The main line valves, except for those in access vault AV-2, will shut off water tight but are stiff to operate. The valves in AV-2, which circulate water back up to the Signal Hill facility and thereby bypass the entire water distribution system, do not shut water tight. Until these valves are replaced, it is not possible to isolate the distribution system without shutting down the Signal Hill facility.

Repairs to most sections of the distribution piping can create problems with piping in other areas of the distribution system. There are few provisions to bypass sections of piping during repairs which can cause no flow situations resulting in frozen lines.

There have been approximately seven breaks in the water distribution system piping which have been repaired with pipeline repair clamps and replacement pipe sections if required. These are located as follows:

.1 Inside Access Vault AV-21.
.2 Between Access Vaults AV-21 and AV-30.
.3 Inside Access Vault AV-30.
.4 Between Access Vaults AV-29 and AV-30.
.5 Between Access Vaults AV-10 and AV-11.
.6 Between Access Vaults AV-9 and AV-10.
.7 Between Access Vaults AV-4 and AV-5.

The number and location of line breaks in the building services were mentioned but not specifically identified by the DPWS Maintainer. Repairs to the building services generally include replacement of the damaged pipe section or entire service.

According to the DPWS Maintainer and the Hamlet Council, the frequency of breaks in the distribution piping and building services has increased in the past two or three years.

The water distribution system was installed in two stages, 1A and 1B, as shown in Figure 3-2. All seven line breaks listed above have occurred in piping laid the first construction year (Stage 1A). When the repairs were made to these joints, the DPWS maintenance staff observed evidence of defective butt fusioning with the joint. According to the DPWS staff, the defective joints were likely caused by improper fusioning procedures when the pipes were installed.

3.4.3 Remaining Life

The condition of the buried piping has deteriorated more than that for the other facilities. However, the extent of this deterioration cannot be fully determined without exposing the piping and video taping the interior surfaces.

The capacity of the water distribution piping could be checked by flow and pressure tests. However, the current system was designed for a much larger population than it currently serves, and therefore capacity is expected to be adequate. The condition of the piping could be checked through pressure testing, however the pressure test could result in pipe failures that would not occur under normal operating conditions. The costs of pressure testing and possibly repairing line breaks that would not normally occur would indicate that it is not desirable to proceed with pressure testing.

From the recent history of the system and the discovery of the defective pipe joints, it would appear that the piping will be useable for the next 20 years, but may experience frequent and costly line breaks. The cost of line breaks which will occur in this system cannot be predicted with any accuracy. Repair costs vary according to the amount of damage, location of break, length of frozen pipe, external damage caused by flooding or erosion, number of buildings affected, etc. The frequency of line breaks also cannot be predicted with any accuracy, however, the frequency will likely increase, rather than decrease, if further defective pipe joints exist, as have already been discovered.

3.4.4 Capacity

The piped water distribution system for Resolute Bay was designed to deliver 5,400 L/min., which is equal to combined fire and peak consumption flow for a population of 1,500, with a minimum residual pressure of 140 kPa in any part of the distribution system (UMA, 1977). This capacity is sufficient for the projected 20 year population of 251.

3.4.5 Compliance with Codes and Regulations

The documents listed in Section 3.1.5 of this report were reviewed to check compliance with applicable codes, regulations and bylaws. The results of this review are described below.

The access vaults have been constructed with both water and sewer mains in the same vault. This practise is not allowed in most Canadian provinces (Alberta is regulated by Alberta Environment) and is also not allowed by the NWT Public Health Act (Public Health, 1992) unless the sewer pipe is of an approved watertight construction. However, this practise is used quite frequently in the Northwest Territories. Having both water and sewer mains in the same vault provides a risk of contamination of the water in the water main from the sewer piping particularly when the water main is depressurized to carry out work on the line. In order to reduce this risk, steel piping is used with all openings and access points sealed and bolted.

The access vaults in Resolute Bay have had sewer cleanout lids removed to allow for bleeding water into the sewer mains to prevent them from freezing. This bleeding became necessary due to the significantly lower than design population and the low spots in the mains caused by settlement of the pipes. Removing the clean out lids has increased the risk of cross-contamination of the water main. If there were to be any surcharging of the access vaults due to a line freeze up or other reason, the water main in the vault would be immersed in raw sewage. Since most manholes have an open pipe from the water main to allow for the bleeding, contamination of the water is quite possible during surcharge conditions if the water pipe happens to be depressurized through water main blockage as described in Section 3.4.2.

This condition should be improved to maintain a water system that is relatively secure from contamination yet allows bleeding to prevent water and sewer main freezing. The installation of backflow preventer valves should be reviewed with Public Health to determine whether this is a suitable means of preventing water system contamination and thereby comply with their regulations.

