleming Chief Environmental Health Officer Office of Chief Medical Health Officer

FLEMING\dc
H:\epi-dc\duane\hss acceptance of cartridge filtration

APPENDIX H Control DESIGN DRAWINGS

SACHS HARBOUR WATER UPGRADES



ISSUED FOR TENDER
CIVIL, STRUCTURAL, PROCESS, MECHANICAL,
ELECTRICAL, INSTRUMENTATION

PMIS No. 3421 FEBRUARY 2004

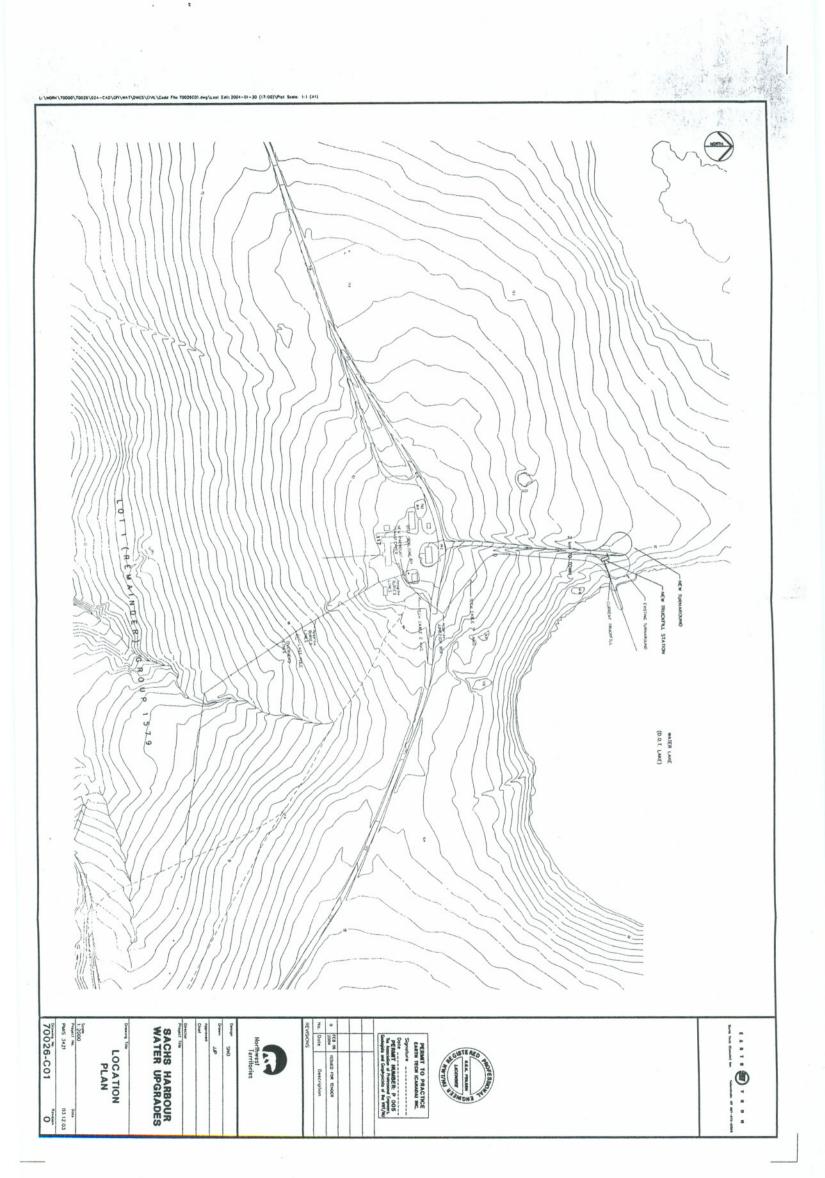


YELLOWKNIFE, NT

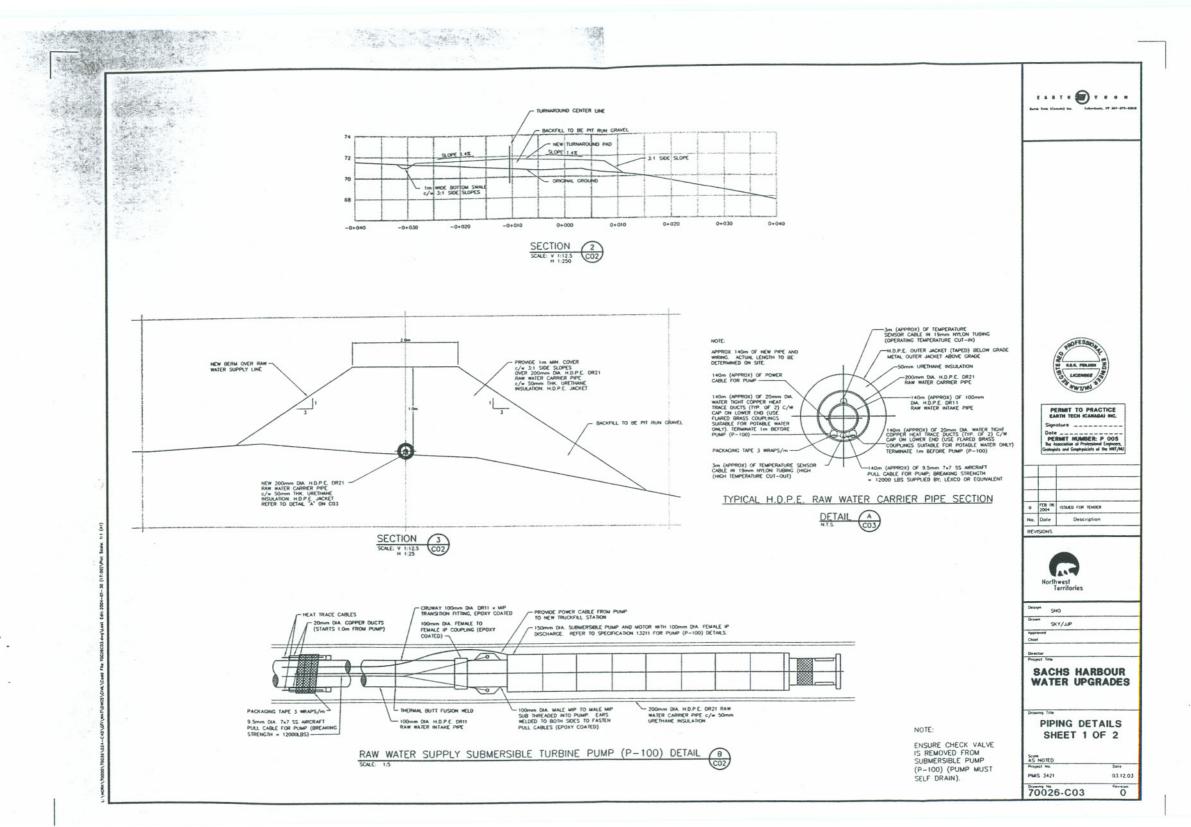
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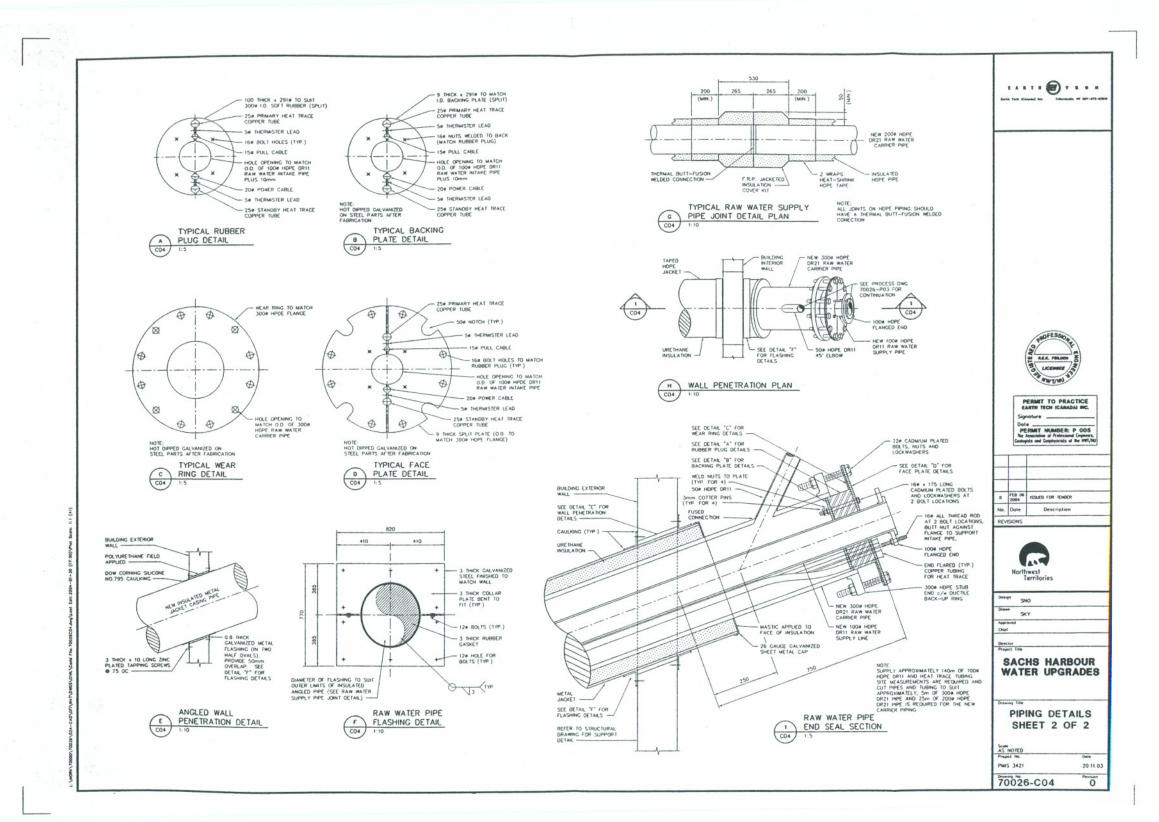
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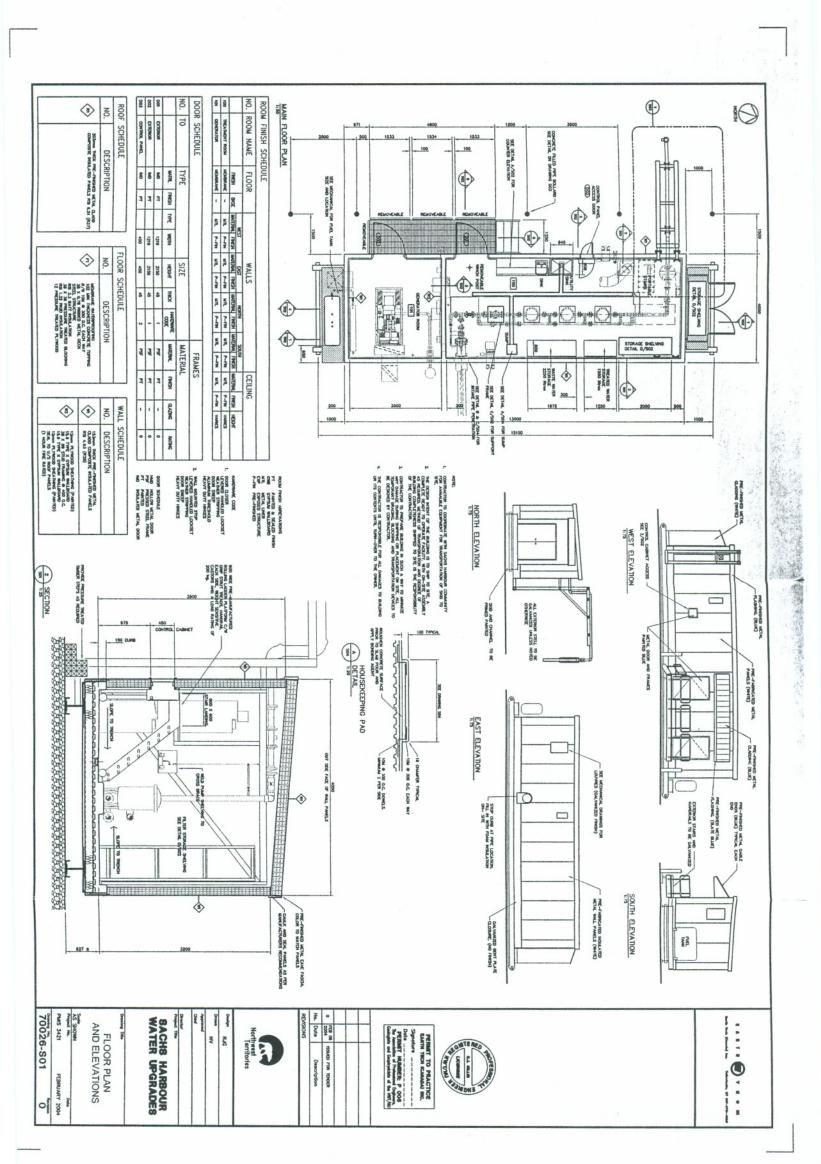
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C01	LOCATION PLAN	0	P01	PROCESS AND PIPING AND INSTRUMENTATION SYMBOLS	0							
C02	SITE PLAN AND PROFILE	0	P02	PROCESS AND INSTRUMENTATION DIAGRAM	0							
