Volume 2 - Water System Building Assessment

Final Report - Revision 1

May, 1999

Volume 2 - Water System Building Assessment
Resolute Bay, NT

Public Works & Service - GNWT
Northwest Territories

98-5748-01-01

Submitted by

Dillon Consulting Limited

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1.0 INTRODUCTION

1.1 General

The Hamlet of Resolute Bay is serviced by a water supply system that uses a utilidor system to deliver water to houses and commercial users, and collect the sewage from these users. The water supply and sewage disposal systems are comprised of several components, namely:

- The raw water source known as Char Lake
- The Char Lake pumphouse
- The water supply line from the Char Lake pumphouse to the Water Treatment Plant (WTP)
- The utilidor system that is comprised of the water distribution system and the sewage collection system
- The Sewage Treatment Plant
- The sewage outfall.

The above components are shown in **Figure 1.1** and will be described in more detail in the body of the report. Previous studies (UMA 1996) assessed each of the system components for condition, expected remaining life and required remedial action to be undertaken to extend the current facility life to 20 years. The results of this study indicated that in general the facility components are well maintained, and will meet the Hamlet's requirements for the next 20 years. The exception is the utilidor system that has experienced a number of failures over the past 5 to 7 years. The increase in failures is of significant concern to the utilidor maintainers and the Hamlet Council.

The GNWT, Department of Municipal and Community Affairs (MACA) owns the assets of the water and sewer systems. The Department of Public Works & Services (DPW&S) completes the operation and maintenance on the systems. The GNWT has identified the transfer of the community assets to the communities as a priority. In this vein, the GNWT intends to transfer the water and sewer system to the Hamlet of Resolute Bay. Prior to the transfer of the facilities, the systems are to be upgraded to meet the requirements of the Hamlet for the 20 year design life. Dillon was retained to review the system in this light, and develop an upgrading plan for the sewage and water systems assuming that the piped distribution system will be maintained in the community. Three reports were produced, namely;

Volume 1 - Utilidor Upgrade
Volume 2 - Water System Building Assessment
Volume 3 - Sewage treatment and Future System Expansion

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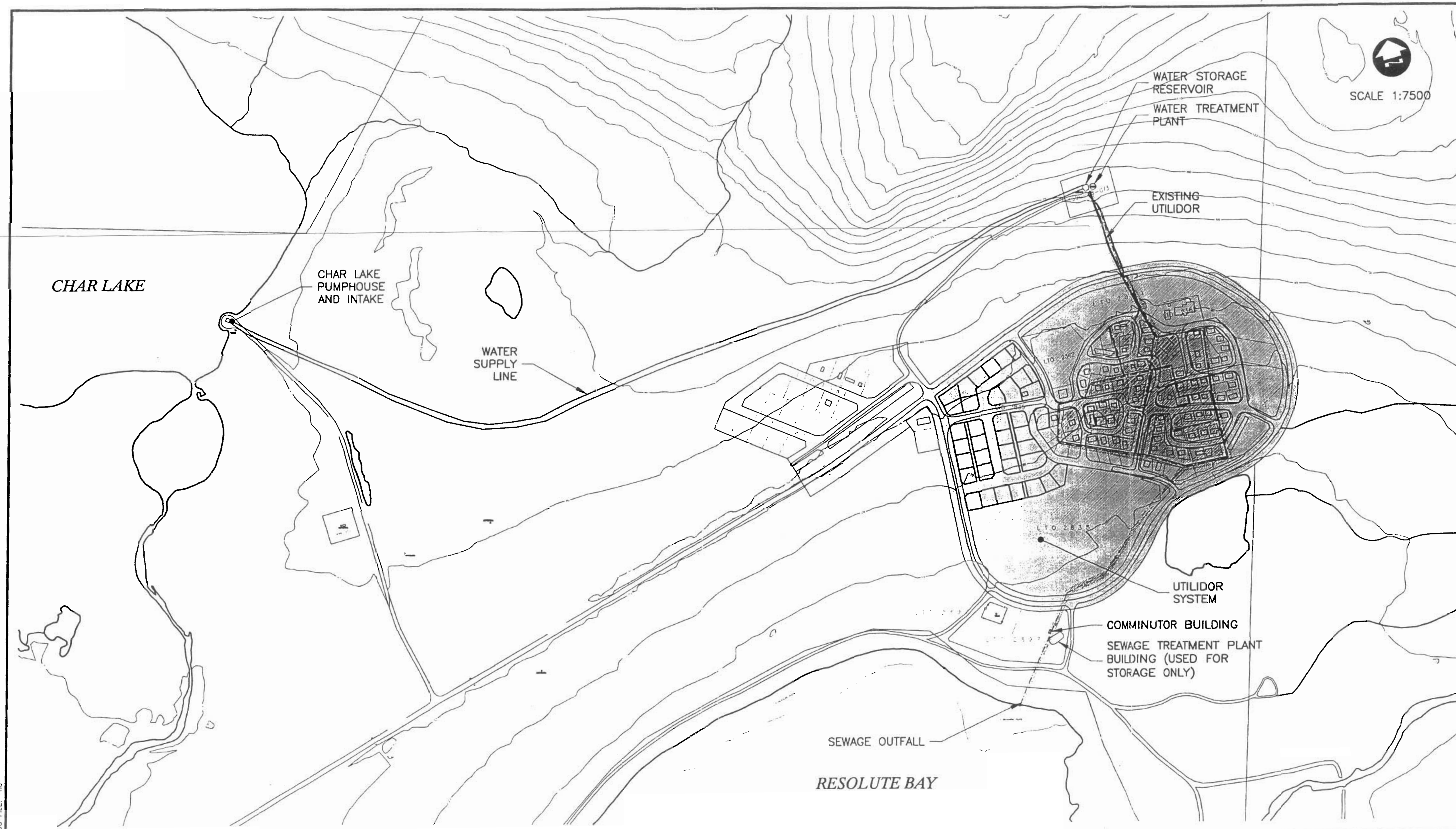