3.5 SEWAGE COLLECTION SYSTEM

3.5.1 Operation of System

The sewage collection system consists of graded, Series 45 HDPE sewer mains which are fed by HDPE sewer service lines from the buildings and cast in place concrete access vaults containing cleanouts for the sewer mains. The sewage is gravity fed through the graded mains to the sewage comminutor station located near the shore of Resolute Bay.

Bleeders (water bled from the water mains into the sewer mains) are operating to keep water flowing in each section of sewer main to prevent freeze up of the sewer mains.

3.5.2 Condition of the System

The sewer mains and building services are showing signs of settlement and possible ovalling according to the DPWS Maintainer. Remediation of HDPE pipe ovalling is described in Section 3.2.2 of this report. A video inspection of the mains would provide accurate information on the current status of the pipes in this system and whether remedial work is required. Freeze-thaw cycles of the ground are the primary cause for sewer main settlement, which is very common for a piped sewage collection system in the NWT. Unless the mains are excavated and regraded regularly, sewer main settlement cannot be completely avoided.

The sewage flow rate in access vault AV-20 is very slow which has caused freezing problems. The sewer line settlement is most noticeable in the mains between access vaults AV-12 and AV-13, east of AV-15, east of AV-16 and south of AV-17.

The main between AV-12 and AV-13 has been blocked for a number of years possibly due to freezing according to the DPWS Maintainer. Due to the layout of the sewage collection system and the low flow rates in the system, this section of pipe can be bypassed without overloading other sections of the system.

There have been no reports of breaks in the sewer mains or building services. However, due to the low pressure in the sewer mains causing a low flow rate from leaks and the soil conditions in Resolute Bay, sewer main leaks would be difficult to detect.

The condition of the access vaults is described in Section 3.4.2 of this report.

3.5.3 Remaining Life

As with the water distribution system, the sewer mains have experienced some deterioration, but the extent of this deterioration requires a more detailed investigation.

The sewer mains should be suitable for service for the next 20 years, with possible replacement of some sections of mains prior to this time due to insufficient capacity caused by continued settlement and/or pipe ovalling. The occurrence of this is difficult to predict without a video camera inspection of the sewer mains.

It is expected that bleeding water into the sewer main will continue to be required, however bleed rates could possibly be reduced in some areas.

3.5.4 Capacity

The sewage collection system for Resolute Bay was designed for a minimum velocity of 0.16 m/s (UMA, 1977). This is equivalent to a flow rate of 650 L/min. for 150 mm sewer main and 1,100 L/min. for 200 mm sewer main. Using the design peak hourly sewage flows of 1,280 Lpcd, the 150 mm and 200 mm diameter mains are suitable for loads from 730 and 1,230 persons, respectively. The system therefore has sufficient capacity for the projected population of 251, provided the settlement of the mains has not significantly affected their capacity. This situation could be further assessed as described previously.

3.5.5 Compliance with Codes and Regulations

Refer to Item 3.4.5 above for information on compliance with codes and regulations.

3.6 SEWAGE TREATMENT SYSTEM

3.6.1 Operation of Facility

The sewage treatment facility for Resolute Bay was originally designed as a Rotating Biological Contactor (RBC) system including primary and secondary clarifiers and digestion tank to be enclosed in a 31 m x 15 m heated insulated building (UMA, 1975). The building was constructed, but the sewage treatment equipment was not installed at the direction of the GNWT. The decision not to install the RBC was made based on anticipated high maintenance costs for the facility. In order to provide sewage disposal for the Hamlet, a second, smaller prefabricated Bally refrigeration type building was erected for sewage comminution.

Sewage from the sewage collection system flows into a comminutor in the building. The comminutor grinds the sewage as it passes through. The sewage then flows through a flow metering device then a gravity flow pipe to a non-submerged outfall at the shore of Resolute Bay. The operation of the facility is consistent year round.

Sewage collected from those buildings with trucked services is dumped directly into the bay near the piped system sewage outfall (Armstrong, 1995).

3.6.2 Condition of the Facility

The sewage comminutor has required regular maintenance only in the past few years and has been operating essentially trouble free according to the DPWS Maintainer. The flow metering device has not worked since 1987 although the repair parts are in Resolute Bay. The metering device should be repaired.

The building is in average condition for its age. There is some damage to the building particularly the wall panel near the door caused by snowplows, but the integrity of the building does not seem to be affected. There are no signs of water infiltration into the building. Due to the damage by snowplows, the building is not as air tight as a newly constructed Bally refrigeration type building

The exhaust fan for the building has been disabled and the opening is filled with insulation, however, there is not a strong sewage smell. Some ventilation is currently provided by infiltration into the building. Reactivation of the ventilation fan should be done to protect personnel from potentially harmful fumes while in the building.