C03	PIPING DETAILS SHEET 1 of 2	0	P03	PROCESS PIPING LAYOUT PLAN	0							
C04	PIPING DETAILS SHEET 2 of 2	0	P04	PROCESS PIPING SECTIONS & DETAILS	0							
			P05	STANDARD DETAILS	0							
	STRUCTURAL DRAWINGS		P06	STANDARD DETAILS	0							
S01	FLOOR PLAN AND ELEVATIONS	0										
S02	SECTIONS AND DETAILS	0		MECHANICAL DRAWINGS								
S03	TRUCK FILL ARM AND DETAILS	0	M01	MECHANICAL SYSTEMS PLAN	0							
S04	SKID FLOOR PLAN AND DETAILS	0	M02	MECHANICAL SCHEMATICS AND DETAILS	0							
_				ELECTRICAL DRAWINGS	-							
			E01	SITE PLAN, LIGHTING SCHEDULE AND DETAILS	0							
			E02	POWER & SYSTEMS PLAN	0							
			E03	ALARM PANEL CONTROL SCHEMATICS & DETAILS	0							
			E04	CONTROL PANEL SCHEMATICS & DETAILS	0							
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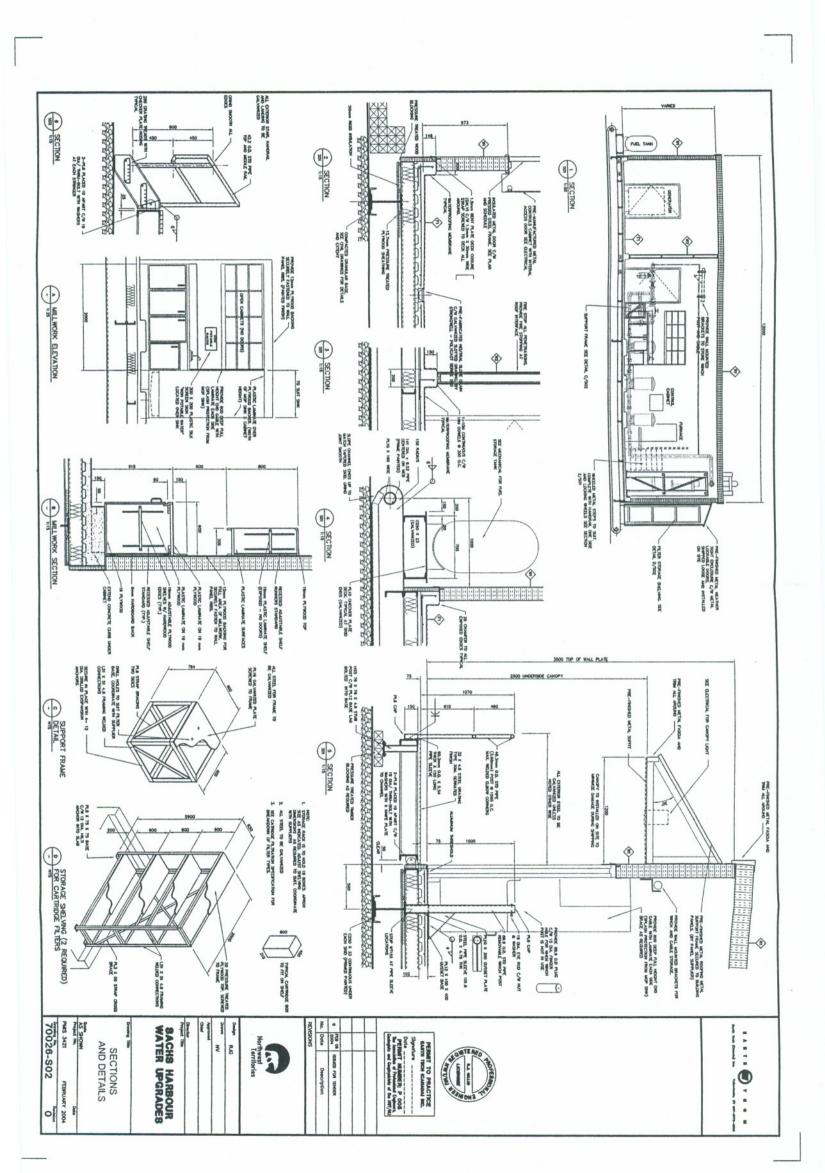


