Sewage and Water Works Technical Evaluation – Phase 2

Hamlet of Resolute Bay, Nunavut
CGSHQ-09023-01

Prepared For:
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Executive Summary

General

The Government of Nunavut (GN) has retained Trow Associates Inc. (Trow) to conduct a technical evaluation of the existing water and sewer system serving the Hamlet of Resolute Bay (Hamlet). The GN is currently in the process of establishing a long term strategy for the provision of water and sewer services in Resolute Bay. In the interim the existing system must remain in service and this interim requirement will likely continue for five years. The following study was commissioned to examine the current systems and recommend measures to permit continued service for a further five years.

This study has been advanced in two phases. The initial phase represents an evaluation of the existing systems. In general terms this represented a cataloguing of activities since 1996 and an assessment of current conditions. The second phase presents recommendations targeted at continuing operation for a further five years. The recommendations presented in Phase 2 include capital rehabilitations and upgrades, operational improvements and a contingency plan.

Community Information

Resolute Bay, the second most northerly community in Canada is situated on Cornwallis Island at 74°42'N and 94°50'. Currently a population of approximately 250 is served by the existing piped water and sewer (utilidor) system.

The climate in Resolute Bay is especially challenging. Average annual temperature is -16.7°C and average annual wind speed is 21 km/hour. The lowest temperature recorded at this site is -52.2°C and the highest recorded hourly wind speed is 142 km/hr. A wind chill as low as -72°C has been observed. The extremely low temperatures are combined with a protracted period of dark during the winter. The sun does not rise above the horizon between early November and early February. The combination of temperature, high winds and lack of daylight create challenging operating conditions for much of the year.

The current water system was constructed as part of the relocation of the town site in the late 1970's. The system has encountered some operating challenges, including freeze of some of the piping and high rates of water bleeding. The question of replacement of the existing piped systems with trucked delivery of services has previously been examined. There is a strong sentiment within the community that the piped delivery of water and sewer services should continue.

System Description

Water System

Water is drawn from Char Lake through a heat trace intake into a pumping well below the Char Lake Pump House. Heated water is injected into the water in the well prior to pumping through a 1.8 kilometre heat traced and insulated transmission main to Signal Hill Water Treatment Plant. Incoming water from Char Lake refills a 570 m^3 welded steel storage tank. Water pressure to the townsite is boosted by pumps at the Signal Hill Water Treatment Plant. The primary purpose of these pumps is to assure circulation through the looped water mains, which loop back to the water treatment plant.

Water is distributed within the townsite through a looped system of insulated high density polyethylene piping. This piping is typically buried at a depth of 1 metre. Freeze prevention of the watermains is achieved through circulation, reheating at the water treatment plant and some bleeding. Access to valves and fittings on the water distribution system is provided by Access Vaults (AV's). The AV's are shared with the sewer system.

Service connections have been extended into each served building. These service connections were constructed using a pair polyethylene tubes enclosed within a 100 mm insulated duct. Circulating pumps have been installed in each served building to assure freeze protection for the service connections.

Both the Char Lake Pumping Station and the Signal Hill Water Treatment Plant are equipped with boilers and standby generators. The principle heating loads supported by the boilers is potable water heating. This heating is required to prevent freeze of the transmission main between Char Lake and Signal Hill, the town site water distribution system and the water storage tank.

Sewage System

The sewage collection system was constructed using insulated high density polyethylene piping buried in common trenches with the water distribution system at a typical depth of 1 metre. The sewer system flows by gravity to a macerator, prior to discharge to the ocean. Freeze prevention of the sewage collection system is largely achieved through bleeding of water into the sewer system. Bleed water is also used as a source of heat into the AV's.

Service connections have been extended into each served building. These service connections were constructed using 100 mm insulated polyethylene piping. Water is bled into almost all of the service connections as a freeze prevention measure.

There is currently no significant treatment of sewage. Sewage treatment is limited to a macerator. Effluent strength is likely very low due to the large amounts of bleed water that are directed into the sewer system.

Phase 1 Assessment

General

Phase 1 of the Technical Evaluation of the Resolute Bay Sewage and Water Systems focused upon the current status of these systems and the actions relating to these systems since 1996. During Phase 1 the following were conducted:

- A review of previous investigations and engineering studies.
- A field visit that included an examination of those various components that make up the systems.
- An evaluation of the current condition and technical status of the systems and components including:
    - The buildings,
    - Civil works (intake, piping, AV's, water storage and treatment and service connections),
    - Mechanical systems, and
    - Electrical systems.
- A compilation of improvements made to the sewer and water systems since 1996.
- A review of Preventative Maintenance, including an examination of practices and capabilities.

Findings

General

Various observations and conclusions were drawn based upon the observations and investigations. These included conditions that required urgent actions.

Conditions Requiring Urgent Actions

The following conditions were observed, for which action is urgently required:

- The fuel system at the Char Lake Pump House does not conform to codes and represents a contamination risk for the community water supply. The system should be replaced at the first opportunity.