The wiring and electrical equipment in the building are in poor condition. The corrosive gasses, although relatively mild, together with the lack of ventilation have caused some corrosion on this equipment. The rating for the existing electrical equipment is for hazardous environments but does not have consistent ratings and some of the protective covers on junction boxes have been removed.

The sewage outfall is in good condition. There are no signs of any significant physical damage and the DPWS Maintainer reports that the outfall has not experienced any freeze up or blockage problems. The condition of the heat trace in the outfall piping was not checked during the site visit.

There is some algae type growth in the bay near the sewage outfall and one resident reported seeing algae while diving in the area.

3.6.3 Remaining Life

The sewage disposal system was constructed in 1976, and based upon the information available has been operating satisfactorily. Although the building is reported to be in average condition for its age, the electrical and control systems, including the flow recorder, in the building are in poor condition. On the basis of this information, these systems should be repaired or replaced and brought up to code. The sewage comminutor has received regular maintenance, however, the comminutor itself is 19 years old. Depending upon the parts replacement which has occurred during the routine maintenance, the comminutor may be reaching the end of its expected useful life.

The sewage outfall is a 19 year old high density polyethylene (HDPE) system; the system is also heat traced, insulated and steel jacketed. The sewage piping should last another 20 years considering its current condition, limited traffic in the area and relatively mild service conditions. The electrical heat trace system may not be expected to function for as long a period, however, with the current sewage disposal flow rates, freezing of the outfall is not anticipated as a likely occurrence.

3.6.4 Capacity

A sewage collection and disposal system which does not have storage capabilities is designed for the anticipated peak hourly sewage flows from the area serviced. The peak hourly sewage flows used to design the system in Resolute Bay are 1,280 Lpcd for a population of 1,500 (UMA, 1977).

The currently projected 20 year population is 251. Therefore, it is expected that the sewage disposal system will have sufficient capacity.

3.6.5 Compliance With Codes and Regulations

The operation of the sewage disposal system in Resolute Bay falls under the jurisdiction of several pieces of legislation including the Northwest Territories Water Act (Water License N4L4-1571), the Northwest Territories Health Act, and the Federal Fisheries Act.

Compliance under the NWT Water Act is judged by review of a report submitted annually by the community in addition to an annual inspection by an Indian and Northern Affairs employee. The most recent available compliance report (DIAND, 1994) stated that compliance for the sewage disposal was unacceptable only in the areas of failure to submit annual reports and missing the required Warning Surveillance Network Program signage.

Samples of the sewage discharge are taken during the annual DIAND inspection for laboratory testing. The results, which are contained in Appendix IV, were reviewed but contained little relevant information because values for BOD_5 and coliforms were not included.

Compliance under the NWT Health Act may be judged by an inspection of the Environmental Health Officer, in conjunction with information provided as part of the water license. Correspondence from the Baffin Region Medical Health Officer (Allen, 1993) indicates that the sewage disposal system does not comply with the Public Health Act because "the discharge of sewage is directly into the ocean without any prior treatment" (Allen, 1993). However, this position may not be appropriate because of the dilution of the wastewater which occurs as a result of water system bleeding. The sewage is presently diluted on average by a factor of 5:1 by the system bleeding; if one assumes a raw sewage concentration of 250 mg/L for suspended solids and BOD_5, the effluent concentrations would be 50 mg/L. For practical purposes, it may be stated that the raw sewage does receive treatment.

If additional treatment is required to comply with the Public Health Act or any future changes to legislation, codes, regulations, etc., modifications to the existing sewage collection system will likely be required. There are currently no pending changes as described which have been made public. The current effluent discharge rate is excessive for a community the size of Resolute Bay due to the large volume of water entering the sewer system through "bleeders". This current practise would require treatment systems such as lagoons to have substantial additional capacity to handle the "bleeder" effluent, thereby increasing the treatment system capital cost.

Compliance with the Fisheries Act may be judged by an inspection of a Fisheries Officer, in conjunction with information provided as part of the water license. No information is available at this time to confirm that the sewage disposal system does or does not comply with the Fisheries Act. However, litigation against the Government of the Northwest Territories over a sewage spill in Iqaluit suggests that compliance with the Fisheries Act may only occur when the sewage disposal system produces a non-deleterious discharge. It is not known whether the current discharge would be considered deleterious under the Fisheries Act, however, preparation of a position brief on Resolute Bay from Fisheries and Oceans is being considered (Stephenson, 1994 and 1995). The preparation of the position paper will be delayed until a jurisdictional agreement is reached on this issue between the Department of Environment and the Department of Fisheries and Oceans (Peete, 1995).