LEGEND
- WATER
- SEWER

DILLON CONSULTING	PROJECT: HAMLET OF RESOLUTE BAY UTILIDOR UPGRADE	PROJECT NUMBER: 98-5748
		DATE: OCT 98
	TITLE: WATER SUPPLY AND SEWAGE DISPOSAL SYSTEM	FIGURE NUMBER: FIG 1.1

1.2 Scope of work

The scope of work for this volume relates to the water system buildings, namely the Char Lake Pump House, the Signal Hill Water treatment Plant, and the Water Storage Tank.. A summary of the scope of work is described below:

- Complete a review of the existing documentation.
- Complete a site investigation to update the previous work.
- Debrief the system operator on his concerns, and review the system operator's records of the system.
- Develop a list of required upgrades to be completed to have the system meet the Hamlet's system needs for the next 20 years and complete cost estimates for these upgrades.

2.0 EXISTING DATA REVIEW

2.1 Community Data

Resolute Bay is located on the south coast of Cornwallis Island and is about 1,660 km north east of Yellowknife and 1,550 Km north west of Iqaluit. The community is located at latitude N74-43-01 and longitude W94-58-10 (NAV CANADA). The average daily minimum and maximum temperatures for July and January are 1.3°C & 6.8°C and -35.8°C & -28.5°C respectively. An average of 50.4 mm of rainfall and 97.3 cm of snowfall for a total of 139.6 mm of precipitation is received each year (Environment Canada).

The community was founded in the early 1970's when it was decided to relocate the existing community from the beach area near the existing south camp to the present location. The development of the community and the initial infrastructure was based on a projected population of some 1,500 people. The expected growth was not realized and the current population is slightly less than 200 persons.

2.2 Population Projection

To be able to develop the system requirements it is necessary to determine the design flow rates for the piped system. The flow rates are based on the population of the community and the expected per capita consumption. The historic populations and per capita water use rates are based on the records found at the Hamlet's office, MACA's records and in previous reports (UMA, 1993, 1996). The population projections are based on the data supplied by the Bureau of Statistics. These are as follows:

Table 2.2.1
Population Projects from the Bureau of Statistics

Year	Population
1991	171
1992	174
1993	178
1994	181
1995	184
1996	197
2001	224
2006	238

The consumption is based on the formula developed by MACA (MACA, 1986) and on the historic consumption of the community. The formulae for predicting water consumption of communities with piped water distribution and populations less than 2,000 people is:

$$\text{Daily Consumption} = 225*(1 + 0.00023 * (\text{Population})) * \text{Population}$$

Based on this formula and the population projections shown in Table 2.2.1, the projected annual consumption for the Hamlet of Resolute Bay for the next 20 years can be predicted. The system uses bleed water from the watermains to provide freeze protection to the sewermains. The bleed water is not metered. The total water pumped into the system is metered, and the individual consumers are metered. The resultant of the water supplied to the system and the metered volume of the consumers is the total of the system losses. The total system losses include the bleed water, losses due to watermain breaks, and water losses within the system. Prior to 1996, this value was fairly constant at approximately 38,000 m^3 per year. As a result of increased problems with the system the amount of bleed water has increased in 1996 to 52,000 m^3 and again in 1997 to 56,000 m^3. At the time of reporting, the Hamlet was projecting an annual total consumption for 1998/99 of 55,000 m^3 of which 45,000 m^3 would be the bleeders and other system losses. For the purposes of water consumption projections the value of 45,000 m^3 of bleed water and other system losses is used. The projected annual consumption is shown in **Table 2.2.2.**

2.3 System Description

The following is a description of the complete water and sewage system from the up gradient intake to the down gradient sewer outfall. **Figure 2.1** illustrates this system in a schematic diagram.