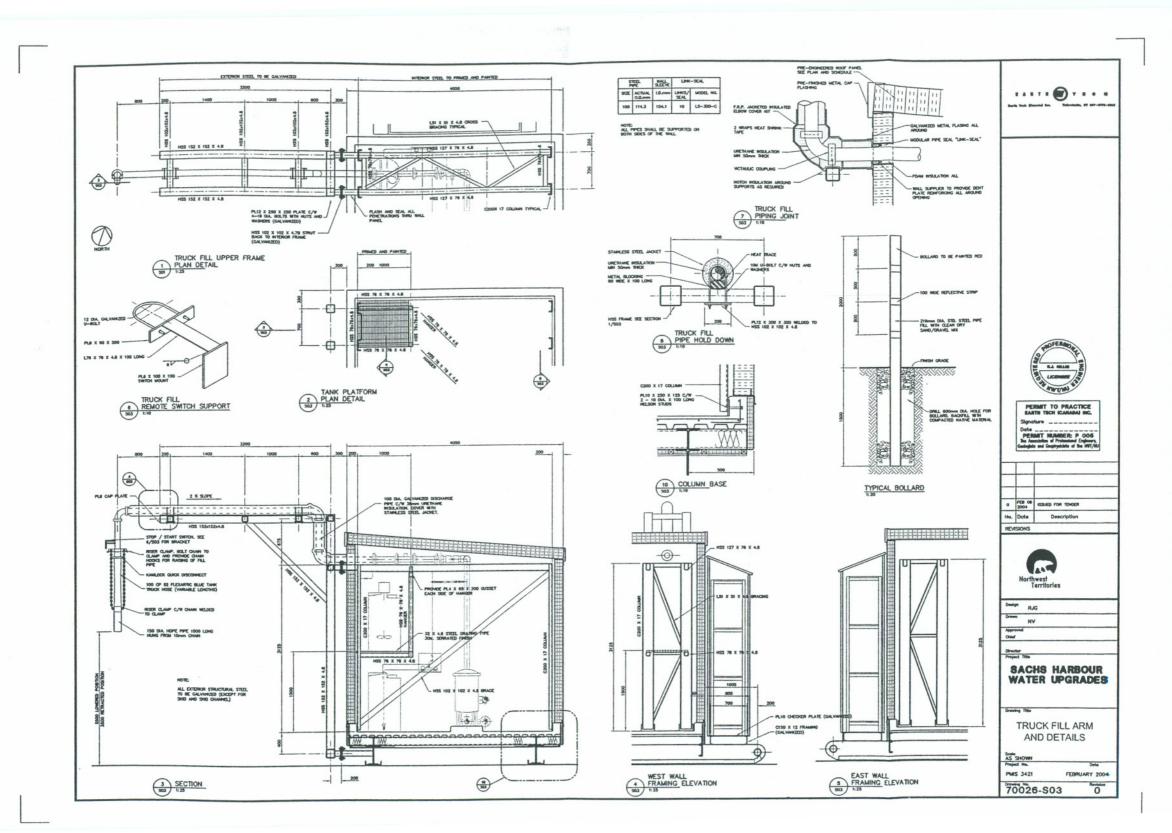
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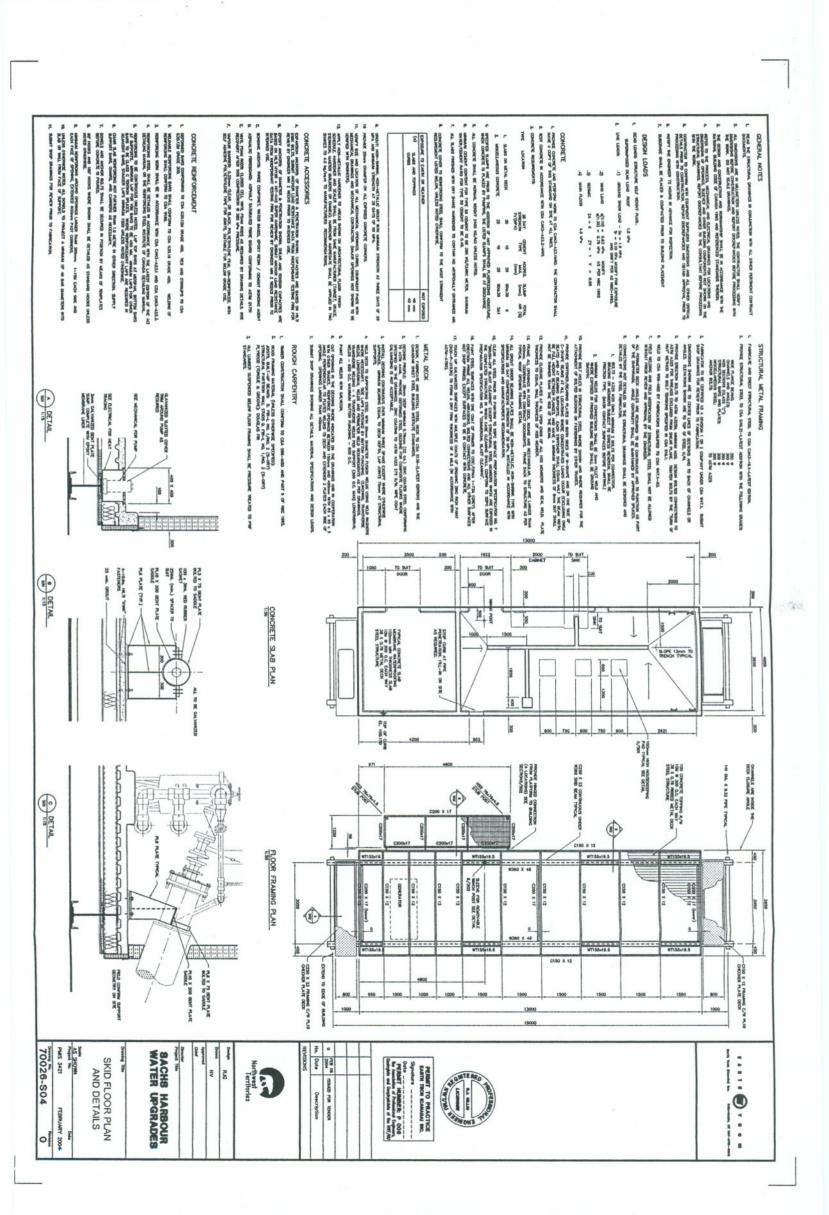