The algae observed in the water of the receiving body near the outfall is, to some degree, normal and/or acceptable. An assessment of the aquatic environment (shellfish sampling and toxicity measurements) would be required to determine if the current discharge is within acceptable limits.

3.7 RECOMMENDED UPGRADES

This report has identified deficiencies and possible code/regulation violations with the current water and sewer system which should be corrected. The following items should be addressed if the existing facilities are used in the "as is" condition:

.1 Hard wire the light for the wet well in the Char Lake Pumphouse.

.2 Paint or refinish the exterior of the Char Lake Pumphouse and the Water Treatment Plant.

.3 Relocate the building low temperature switches in the Char Lake Pumphouse and the Water Treatment Plant to prevent further false alarms.

.4 Install high temperature alarms in both buildings.

.5 Replace untreated water in boilers with food grade treated water.

.6 Provide adequate ventilation for chlorine area in Water Treatment Plant.

.7 Ensure all facilities comply with requirements of NWT Water Board, Department of Health and the NWT Safety Act identified in this report.

.8 Check condition of supply line between Char Lake Pumphouse and Water Treatment Plant by flow rate/friction loss test.

.9 Contact the Department of Health for a ruling as to whether installing backflow preventers on the existing access vault bleeders and raising the level of the bleeders, which should reduce the potential for cross contamination of the water main, are an acceptable alternative to the watertight sewer main required by the Public Health Act.

.10 Replace access vault valves which will not close watertight.

.11 Remove electrical equipment from access vaults and replace with alternate supply such as portable genset or power source at nearest power pole.

.12 Repair flowmeter in sewage comminutor building.

.13 Upgrade electrical equipment in sewage comminutor building to ensure all equipment is to code.

.14 Upgrade ventilation and possibly heating system to ensure proper ventilation rates in the sewage comminutor building.

.15 Upgrade ventilation systems in Char Lake Pumphouse and Water Treatment Plant to provide adequate ventilation air for boilers and generator engines.

.16 Obtain a ruling from the Department of Health on the acceptability of the current sewage discharge system as was requested by the Hamlet's letter of September 1993 to the Department.

Cost estimates for this work are contained in Section 5.6 of this report.

4.0 FUTURE INFRASTRUCTURE OPTIONS

The assessment of future infrastructure options includes two primary servicing options; a piped system and a trucked system. Except during a transformation period, the assessment considers the entire community to be serviced by the same type of system. Due to the high capital cost of implementing a trucked system and the high O&M cost of operating two servicing systems, having both trucked and piped services in Resolute Bay for an extended period of time is an option not worthy of further consideration.

4.1 PIPED SYSTEM

In retaining the piped water distribution and sewage collection systems for Resolute Bay, there are a number of options which can be considered for the systems. These range from leaving the system essentially as it currently is to a total replacement of the distribution and collection piped systems. With these options, significant capital expenditures for the Char Lake or Signal Hill facilities are not required due to the current good condition of these facilities. The life cycle cost estimates for these options are contained in Section 5.0 of this report.

Prior to proceeding with any piped system upgrades, the bleeding requirements should be reviewed and reduced where possible to reduce operating costs for the system.

4.1.1 Leave System "As Is"

This option is to continue with the existing system, as well as operating procedures and sequences, without significant upgrading. The advantage of this option is low capital input. The disadvantages of this option include retaining a system which is experiencing increased failures and high O&M costs. The increased failures of the system would mean that the users will have an unreliable water supply which has inadequate back up systems. The problem of the potential for contamination of the water system due to both systems being immersed in surface runoff water or raw sewage at access vaults may also not be resolved with this option.

If the system is left as is, the recommended upgrades listed in Section 3.7 should be implemented.

4.1.2 Partial System Upgrade

The site investigation identified some existing and potential problem areas. These problem areas, along with those uncovered during a more detailed investigation which would include video taping sewer mains, pressure testing water mains and investigation of leaks in access vaults, would be corrected. The remaining system, as well as current operating procedures and sequences, would remain as they currently are.

The scope of the repairs, in addition to those in Section 3.7, is expected to include the following:

- Replace sewer mains between Access Vaults AV-12 and AV-13, AV-14 and AV-15, AV-15 and AV-16, and between AV-16 and AV-17.
- Replace water mains between Access Vaults AV-21, AV-30 and AV-29 and between Access Vaults AV-9, AV-10 and AV-11 where most line breaks have occurred.
- Replace other sections of sewer main identified in (future) video of mains.
- Provide new markers for access vaults.
- Replace sections of pipe which have failed and been repaired or have leaked during the pressure test.
- Repair vaults to prevent groundwater infiltration.
- Repair and placement of all sewer clean out lids.