Char Lake

- A ductile iron gravity intake line extends from Char Lake to wet wells in the Char Lake Pump House.
- Char Lake Pump House tempers the water using a hot water injection into the wet wells. Diesel fired boilers are used to heat the injection water. The tempered water is pumped through the 150 mm heat traced and insulated HDPE Water Supply Main to the Water Storage Reservoir at the Water Treatment Plant (WTP).
- Two jockey pumps and two demand pumps are operated in the Char Lake Pump House. Typically one jockey pump operates 24 hours a day, with one demand pump coming on for less than one hour per day. The second jockey pump and second demand pump are on-line standby pumps and are brought on-line automatically if the first pump fails.
- The Char Lake Pump House pumps are controlled from a level controller located in the Water Storage Reservoir. The controller has a high level alarm, jockey pump off, jockey pump on, demand pump off, demand pump on, and low level alarm control levels.
- A standby diesel engine generator is situated in the Char Lake Pump House in case of loss of power to the Pump House.

Table 2.2.2
Population and Consumption Projections

Design Year	Year	Population	Growth Rate	Consumtion lcd	Consumption Annual (historic)	Consumption Annual (MACA)	Bleeders Annual	Total Volume (Historic)	Total Volume (MACA)	Daily Average (Historic)	Daily Average (MACA)
	1991	171		145	9,050,175		38,400,000	47,450,175		130,000	
	1992	174	0.0175	145	9,208,950		38,400,000	47,608,950		130,435	
	1993	178	0.0230	145	9,420,650		38,400,000	47,820,650		131,015	
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	1996	197	0.0707	145	10,426,225	16,911,678	51,868,684	62,294,909	68,780,362	142,106	188,439
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5	2004	233	0.0219	145	12,331,525	20,160,576	45,000,000	57,331,525	65,160,576	123,288	178,522
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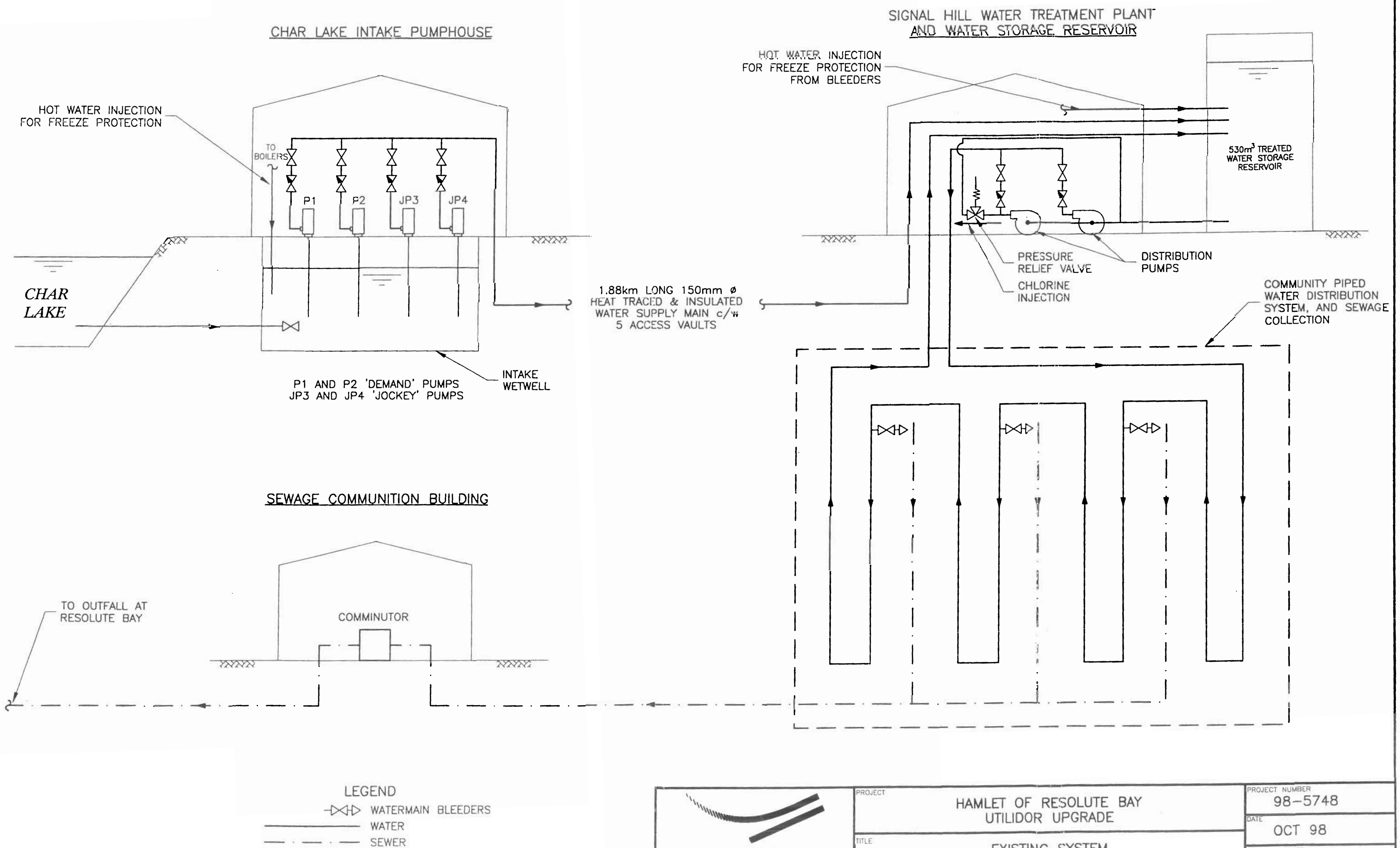
19	2018	250	0.0042	145	13,248,941	21,742,407	45,000,000	58,248,941	66,742,407	123,288	182,856
20	2019	251	0.0042	145	13,304,843	21,839,163	45,000,000	58,304,843	66,839,163	123,288	183,121