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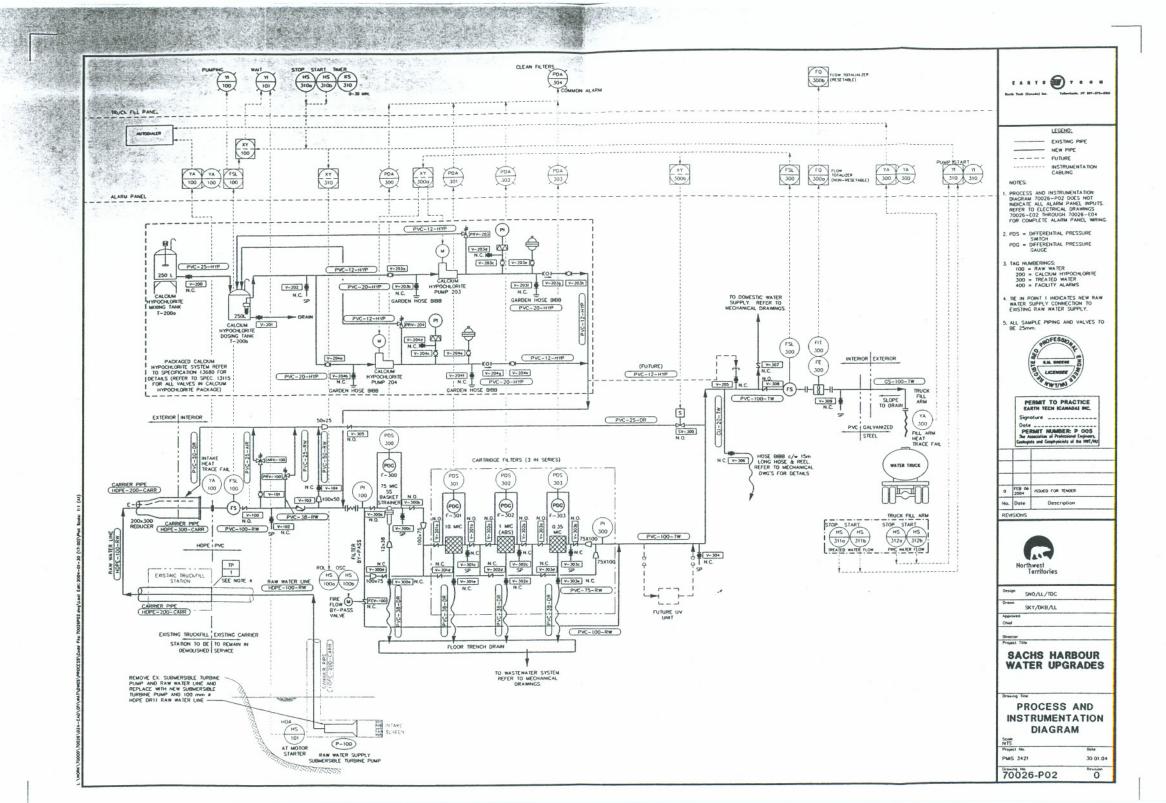
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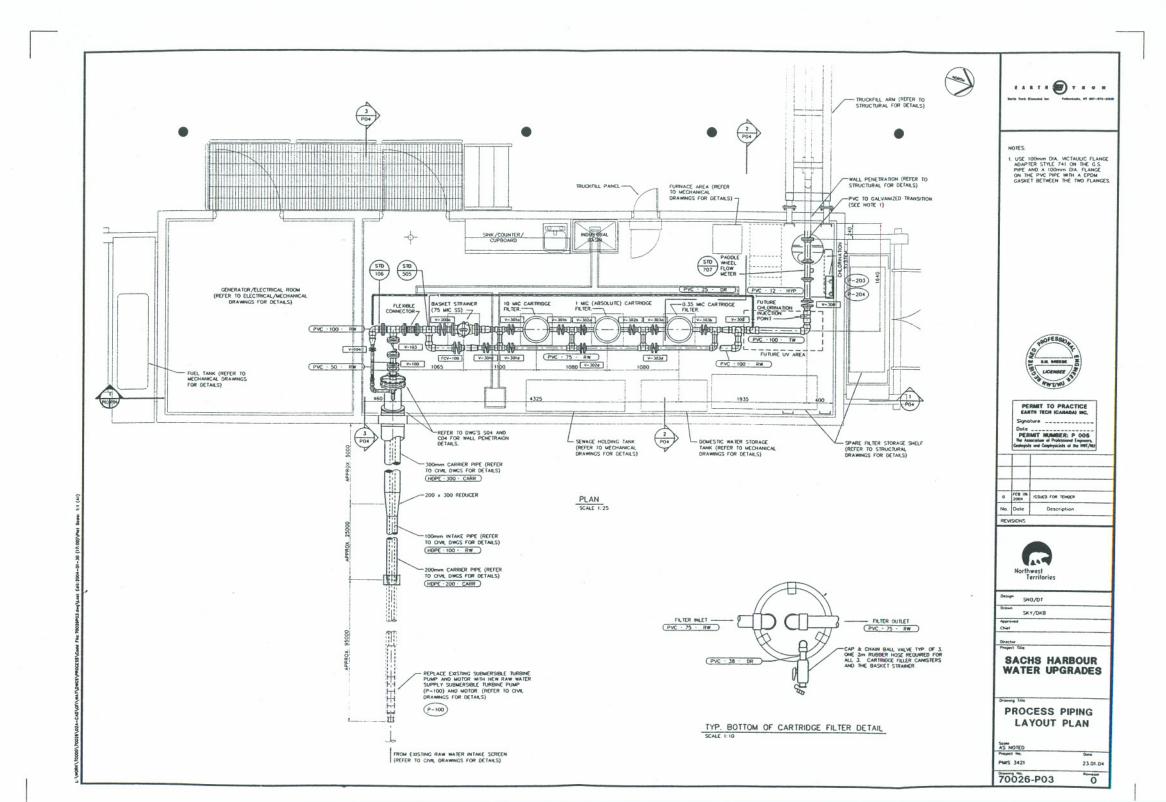
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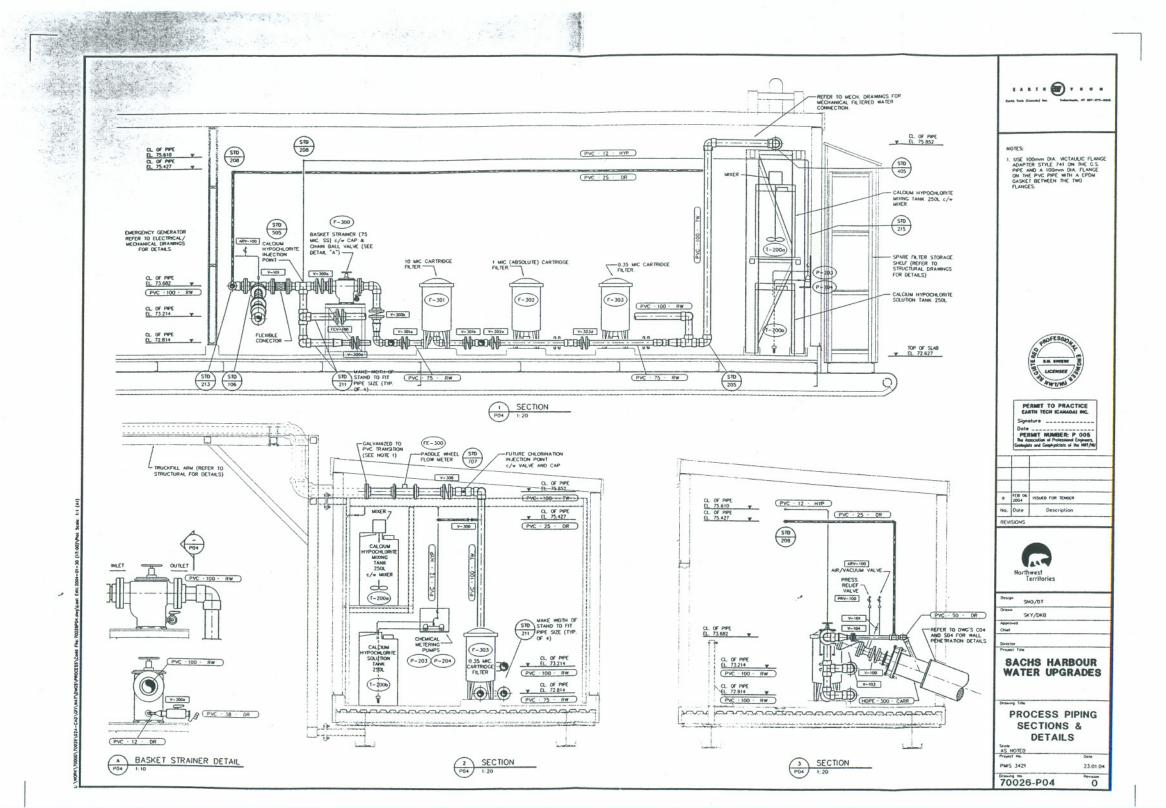