The above list contains items which may or may not be economically viable to upgrade. The complete list would, of course, be finalized once the detailed investigation and detailed cost analysis described above are completed. The cost estimates for this option, which are shown in Section 5.0, have been developed without the benefit of the detailed investigation.

The advantages of this option are the capital cost, while higher than doing nothing, is less than a total system replacement and the piping systems should regain some of their original integrity and reliability. The disadvantage of this option is that all problem areas in the system cannot be detected unless the pipelines are completely excavated and inspected which is costly. Without this type of investigation the upgrading may not remove all problem areas in the system which will affect the reliability of the system. The operating costs of this option are expected to be higher than total replacement, but lower than leaving the system as is.

4.1.3 Replace Entire Piped Systems With New Pipes and Vaults

This option would involve removal or abandonment of all existing water and sewer piping in the community, including access vaults, from the Char Lake facility to the Sewage Comminution facility. These would be replaced with new insulated HDPE piping and GNWT Standard insulated steel access vaults. The system layout would remain essentially the same with more provisions for bypassing pipe sections and freeze recovery where possible.

The advantages of this option are the reliability of a new system, reduced bleeding requirements and reduced maintenance costs. The disadvantages are the very high initial capital cost of this option and the requirement for some bleeding to prevent freezing of the sewer mains.

Upgrades to the Char Lake and Signal Hill facilities would be very minor and their operation would remain essentially the same as it currently is.

4.1.4 Replace Entire Piped System With New Above Ground Utilidor

This option would involve removal or abandonment of all existing water and sewer piping in the community including access vaults from the Char Lake facility to the Sewage Treatment facility. These systems would be replaced with an above ground insulated utilidor which would contain the water and sewer mains.

The advantage of this option is the ease in accessing the mains for repair or thawing which would reduce maintenance costs of the system. The disadvantages of this option are: high capital cost; difficulty in adapting a utilidor system to an existing community including road crossings and current elevations of buildings; and increased potential for vandalism due to its exposure.

Upgrades to the Char Lake and Signal Hill facilities would be very minor and their operation would remain essentially the same.

4.2 TRUCKED SYSTEM

There are also a number of options to be considered in converting the existing piped water and sewer system to a trucked system. These options include location of truckfill, storage of trucks, requirements for storage and phase in of the system. The life cycle cost estimates for these options are contained in Section 5.3.

4.2.1 Truckfill Location

There are two potential locations for the truckfill station for the system; Char Lake Pumphouse or Signal Hill Treatment Plant. The advantages and disadvantages of each are described below.

Char Lake Pumphouse

This facility could be converted to a truckfill station by installing new pumps for filling trucks (current Verti-Line pumps are not capable of required 910 L/min.), constructing a truckfill arm and piping, installing a chlorination system to inject chlorine into the truckfill pipe, and installing controls for the truckfill system.

Storage at this facility would not be required. Char Lake and the pumphouse are located approximately 1.5 km from the Hamlet, which is within 3.2 km, and therefore do not require in-town storage according to GNWT guidelines. All projected annual water demands, including consumption and fire flow, can be met by Char Lake.

The advantages of using this facility include; the Main Supply line and Signal Hill facility would no longer be required and could be decommissioned which would reduce O&M requirements, a turnaround for the water trucks already exists and can be modified relatively easily and the facility is closer to the airport which may allow for the provision of water to the airport facilities which would consolidate the current two separate water supplies into one. The disadvantage of this option is the increased distance from the community for the water trucks.

Signal Hill Treatment Plant

This facility currently has a truckfill system which consists of piping tied into the main circulation pumps for the distribution system and a cam-lock connector inside the building which is accessible through a small door in the building. The trucks load by connecting a flexible hose from the cam-lock to the water truck and opening the appropriate valves. This system was set up to supply water to buildings in Resolute Bay and South Camp which are already on a trucked system, and to fill the reservoir if the Main Supply Line is frozen. This system is also used as a backup supply for buildings located at the airport.

This facility does not meet GNWT Standards for a truckfill facility, but could be converted to a truckfill station by increasing the size of the existing vehicle turn around, installing either a truckfill pump or a gravity feed system from the storage tank, constructing a truckfill support arm and piping and installing controls for the system.

The advantage of this facility is its closeness to the community which would reduce the hauling distances between the community and the facility.