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DILLON CONSULTING

PROJECT: HAMLET OF RESOLUTE BAY UTILIDOR UPGRADE

TITLE: EXISTING SYSTEM SCHEMATIC

PROJECT NUMBER: 98-5748

DATE: OCT 98

FIGURE NUMBER: FIG 2.1

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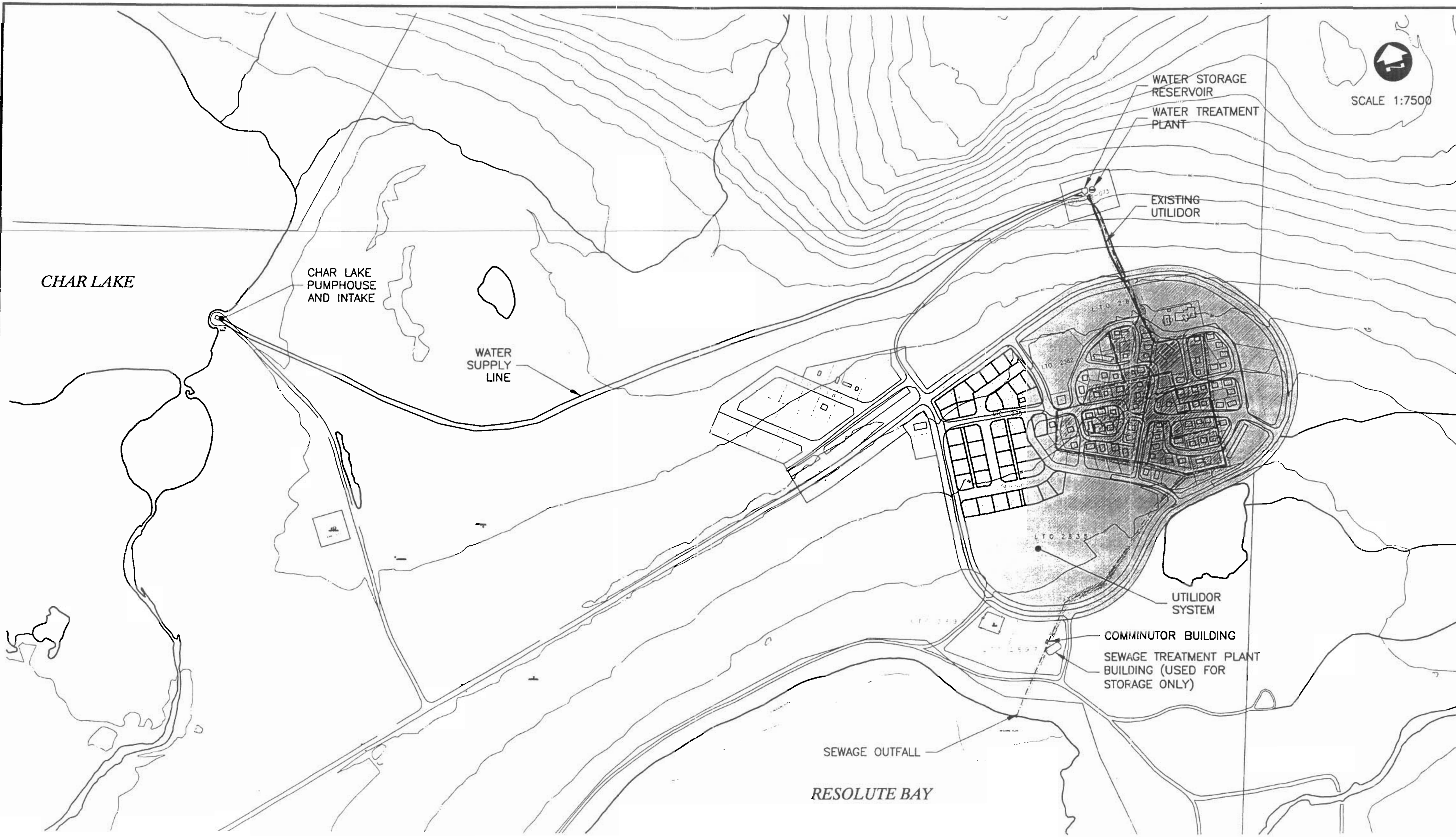