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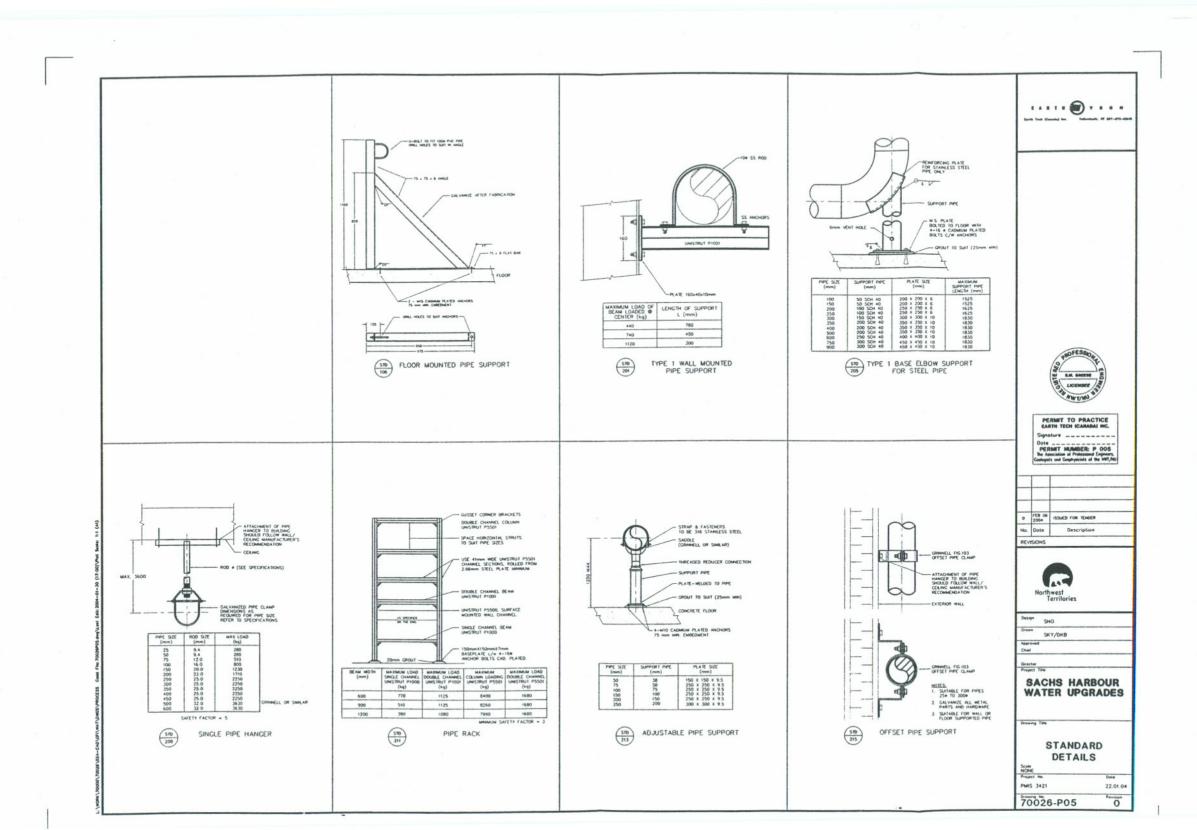
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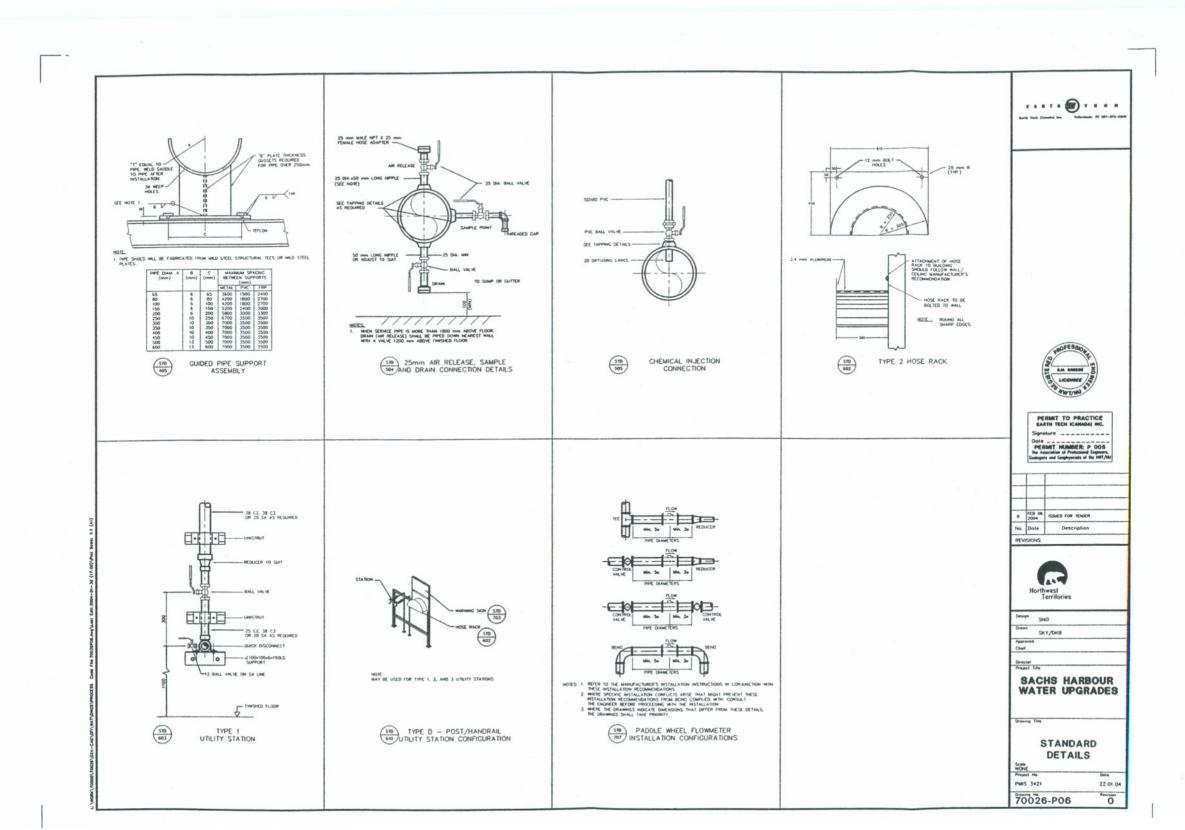
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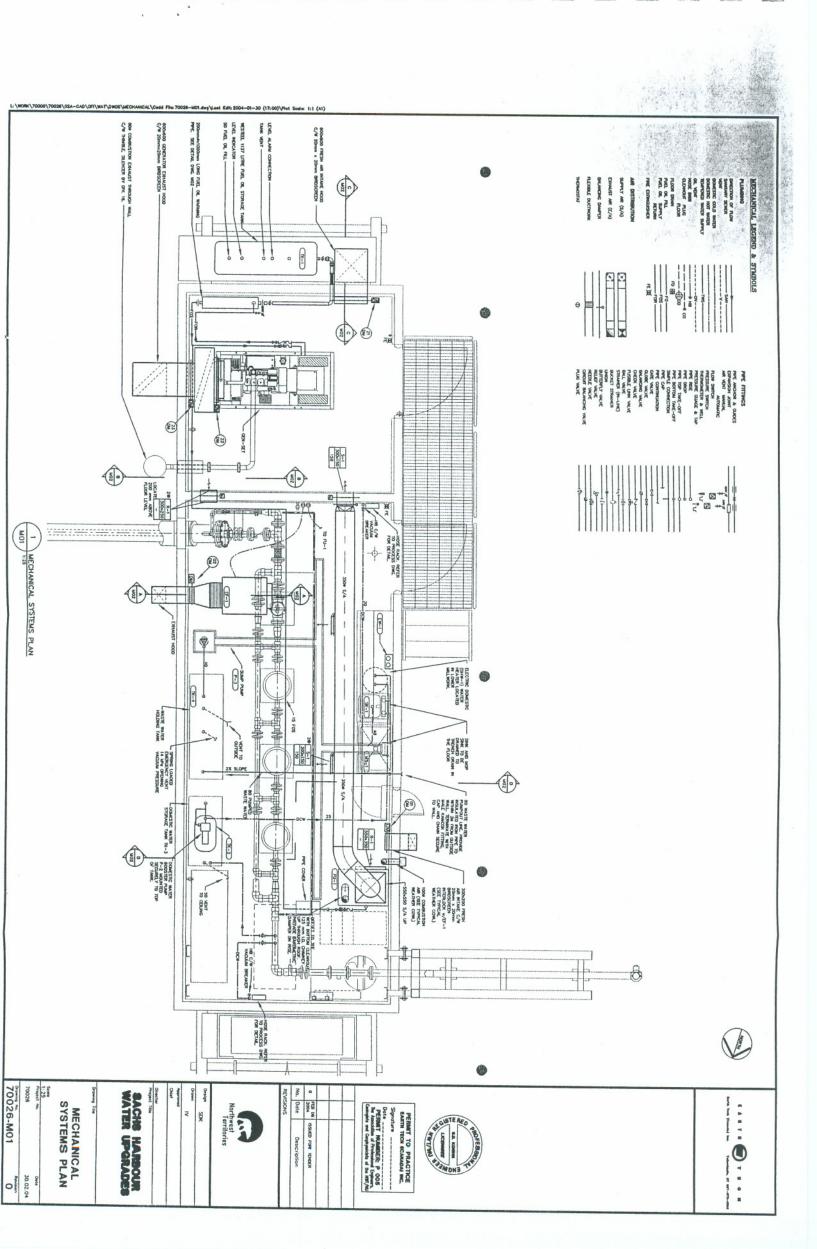