The disadvantages of this facility are that two extra facilities (Char Lake and Supply Line) will have to be operated and maintained and the enlargement of the turnaround area will be more costly and difficult than at the Char Lake facility due to its location on the side of the hill. The reduced water consumption for the community which will likely occur with the trucked system could also create difficulties with using the Signal Hill facility. The guideline for water consumption for a community with a trucked system is 90 Lpcd, which is approximately 16,300 litres per day for a population of 181 persons. The existing 'jockey' pumps at Char Lake Pumphouse are rated for 95 L/min., which is equivalent to 137,000 litres per day. Therefore, the jockey pumps would have to be throttled, or possibly replaced with lower volume pumps, which would supply only the projected demands. However, previous experience has shown that reducing the flow rate in the supply line could lead to icing problems in the line.

4.2.2 Access Roads

The existing access roads to the Char Lake and Signal Hill facilities, except the turnaround at Signal Hill, appear well maintained and suitable for water truck traffic. Therefore, the life cycle costing does not include an allowance for road upgrading, except the Signal Hill turnaround, or for extra road maintenance.

4.2.3 Storage of Trucks

A trucked system will require a truck storage facility to prevent freeze up of the trucks when not in service. The options for truck storage are: build a new facility, use existing space or convert an existing facility.

A new facility could be constructed in a location suitable to GNWT and the Community. The advantage of a new facility would be the additional thermal insulation which a new building would provide and which would reduce its operating costs.

There is currently spare heated and sheltered truck storage space in Resolute Bay. The water truck could be stored in the existing fire hall and the sewage truck could be parked in the Hamlet's parking/maintenance garage. Both facilities are in good condition and should be available for the 20 year design horizon. Therefore, truck storage requires no capital costs and negligible O&M costs. Life cycle costs for a new building versus converting an existing building are contained in Section 5.3.

The most obvious existing facility to convert into a storage facility is the building constructed for the sewage treatment plant. This building is currently used for storage only. The building could be divided into truck storage and other storage to keep some storage space available. The truck garage area would be provided with unit heaters to keep the space heated. There currently is available storage space, so this option will not be considered further at this time.

4.2.4 Conversion of Buildings

The existing plumbing in most of the buildings in Resolute Bay is set up for a piped water supply and gravity sewage collection system. This means that most of the existing buildings will have to have plumbing converted. The conversion will include removing existing circulation pump, service connection piping, heat trace and other equipment, then installing water and sewage holding tanks and system pressure pumps complete with pressurized expansion tanks.

All buildings in Resolute Bay were checked by the DPWS Maintainer in 1993 to determine whether there is sufficient space for the new water and sewage holding tanks. This survey of the houses indicated that all but "a few" of the houses had sufficient space for the water holding tank in the existing mechanical room. Houses which do not have sufficient space will require a small addition to the house for the tank. This survey also indicated that most houses also had space for a sewage holding tank below the floor of the house provided a shallow insulated and heat traced tank is used. When selecting the tank and designing the house modifications, the available space for each house must be carefully evaluated along with the provisions necessary to prevent the tank contents from freezing.

To determine the electrical requirements for conversion, each building would have to be checked. It is assumed that all buildings have sufficient electrical capacity and that new breakers and wiring only will be required to properly connect all new equipment in each building.

4.2.5 Phasing In Trucked Services

With implementing trucked water delivery and sewage collection systems, there will be an initial capital outlay required to purchase the trucks, provide a truckfill facility, convert the plumbing and provide water and sewer storage tanks for the required buildings, and decommission existing facilities.

The conversion of buildings to trucked services could be staged over a number of years to allow funding of these conversions to be spread over a number of years. The phasing would allow for conversion of buildings in identified trouble areas first, along with conversion of one of the water supply buildings to a truckfill facility and the construction of a sewage treatment system.

The phasing in plan should also consider the sequential shutdown of entire sections of the piped system while maintaining operational integrity of the remaining system.

During the conversion, the workload of the Maintainer will not increase significantly provided he is not responsible for maintaining the water and sewer trucks and is not responsible for building conversion work. Once conversion is complete, the workload will decrease somewhat due to the decommissioning of some facilities. However, we understand that the Maintainer is responsible for other GNWT facilities and therefore this position must remain.

4.2.6 Water Consumption Rate

The current water demand rate for Resolute Bay, according to the Hamlet's water meter records (Hamlet, 1994), is approximately 145 LPCD. If the Hamlet were converted to a trucked system it is expected that this demand rate would drop to approximately 90 LPCD, which is a common consumption rate for trucked systems. The length of time required for the reduction will depend upon water consumers and by the regularity of water delivery.