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DILLON CONSULTING	PROJECT: HAMLET OF RESOLUTE BAY UTILIDOR UPGRADE	PROJECT NUMBER: 98-5748
		DATE: OCT 98
	TITLE: WATER SUPPLY AND SEWAGE DISPOSAL SYSTEM	FIGURE NUMBER: FIG 1.1

Water Treatment Plant

- The Water Storage Reservoir is a steel 530 m^3 vertical steel tank constructed above grade. The tank is insulated and is freeze protected by the use of hot water injection.
- The Water Treatment Plant uses diesel fired boilers to provide tempering water for the Water Storage Reservoir hot water injection.
- The distribution water to the community is chlorinated using calcium hypochloride through injection pumps.
- The WTP uses pumps to provide distribution flow. The pressure is maintained at approximately 170 kPa (25 psi) at the WTP (October 1998 reading), and approximately 600 kPa (85 to 90 psi) at the low end of distribution system. The difference between the discharge pressure and the low end main pressure is the result of the static head difference in the mains due to elevation changes. The supply pump runs continuously at a constant rate of 1,700 rpm. The flow to the distribution mains is not regulated. Whatever water is not used within the distribution system is returned to the reservoir through the 150 mm return line.

Utilidor

- The distribution system is a looped HDPE insulated pipeline. The pipes are mostly 200 mm in diameter with two sections of 150 mm supply line and a 150 mm return line.
- Water is supplied to users (approximately 60 buildings) through a 20 mm copper heat traced (Stage 1A only) and insulated services. A return service is also installed from each building to the water main. Flow is moved continuously through the supply and return services by a small recirculation pump (1/4 h.p.) located in each building.
- The return water is directed back to the Water Storage Reservoir.
- The building sewage is collected using 100 mm insulated HDPE sewers to the sewer mains.
- The water and sewer services are in a common insulated jacket. The latent heat from the recirculation of the water services is used to freeze-protect the sewer service.
- Bleed water from the water mains is also used to provide freeze protection to the sewer mains during power failures when the water service recirculation pump is not operating
- The sewer mains are gravity run 150 mm insulated HDPE. These are installed in the same trench as the watermain.
- The sewermains and watermains are accessed through common concrete cast in place Access Vaults (AVs). The AVs contain all valves, hydrants, pipe connections and sewer clean outs.
- The sewer main is freeze-protected by the use of bleed water from the watermain to the sewermain. The bleeders are unmetered and located in the AVs.

Sewage Discharge

- The sewer mains join at the low end of the community and flow by gravity to a community building.
- The sewage is macerated in this facility and discharged by gravity through an outfall pipe to the

shore line of the marine environment.