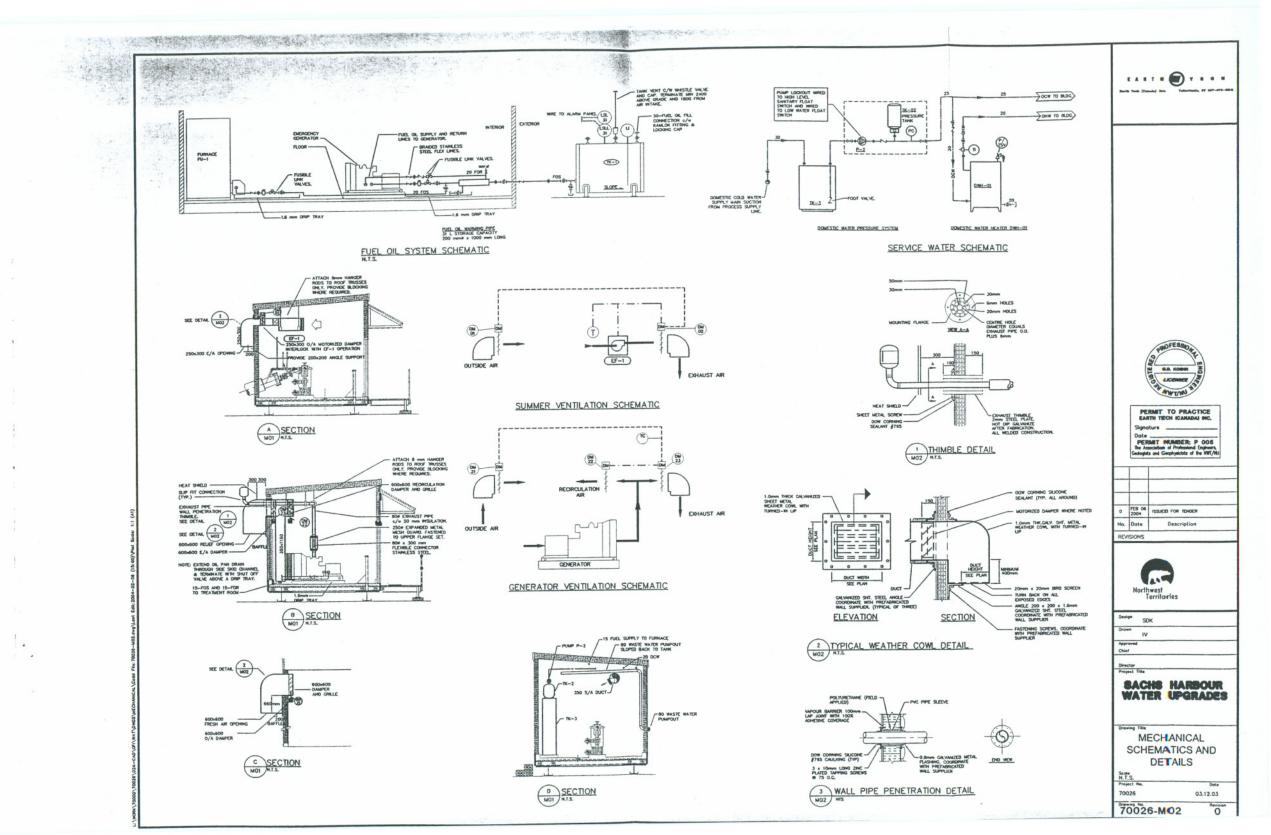


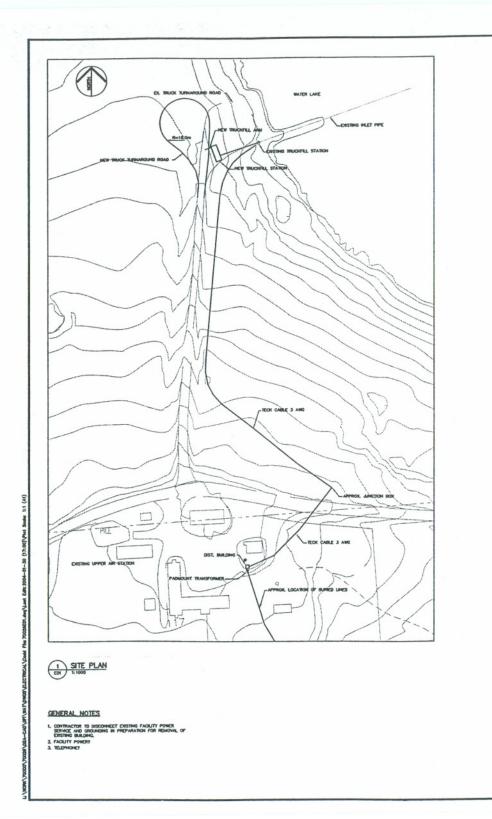












ELECTRICAL LEGEND

H HJ.D. LUMINAIRE - WALL MOUNTED WALL MOUNTED EXIT LIGHT PLUORESCENT LIMINARE - SURFACE MOUNTED OR SUSPENDED PHOTO ELECTRIC CELL PHOTO-ELECTRIC CELL CONTROLLED LIMINAIRE PEC

BATTERY PACK C/W HEADS AS INDICATED H DIERGENCY REMOTE HEADS

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HO-MP MANUAL MOTOR STARTER C/W PLOT UGHT

LAMP TYPE: 200 WATT, INCANDESCENT

HOUSING: CAST FERROUS ALLOY, COATED

COMPLETE WITH WIRE QUARD CLASS L DIV. I Products are based to exhalted extensive electricity. For approved of equivalent entire to financial functions of operations.

LAMP TYPE: 32 WATT, T-8, FLUORESCENT

TYPE No.

TYPE No.

CLEAR, HEAT RESISTANT CLOSE

MOUNTING: SURFACE, CEILING

LAMP QTT: 1

REPLECTOR: NOME

SPECIAL REQUIREMENTS

ACCEPTABLE PRODUCTS: MANUF ACTURER APPLETON CROUSE—HINDS

LUMINAIRE

SCHEDULE

LAMP OTT: 2

MOUNTING SUFFACE

REFLECTOR: NOME LINS: POLYCARBONATE

ACCEPTABLE PRODUCTS:

LUMINAIRE

SCHEDULE

LAMP TYPE: 9 WATT TUNGSTEN

MOUNTING SURFACE, WALL HOUSING: STEEL WHITE FINISH

OR APPROVED EQUAL

LAMP QTC 2

REPLECTOR: HONE

LENS: TUNCSTEN

SPECIAL REQUIREMENTS:

ACCEPTABLE PRODUCTS: MANUFACTURER READY-LITE LD12-75

LUMINAIRE

SCHEDULE

OR APPROVED COUAL

REMOTE HEADS RT SERIES RT-1 AND RT-2

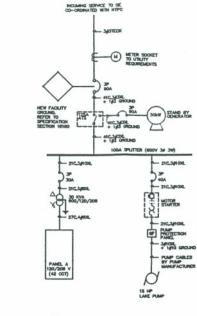
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2 ELECTRICAL SINGLE LINE DIAGRAM
RT.S.



EXIT

LAMP TYPE: 70 WATT, HIGH PRESSURE SCORUM LAMP QTY: 1 MOUNTING: SURFACE, WALL HOUSING WEATHER RESISTANT DIE CAST REFLECTOR: SPECULAR ALZAK ALIMPRAN

LENS: BOROSRICATE GLASS

Personal are bond by extending extension described. For expersed or ACCEPTABLE PRODUCTS: COOPER OR APPROVED EQUAL

TYPE No. LUMINAIRE SCHEDULE

LAMP TYPE: LED LAMP QTY: 1 MOUNTING SURFACE WALL HOUSING: DIE CAST ALLMINUM

REPLECTOR NONE LENS: RED STENCH. SPECIAL REQUIREMENTS:

WALL MOUNTED C/W DC LAMP SOCKET

Products are blind to which where distribute for opposed of opening order to based based or opening. ACCEPTABLE PRODUCTS:
MANUFACTURER
READY-LITE DIN-L121
DIN-W BACK WALL HOURT

LUMINAIRE X1

. Surth Took (Connts) Inc. Televisetts, ST 657-679-60

PERMIT TO PRACTICE EARTH TECH ICAMADAI INC. Signature _ PERMIT NUMBER: P 005 The Association of Professional Engineers, Geologists and Geophysicists of MWT / MU

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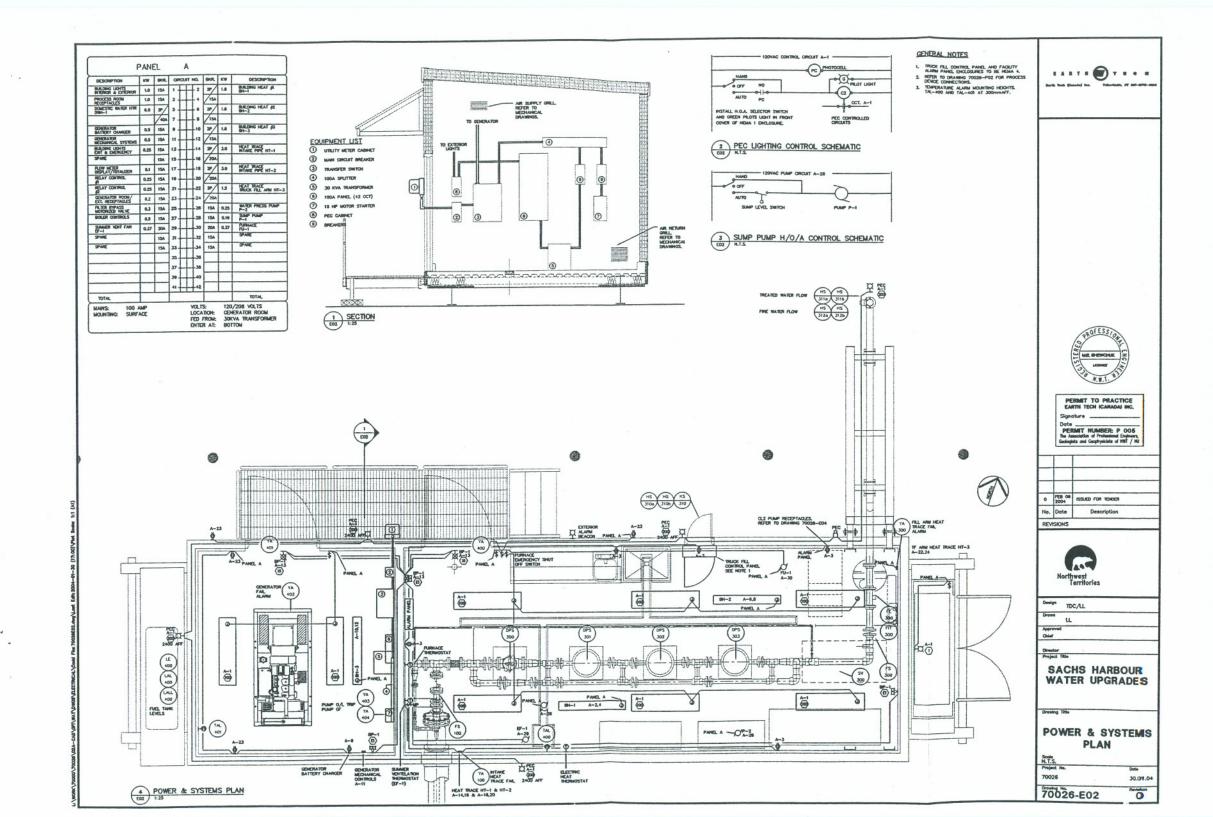