4.3 SEWAGE DISPOSAL

4.3.1 Existing System and Concerns

The sewage from Resolute Bay is discharged directly into Resolute Bay after being ground up (solid size reduction) in the comminutor. There has been some concern expressed by the Baffin Region Medical Health Officer over this form of sewage discharge because it may be in violation of the Public Health Act (Allen, 1993). The Public Health Act does not allow a sewerage system to be operated or maintained which discharges its effluent "into any stream, channel, water course or lake, unless the written permission of a Medical Health Officer has been obtained". This permission was requested by the Hamlet of Resolute Bay in September 1993, but we are not aware of approval being granted.

The Federal Government's Fisheries Act subsection 36(3) states that it is a violation of the Act to deposit a deleterious substance into water frequented by fish unless the deposit is authorized by a regulation recognized by the Act. The Act does define tests which determine whether a discharge is deleterious.

The existing piped system in Resolute Bay requires a significant amount of bleeding to keep the sewer lines from freezing and therefore the effluent which is discharged into the bay is diluted in a ratio of approximately 5:1. Under these circumstances, the effluent may or may not currently be considered deleterious. However, the Department of Fisheries and Oceans has not yet prepared a position paper on this issue. Regardless of the current status, any changes to the system which reduces the dilution of the sewage will increase the toxicity of the discharge.

4.3.2 Previous Work

A report (UMA, 1974) prepared prior to design and construction of the current water and sewer systems recommended a rotating biological contactor (RBC) as the appropriate means of treating the wastewater from Resolute Bay. The report investigated a number of options including activated sludge (contact stabilization), RBC, and lagoons.

The RBC process was recommended in this report for the following reasons:

.1 Other treatment alternatives such as aerated lagoons, natural lagoons, and oxidation ditches may be unsuitable from a geotechnical perspective. Large earthen basins which are required for these processes may be difficult and expensive to construct due to unfavourable soil conditions.

.2 An RBC does not require an experienced fully-trained operator, however, the operator should have a background in sewage treatment.

.3 An RBC requires less electrical power to operate than other types of treatment plants, which will result in lower power costs.

.4 An RBC has less moving parts and mechanical devices than other types of treatment plants, and therefore it requires less maintenance and servicing time.

The report recommended that the plant effluent be discharged into Resolute Bay through an outfall line from the plant to the shoreline of the bay. It was proposed to extend the outfall line into Resolute Bay for a distance of approximately 500 to 1,000 feet.

4.3.3 Potential Environmental Impacts of Ocean Sewage Discharge

The community of Resolute Bay is located adjacent to the oceanographic feature, Resolute Bay. The bay occupies an area of approximately 1,000 hectares, and is approximately 2,400 metres in length. The bay is deepest in its center at approximately 27 metres, and becomes shallower (10 to 15 metres) at its edge.

The majority of the NWT coastal communities are located adjacent to embayed areas. The characteristics of the embayment vary considerably, but the major concern of an embayed area will be that the potential for dispersion of wastewater is reduced compared to an open coast location.

This situation often makes installation of a submerged pipe outfall into sufficiently deep water to achieve proper dilution both difficult and costly. The shallower depths and the enclosed nature of arctic bays may also result in minimal flushing action that will reduce the potential for waste dispersion.

The large tidal range in the eastern Arctic produces, in many cases, strong tidal currents in enclosed bays that will improve wastewater dispersion. However, Resolute Bay has a mean tidal variation of 1.3 m and a maximum tidal variation of 2.1 m, which is a small tidal variation for eastern standards (Iqaluit experiences 11 m tides).

In general, it may be concluded that an embayed area is not as ideal a recipient of wastewater as an open coast location and that the potential for environmental problems is much greater.

The principal concerns associated with sewage disposal in the ocean in general, and embayed areas in particular, are as follows:

.1 The survival rate of pathogenic organisms contained in domestic sewage is increased at low water temperatures and under ice-cover where the biocidal effects of solar radiation are decreased.

.2 Where the initial dilution and subsequent dispersions of the wastewater are not sufficient, the potential for a significant depletion of dissolved oxygen in the marine receiving water exists due to the long periods of ice-cover that effectively prevent atmospheric re-aeration.

.3 Nutrient increases from community domestic wastewater discharges will likely have a beneficial effect on marine receiving waters in most cases, as Arctic marine waters are generally nutrient deficient. Increased nutrient concentrations could increase biological production throughout the food chain, resulting in an enhanced local fishery. The potential for biological over-stimulation, however, may be present in some embayed areas receiving large wastewater flows where dilution and dispersion of the wastewater is not adequate.

.4 The toxic constituents of wastewater, such as un-ionized ammonia and surfactants may generally be reduced to a non-toxic level following initial dilution in the receiving water. However, areas of poor dispersion may develop localized areas with elevated concentrations of toxic constituents.