There have been several changes to the system since the original design. Some of these changes have been incorporated into the O&M manuals. The changes recorded during the site investigation completed on October 20 to 22, 1998 are from the discussions with the DPW Maintainer, Mr. Neil MacDonald, the Hamlet Administration, Mr. Dan Leman & Mr. Ralph Alexander, and from the existing documentation are as follows:

- A heat trace has been installed in the Water Supply Line from the Char Lake Pump House to the WTP in 1993. Five access vaults have been installed along this line as well. (Record Drawings)
- Two jockey pumps have been installed in the Char Lake Pump House.
- The utilidor heat trace system was abandoned in 1984 due to corrosion problems.(UMA, 1996)
- All electrical devices and service were removed from the Access Vaults in 1998. This includes the sump pumps, heat trace, and AV heaters. (N. Macdonald)
- The line to Block 1 is abandoned due to a freeze-up prior to 1986. The Health Centre water service currently uses the abandoned water main as a carrier pipe. The other buildings in this area are connected to the water and sewer mains between AV2 & 3. (N. MacDonald) The sewer service to the Health Centre is still in operation (D. Leman).
- The Hydrant in AV 20 was removed prior to 1986.
- AV 15 was never installed during the original construction. (N. MacDonald)
- A new hydrant was installed in 1998 in AV 13, (N. MacDonald)
- The valves in AV3 were replaced in 1998. These are the valves that were indicated to leak in the UMA 1996 report, but were incorrectly identified as AV2 valves in the UMA report (N. MacDonald).
- A new valve was installed in AV30 in 1998. This allows the section of main between AV21 and AV30 to be shut off. (N. MacDonald)
- The ventilation systems for the WTP and Char lake Pump House have been disabled and are blocked up in the winter. Combustion air for the facility burners is supplied through building envelope infiltration. It is reported by the DPW Maintainer that the buildings are very leaky and have poor insulation.

With respect to the building systems there are no known changes made from the original construction other than the changes noted above. The complete system description and components is found in three sets of O&M Manuals. Copies of these manuals are stored in the community, DPW&S Iqaluit, and DPW&S Yellowknife.

2.4 System Deficiencies

The previous assessment of the facility as a whole was completed by UMA and documented in a report dated 1996. The report identified a number of concerns with the system, some of which have been addressed through the maintenance of the system while others are still outstanding. **Table 2.4.1** lists the deficiencies noted in the UMA report, and the changes that have occurred with respect to these deficiencies since the writing of the UMA report.

Table 2.4.1
Reported System Deficiency Update

Deficiency Noted in 1996		Current Status
1.	Building ventilation may not meet code requirements.	The building envelopes are poor, and there is significant leakage of air into the building. The ventilation system has been disconnected to prevent the buildings from freezing. These systems can be re-instated if the building envelope is improved.
2.	Wet well in Char Lake pump house requires confined entry safety equipment to access.	No action taken.
3.	Inadequate safety equipment. (First Aid kit and fire extinguisher)	Fire extinguishers installed. First aid kits ordered but not yet received in Hamlet
4.	The heat trace for the water supply line must be manually turned on when there is a no flow alarm on this line.	No action required. The no flow alarm is a major alarm, and the operator must go to the Char Lake Pump House to respond to the alarm. The no flow alarm only occurs if the Water Supply Line is frozen, which is very infrequent. The DPW&S Maintainer does not see any reason to make changes to the control system on this issue.
5.	The lighting level in the Char Lake Pump House is insufficient.	No action taken.

2.5 Occupational Health and Safety

Occupation Health and Safety Act (OH&S) regulates the entry into confined spaces. The AVS are clearly considered to be a confirmed entry location and require the appropriate safety requirements. These requirements include:

- A metre to detect and monitor gases in the AV during the entry into this space. Gases of concern are methane from the sewage, and for low oxygen levels. The maintainers are not supplied with these meters.
- Safety harness and extraction equipment. These devises are required to remove a person from the AV in the event of injury or if the person becomes unconscious. This equipment is required to be on hand and used for entry into the AVS

3.0 STORAGE TANK ASSESSMENT

The water storage tank has an approximate capacity of 530 m^3. This volume is to be compared to the volume of storage required to meet the Hamlet's requirements over the next 20 years. MACA provides criteria for the storage volumes required in municipalities. The storage is required when the raw water source is 3.2 km (2 miles) from the town and is to be sized to meet the following demands;

- Interruption of supply from the raw water source. The intent of the storage is to allow for continued service to prevent distribution mains freeze up while the repairs to the supply can be made. The criteria indicate that the emergency supply should be sized to meet the communities needs for the length of a maximum probable interruption. This is difficult quantify, and MACA has in the past used two days storage.
- Fire demand,
- Daily balancing of the water supply. This allows the supply from the raw water source to be pumped at the average daily consumption, and the tank is used to meet the peak daily demand.