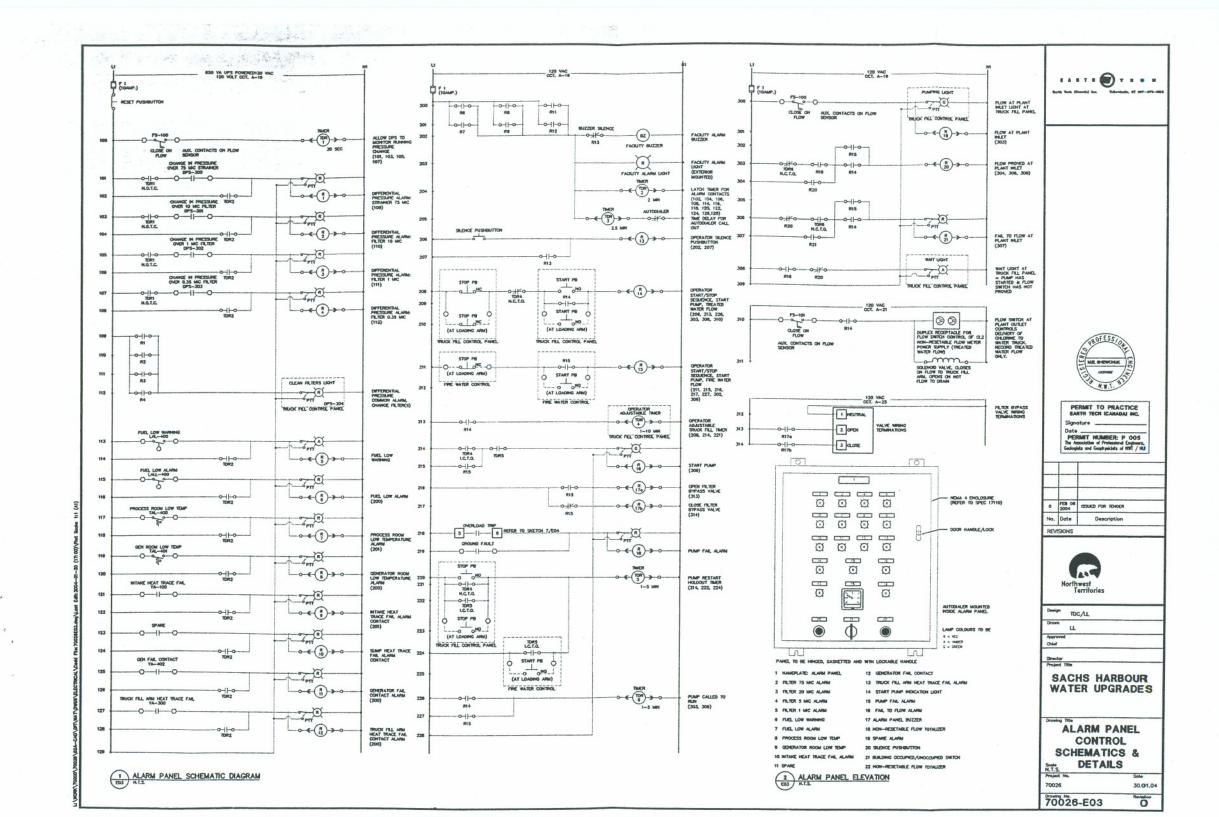
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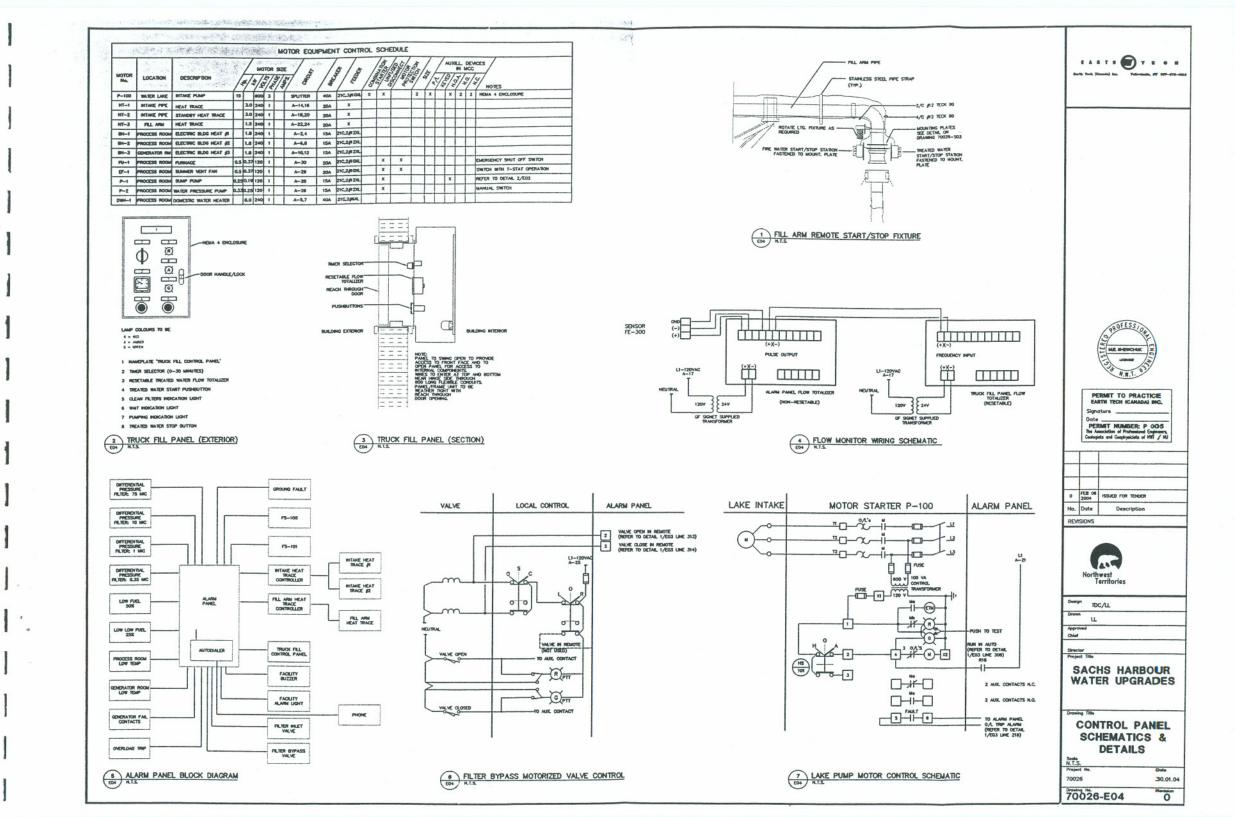
SACHS HARBOUR WATER UPGRADES

SITE PLAN, LIGHTING SCHEDULE. AND DETAILS

70026 30.01_04 Revision 70026-E01







APPENDIX I



CAPITAL AND OPERATING & MAINTENANCE COST ESTIMATE

SACHS HARBOUR WATER UPGRADES - FINAL DESIGN REPORT APPENDIX I: Capital and Operation and Maintenance Cost Estimate

Date:

20-Feb-04

Table I-1: Capital Cost Estimate

Description	Quan.	UofM	Unit	Material/Labour Cost	Northern Cost Allowance 1	Total Cost \$
CIVIL/SITEWORKS						
Demolition of Existing Truckfill Facility	1	ls	10,000	\$10,000	already incl in unit cost	\$10,000
Removal of 45 gal Drums from Lake Shore (number of drums unknown)	1	ls	2,500	\$2,500		\$2,500
Raw Water Intake	1	1s	\$15,000	\$15,000	\$17,625	\$32,625
Excavation	35	m ³	45	\$1,575	already incl in unit cost	\$1,575
Backfill	1880	m ³	60	\$112,800	already incl in unit cost	\$112,800
General Subcontractor Mark-up (10% of Civil/Siteworks)				\$13,938	-	\$15,700
			subtotal >	\$143,313	-	\$162,700
PROCESS						
Raw Water Intake Pump ²	3	ea	\$4,300	\$13,975	\$16,421	\$30,396
Chlorination System (Pumps/Tanks/Mixer/piping/ lyr supply of Hypo Tablets)	1	ls	\$14,000	\$14,000	\$16,450	\$30,450
Filtration System						
- PVC Simplex Strainer (75 MIC) and canister	1	ea	\$5,000	\$5,000	\$5,875	\$10,875
- Spare basket Strainers	2	ea.	\$850	\$1,700	\$1,998	\$3,698
- HIF-75 SS Cannister	3	ea	\$9,400	\$28,200	\$33,135	\$61,335
- 10 MIC Cartridge Filter ³	125	ea	\$40	\$5,000	\$5,875	\$10,875
- 1 MIC (absolute) Cartridge Filter ³	500	ea	\$80	\$40,000	\$47,000	\$87,000
- 0.35 MIC Cartridge Filter ³	225	ea	\$55	\$12,375	\$14,541	\$26,916
WTP Internal Piping/Fittings/Valves	1	ls	\$20,000	\$20,000	\$23,500	\$43,500
Paddle Wheel Flow meter	1	1s	\$500	\$500	\$588	\$1,088
General Subcontractor Mark-up (10% of Process)				\$11,108	\$13,051	\$24,159
			subtotal >	\$123,883	\$145,562	\$269,444
STRUCTURAL						
Insulated Metal Building	1	ls	20,000	\$20,000	-	-
Steel Skid with Concrete Floor	1	ls	25,000	\$25,000	-	-
Miscellaneous Steel, Fill Arm, Stairs, etc	1	ls	10,000	\$10,000	-	-
			subtotal >	\$55,000	see note 5	\$122,310
MECHANICAL						
Fuel System	1	1s	6,000	\$6,000	\$7,050	\$13,050
Sheet Metal	1	1s	8,000	\$8,000	\$9,400	\$17,400
Heating and Ventilation Systems	1	ls	6,000	\$6,000	\$7,050	\$13,050
Plumbing Systems .	1	ls	7,500	\$7,500	\$8,813	\$16,313
HVAC Controls	1	ls	1,000	\$1,000	\$1,175	\$2,175
General Subcontractor Mark-up (10% of Mechanical)				\$2,100	\$2,468	\$4,568
			subtotal >	\$30,600	\$35,955	\$66,555

SACHS HARBOUR WATER UPGRADES - FINAL DESIGN REPORT APPENDIX I: Capital and Operation and Maintenance Cost Estimate

Date:

20-Feb-04

Table I-1: Capital Cost Estimate

Description	Quan.	UofM	Unit	Material/Labour Cost	Northern Cost Allowance 1	Total Cost
ELECTRICAL						
New Service Main Distribution ⁴	1	ls	7,500	\$7,500	\$8,813	\$16,313
600V Reduced Voltage Motor Starter:(c/w Bypass)	1	ls	4,500	\$4,500	\$5,288	\$9,788
Standby Power Generation and Distribution	1	ls	26,000	\$26,000	\$30,550	\$56,550
Facility Distribution Equipment	1	ls	2,000	\$2,000	\$2,350	\$4,350
Interior/Exterior Lighting	1	ls	2,800	\$2,800	\$3,290	\$6,090
Emergency Lighting/Exit Signage	1	ls	1,500	\$1,500	\$1,763	\$3,263
Conduit & Wiring	1	ls	7,500	\$7,500	\$8,813	\$16,313
Telephone/Alarm Dialer System	1	ls	2,800	\$2,800	\$3,290	\$6,090
Building Electrical Heat	1	ls	2,800	\$2,800	\$3,290	\$6,090
Heat Trace System (Intake Pipe)	1	ls	8,500	\$8,500	\$9,988	\$18,488
General Subcontractor Mark-up (10% of Electrical)				\$6,590	\$7,743	\$14,333
			subtotal >	\$72,490	\$85,176	\$157,666
CONTROLS	***************************************					
Truck Fill Panel	1	ls	2,000	\$2,000	\$2,350	\$4,350
Facility Control/Alarm Panel	1	ls	6,500	\$6,500	\$7,638	\$14,138
Sensors	1	ls	4,500	\$4,500	\$5,288	\$9,788
Conduit / Wiring and Cabinets	1	ls	3,000	\$3,000	\$3,525	\$6,525
General Subcontractor Mark-up (10% of Controls)				\$1,600	\$1,880	\$3,480
			subtotal >	\$17,600	\$20,680	\$38,280
Sub-Total						5016.055
General Contractor Requirements (5%)						\$816,955
						\$40,848
20% Contigency				The state of the s		\$163,391
Total Estimated Capital Cost						\$1,021,000
Engineering						\$150,000
Total Estimated Project Cost						\$1,171,000

GST Excluded

Notes:

- 1. 50% Edm to YK + 45% YK to Sachs Harbour = 215% Northern Allowance from Edmonton
- 2. Includes Optional Spare pump that is in the Contract (Appendix F in the Front End)
- 3. Each cannister contains 25 triple length cartridge filters. The quantity includes the initial two year supply: 5-10 MIC; 20-1 MIC (abs); 9-0.35 MIC
- 4. New service main distribution costs are for the building only and do not include any costs from NTPC
- 5. Building cost is based on Tsiigehtchic WTP (Oct. 2003) per square metre cost (plus 10% for construction of a smaller building) plus 13% for Sachs Harbour.

Tsiigehtchic per square metre cost = \$1,570

Sachs Harbour per square metre cost = \$2,000

Therefore, Sachs Harbour Truckfill Building Cost = \$122,310

SACHS HARBOUR WATER UPGRADES - FINAL DESIGN REPORT APPENDIX I: Capital and Operation and Maintenance Cost Estimate

Date:

20-Feb-04

Table I-2:Operation and Maintenance Cost Estimate

Description	Quan.	UofM	Unit	Material \$	Northern Cost Allowance	Total Cost \$
PROCESS						
Calcium Hypochlorite Tablets - 1-25 kg pail each year	1		\$130	\$130	0152	0000
Cartridge Filters: 1 year supply	1	ea	\$130	\$130	\$153	\$283
10 MIC	75	ea	\$40	\$3,000	©2.525	06.505
1 MIC (absolute)	250	ea	\$55	The second secon	\$3,525	\$6,525
0.35 MIC	125	THE RESERVE THE PARTY NAMED IN	\$80	\$13,750	\$16,156	\$29,906
Basket Strainer	123	ea	\$850	\$10,000	\$11,750	\$21,750
Dasket Strainer	1	ea	\$850	\$850	\$999	\$1,849
Power Supply						
Calcium Hypochlorite metering pumps	18.72	kWH	0.85	20	N/A	\$20
Raw Water intake pump	2340	kWH	0.85	1,990	N/A	\$1,990
			subtotal >	\$26,610	\$28,905	\$55,515
MECHANICAL						4
Filter changes (furnace and oil)	1	ls	1,000	1,000	N/A	\$1,000
Fuel Oil (\$1.044/L)	2011	L	1.044	2,100	N/A	\$2,100
Furnace Fan replacement	1	ls	250	250	N/A	\$250
			subtotal >	\$3,350		\$3,350
ELECTRICAL						40,000
Heat Trace (75% duty cycle for 1/2 of the year)	6570	kWH	0.85	5,580	N/A	\$5,580
Lighting	2190	kWH	0.85	1,860	N/A	\$1,860
Building Electric Heat (standby only)	96	kWH	0.85	80	N/A	\$80
Receptacles etc. (1.5kW average continuous)	13140	kWH	0.85	11,170	N/A	\$11,170
			subtotal >	\$18,690		\$18,690
Total Annual O&M Material Cost						977 858
Miscellaneous Supplies and Replacement Item						\$77,555 \$7,756
Total Annual O&M Labour Cost				THE PUBLICATION OF THE PUBLICATI		
Total Annual Owil Labour Cost						\$13,114
Total Annual O&M Cost ³						\$98,425
Interest Rate				-		8%
Total NPV over 20 years				TO THE PARTY OF TH		\$ 1,043,654

Notes:

- 1. 50% Edm to YK + 45% YK to Sachs Harbour = 215% Northern Allowance from Edmonton
- 2. The Labour Cost was provided by the Hamlet office in Sachs Harbour (Labour costs = \$10,479; Benefits= \$2,635- TOTAL = \$13,114).
- 3. The O&M cost estimate does not include replacement costs for major pieces of equipment. It is assumed that the major equipment items will have a life equal to or greater than 20 years.