The overall impact of a domestic wastewater discharge to Arctic marine waters depends to a large extent on the available dilution and subsequent dispersion of the wastewater in the receiving water. In situations where an outfall can be located at a sufficient depth to obtain a large initial dilution and the prevailing currents are such that rapid dispersion of the effluent field occurs, the discharge will have a negligible effect on the environment.

4.3.4 Wastewater Effluent Quality Guidelines

Table 4-1 presents the effluent quality guidelines outlined in the "Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories" (NWT Water Board, 1992).

The guidelines are categorized by the wastewater flow. Resolute falls into the category for flows greater than 600 litres per capita per day because of the bleeding which occurs year round (48,000,000 litres/year / 365 days/year / 177 people = 743 Lpcd). The community is at the head of an embayed area, therefore, the receiving environment may be considered to be a bay.

TABLE 4-1
EXPECTED WASTEWATER EFFLUENT QUALITY GUIDELINES FOR RESOLUTE

Parameter	Existing Conditions (> 600 L/c/d)	Reduced Flow Condition (150 - 600 L/c/d)	Trucked Collection System
Biochemical Oxygen Demand (BOD)	80 mg/L	120 mg/L	100 mg/L
Suspended Solids (SS)	70 mg/L	180 mg/L	120 mg/L
Phosphorous (P)	Flexible	Flexible	Flexible
Fecal Coliforms (F.Col)	Dependant upon local effects	Dependent upon local effects	Dependent upon local effects
Grease	None visible	None visible	Non visible
pH	Greater than 6	Greater than 6	Greater than 6

Although no specific wastewater parameter measurements are available for Resolute Bay, if one assumes a typical value of 250 mg/L for suspended solids and BOD, then the anticipated effluent quality would be 50 mg/L for the 5:1 dilution rate experienced in the community. Based upon these assumptions and this existing operating scenario, the system will meet the expected effluent criteria.

If the system bleeding is significantly reduced or eliminated, the effluent quality may exceed these criteria (refer to Table 4-2); however, the effluent criteria may also change (refer to Table 4-1) because the per capita discharge would decrease.

TABLE 4-2 EFFLUENT QUALITY CHANGES AS A RESULT OF SYSTEM CHANGES				
Dilution	BOD mg/L	LPCD	Limits mg/L	Limits Exceeded
Piped				
5:1	50	743	80	No
4:1	63	594	120	No
3:1	83	445	120	No
2:1	125	296	120	Yes
1:1	250	148	120	Yes
Trucked				
1:1	500	90	120	Yes

In conclusion, a wastewater treatment system may be required if the bleeding is reduced or eliminated, particularly if a truck collection system is initiated.

4.3.5 Wastewater Treatment Options

4.3.5.1 General

A variety of treatment options for wastewater are available, however, the ultimate choice for Resolute Bay should depend upon technology which meets the regulated effluent criteria and is appropriate for the location. The treatment technologies available may be categorized into the two general areas of mechanical and non-mechanical treatment, which describes the mechanism by which the sewage treatment is completed.

Mechanical treatment may be characterized by the need for a power supply, construction to accommodate devices imported to the community, and a reasonably sophisticated operating system. A common example of mechanical system is an RBC as previously recommended for Resolute Bay. A report by UMA (1993) recommended that the only appropriate mechanical treatment technologies for achieving a high quality effluent are a sequencing batch reactor (SBR) and RBC or conventional extended aeration (EA).

Non-mechanical treatment may be best characterized by using the very common example of a sewage lagoon. This system often does not require a permanent power supply, and may be constructed using mainly local materials.

Mechanical treatment systems have not been widely utilized in NWT communities. The use of mechanical systems for biological treatment in the NWT has been unsuccessful. The examples to illustrate this are the RBCs in Nanisivik and Norman Wells. The application of the technology, as previously stated, must be based upon a site specific study.

On the basis of UMA's conceptual review, a mechanical treatment system may not be appropriate technology in Resolute Bay for the following reasons:

.1 Extreme operating conditions for temperature.
.2 Extreme geographic distance and limited access for maintenance.
.3 Low wastewater volume causing relatively infrequent discharges with high flow rates (truck collection system only).
.4 Availability of trained operating personnel.
.5 Long term performance uncertainty.
.6 Effluent quality may greatly exceed license requirements (RCB, SBR and EA systems).

This position is supported by the Standards and Criteria for Sewage Facilities (MACA, 1993).

A non-mechanical treatment system utilizing a sewage lagoon is therefore the most appropriate technology for Resolute Bay.

Dilution of the sewage is not considered as a treatment option for any of the upgraded piped systems or trucked systems. While dilution may be accepted by regulatory authorities for the existing system, it is expected that this practise would be considered unacceptable once "significant" upgrades were done to the system.