The following is the requirement for each of these demands.

Storage During Interruption of Water Supply

MACA has set that two day of average consumption is required for storage when the raw water supply is more than 3.2 kilometres from the community. Based on this criteria, the year 20 average daily deamnd for Resolute Bay is 366,000 litres (366 m^3).

Fire Flow Requirements

The fire flow requirements for a piped distribution system is set by MACA at 3,600 l/min for 2 hours. This equates to a total storage of;

3,600 l/min x 60min/hr x 2hrs = 432,000 litres or 432 m^3

Daily Balancing

The difference between the average day, and the peak day water consumption is the required daily balancing to be provided by the water storage tank. A peaking factor of 2.25 is used for this calculation. The amount of water that is used for bleeders is not considered in this calculation since the bleeder rate is relatively constant on a day to day basis. Therefore the peak day storage requirement in year 20 is;

Peak day - average day = 74,800 litres or 74.8 m^3

Total Required Storage

MACA has in the past calculated the maximum storage, and the minimum storage requirements using the above values. This is based on the following;

1) The maximum storage is the sum of all of the above values, namely
Emergency Storage + Fire Flow + Daily Balancing = 873,000 litres or 873 m^3

2) The minimum storage requirement is the greater of;
   A) Emergency Storage + Daily Balancing = 440,800 litres, or 440.8 m^3
   B) Fire Flow Storage + Daily Balancing = 506,800 litres, or 506.8 m^3

The rational for criteria 2) is based on the assumption that it would be unlikely for the supply system to be down and the same time as a fire flow condition. The risk of this event has not been evaluated for the community of Resolute Bay, and is beyond the current scope of work. The fire marshal of the NWT has in the past allowed for the fire storage and the emergency storage to be considered as part of the same storage volume. At this time it is unknown what the position of the Fire Marshall of Nunavut will be on this matter. It is noted that since 1975 there has not been a period of time when the supply was disrrupted when there was a fire.

Based on the above, the available storage of 530 m^3 meets the 20 year requirements of the community if the scenario 2) is used. However, this should be revisited once the Fire Marshal of Nunavut is fully established.

4.0 UPGRADE REQUIREMENTS

The water and sewage system in Resolute Bay has previously been assessed by UMA, and the findings of that assessment are in the 1996 report. Several of the recommendations from the UMA report that relate to the building have been completed, while others are outstanding. For the purpose of providing an overall picture of the current upgrading requirements, the outstanding issues relating to the building from the UMA report are brought forward. The following sections describe the system upgrade requirements, the alternatives to the upgrades and the recommendations for the upgrades.

Char Lake Pumphouse

Building Envelope is Poor

The vapour seal on the building and insulation value of the building need to be upgraded to improve the overall building envelope performance. There are two approaches to this upgrade;

- Add insulation, air barrier and cladding to the outside of the building. This will require an structural assessment of the building frame to determine if the rigid frame of the building meets the structural requirements for the additional load.
- Add insulation to the inside of the building using spray foam.

Typically the external construction is the less expensive approach. As this would require an assessment of the structure, which is beyond the current scope of work. The use of the internal spray foam will be used for costing purposes. The cost to complete this work typically runs at $150/m^2 of building wall and roof space. The Char Lake Pump house is approximately 9.7 m x 7.9 m (32' x 26'). The estimated cost to complete the insulation work is $35,000 to $40,000.

Wet Well

A safety harness and retrieval device is required in the wet well. Safety harnesses cost approximately $200 per harness. A safety lifting device is approximately $5,000.

Lighting Levels

The lighting in the pump house is insufficient for a work space. The wet well also needs a light. Currently a trouble light is used in this space to allow the operator access to the wet well. The lighting levels can be increased for an estimated $5,000.

First Aid Kit

A first aid kit needs to be installed in the pump house. These kits typically cost $100 to $200.

WTP Pump House

Building Envelope is Poor

The vapour seal on the building and insulation value of the building need to be upgraded to improve the overall building envelope performance. There are two approaches to this upgrade;

- Add insulation, air barrier and cladding to the outside of the building. This will require an structural assessment of the building frame to determine if the rigid frame of the building meets the structural requirements for the additional load.

- Add insulation to the inside of the building using spray foam.

Typically the external construction is the less expensive approach. This would require an assessment of the structure, which is beyond the current scope of work. The use of the internal spray foam will be used for costing purposes. The cost to complete this work typically runs at $150/m^2 of building wall and roof space. The WTP Pump House is approximately 25 m x 15 m (80' x 50'). The estimated cost to complete the insulation work is $105,000 to $120,000.

First Aid Kit

A first aid kit needs to be installed in the pump house. These kits typically cost $100 to $200.

Table 4.1 shows a summary of the possible upgrades for the system.

Table 4.1
Summary of Remedial Work

Component	Deficiency	Remedial Action	Estimated Costs
Char Lake Pump House	Building envelope is poor.	Install insulation, vapour barrier, and cladding.	$ 40,000
	Wet well does not have confined entry provisions.	Provide safety harness and retrieval device.	6,000
	Light levels are insufficient.	Install new lighting bank.	5,000
	Requires First Aid kit.	Install First Aid kit.	200
WTP Pump House	Building envelope is poor.	Install insulation, vapour barrier, and cladding.	120,000
	Requires First Aid kit.	Install First Aid kit.	200

4.1 Prioritization

The previous section developed some $175,000 in upgrades that could be completed to the water and sewer system. Not all of these upgrades carry the same importance nor are all necessary in the near future unless conditions change. Some require immediate attention, others may not be completed for several years, while others can be omitted without adversely effecting the system. To prioritize the upgrading requirement, a set of criteria is required. The set has been developed for this system.

Table 4.2.1
Prioritization Rational

Priority	Description	Comments
1	Risk to Human Health Concerns	The maintenance for good health is a fundamental importance for the delivery of water and sewer services. These should be completed as soon as possible in the program.
2	Minimize risk of failure to the system	Work that can be under taken to reduce the potential future risk of the system is of high priority. These should be completed early in the program.
3	Reduce future emergency repair costs.	This is the basis for sound economic management of a system. A dollar spent on maintenance can save several dollars spend on emergency or more costly repairs. Should be scheduled in 1 to 5 year of program.
4	Reduce operating costs	The infusion of capital funds can make a system more efficient, and therefore reduce the future O&M costs. To be implemented at the discretion of the owner.

Table 4.2.2
Priority of Remedial Work

Component	Deficiency	Remedial Action	Priority
Char Lake Pump House	Building envelope is poor.	Install insulation, vapour barrier, and cladding.	4
	Wet well does not have confined entry provisions.	Provide safety harness and retrieval device.	1
	Light levels are insufficient.	Install new lighting bank.	1
	Requires First Aid kit.	Install First Aid kit.	1
WTP Pump House	Building envelope is poor.	Install insulation, vapour barrier, and cladding.	4
	Requires First Aid kit.	Install First Aid kit.	1

At the time of the final report, Public Works and Services were purchasing the required first aid and safety equipment. Once completed there would only be the requirement for improved lighting in the Char Lake pump house to be completed to address all the priority 1 items.

The completion of the items under priority 4 are not required to meet the communities long term needs, but may result in a reduction of the overall operating costs. The following analysis is based on rough estimates, but provides some insight into the expected cost savings from proceeding with the building insulation work. The detailed analysis of the life cycle costs for the improvements to the building envelop were not included in the projet scope.

Table 4.2.3
Cost Benefit Analysis - Pumphouse Insulation

Item	Char Lake Pump House	Signal Hill Pump House
Estimated annual fuel costs for heating with existing building envelop.	$5,100	$7,400
Estimated annual fuel costs for heating after insulation installation	$3,600	$5,300
Net savings on an annual basis	$1,500	$2,100
Amortized savings over 20 years at 8% interest	$15,000	$21,000
Amortized savings over 20 years at 6% interest	$17,000	$24,000
Amortized savings over 20 years at 4% interest	$20,000	$28,000
Cost of capital works	$40,000	$120,000
Net cost benefit at 6% interest over 20 Years	-$23,000	-$96,000

From the above analysis it can be seen that the insulation of the buildings is not cost effective over a 20 year analysis. The buildings are over 20 years old presently, and it would not be prudent to complete the above analysis over a period of time greater than 20 years.

4.2 Summary

The review of the water supply building indicates that the building are meeting the needs of the community, and are expected to meet the needs with normal operational maintenance for the next 20 years. Several items were identified as requiring some upgrading to meet current occupational health and safety requirements. It is understood by the author that these items will be addressed through the operations division of Public Works and Services.

An analysis of proceeding with applying insulation to the buildings was completed, and shown to be not costs effective over a 20 year period. It is therefore recommended that this work not proceed.

The lighting in the Char Lake Pump House does not meet the needs of the operators. It is suggested that a upgrade to this system be completed within the next 5 years.

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