- There is a significant risk to public health due to the potential for cross contamination between the sewer and water systems arising from conditions within the AV's.

- Water consumption rates should be monitored by the GN. Current consumption is approaching water supply pumping ability, which places the system at risk of depressurization due to lack of supply. Depressurization places the water system at risk of freeze and raises public health concerns.

- The GN should confirm that operating personnel have been provided with appropriate health and safety training. Specific concerns include fall prevention and confined space entry.

Conclusions

The following general conclusions are provided.

- High levels of water consumption are currently being experienced in Resolute Bay. These appear to be largely the result of operation efforts to avoid freeze of the piping. Water consumption in the mid 1990's was reported at 48,000 m^3/year, of which 80% was directed to bleeds. Current consumption is approaching 300,000 m^3/year.

- Risks to public health and safety arising from fuel storage arrangements and conditions within shared AV's have been identified.

- The water and sewer system piping was installed near the bottom of the active layer. The vertical location of the piping has led to deterioration of the insulated piping system due to external pressure exerted during re-freeze. Higher rates of heat loss are being experienced from both the sewer and water systems. This burial depth has also enhanced the risks of sags in the sewer profile due to thaw settlement and heave. The combination of greater heat loss and unstable sewer profile increases the risk of sewer freeze and blockage. An apparent operational response to this deterioration of the sewer system is increased rates of bleed flow to the sewer system. The service connections are especially suspectable to these forms of deterioration.

- It is likely that the existing system can continue to serve the community for 5 years. This will require high levels of water consumption and attentive and persistent operator effort.

Phase 2

General

Phase 2 of the Technical Evaluation the Resolute Bay Sewage and Water Systems focused upon responses to the status and conditions identified during Phase 1 of the assessment. The activities with Phase 2 provided the following:

- Rehabilitations for the various facilities.
- Capital upgrades for the various components and systems.
- Operations and preventative maintenance advice.
- A contingency plan.
- A series of recommendations relating to operations and preventative maintenance are provided. Potential improvements examined include reductions in water consumption, improved training and lowering water temperature. A preventative maintenance program was prepared that is based upon the current MMS. The recommended preventative maintenance program represents greater effort than is currently sought from the operating contractor.
- A contingency plan that provides responses to likely sewer and water system failures is provided.

Conclusions

The following are some general conclusions drawn during Phase 2 of the evaluation.

- Table 3.1 summarizes the recommended facility rehabilitations. This table presents the rational, priority and estimated cost for each of the recommended rehabilitations. The estimated value of the recommended rehabilitations is between $2.7 and $2.9 million.
- Table 4.1 summarizes recommended capital improvements. This table presents the rational, priority and estimated cost for each of the recommended rehabilitations. The estimated value of the recommended improvements is approximately $150,000.
- Recommendations are provided regarding operational improvements. It is recommended that efforts be directed towards reducing water consumption. Improved operator training with an emphasis upon the public health safety issues associated with the operation and repair of public water system should be provided. It is not currently recommended that the water temperature be reduced.
- A preventative maintenance program has been developed. This program is based upon the existing maintenance management system. The recommended program represents greater effort that is currently sought from the operating contractor.
- A contingency plan that provides responses for failures that are likely to occur with the sewer and water systems has been developed. This contingency plan includes general recommendations regarding materials and supplies that should be held in stock in Resolute Bay.

Summary

The GN is currently assessing the most appropriate actions in terms of the provision of sewer and water services for the long term in Resolute Bay. Some time will be required to assess these requirements and implement in the selected solution. In the interim the existing system must remain in service. A two phase was commissioned to examine existing conditions and develop actions in response to these existing conditions. Phase 1 of the investigation provided the following.

- A review of previous investigations and engineering studies.
- An evaluation of the current condition and technical status of the systems
- A compilation of improvements made to the sewer and water systems since 1996.
- A review of preventative maintenance

Phase 2 of the investigation provided the following to facilitate the continued operation of the existing systems.

- A program of recommended facility rehabilitations.
- A program of recommended capital upgrades.
- Recommend improvements to operating methods.
- Recommendations regarding enhanced preventative maintenance.
- A contingency plan that provides responses for unusual events.

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1 Introduction

1.1 General

The Government of Nunavut has retained the services of a consulting engineering team to evaluate the Resolute Bay water and sewer systems. In broad terms, this assessment is to provide a course of action that will assure continued operation of the piped water and sewer systems for a further five years. This five year period will provide an opportunity to develop a sound and ongoing program to provide water and sewer services in Resolute Bay.

This is a two phase project. The first of these phases entailed the development of a technical evaluation of the existing systems. Phase two of this project represents the responses developed based upon the current technical status of the water and sewer systems. These responses target the continuing operation of the water and sewer systems for a further five years.

The following report presents the Phase 2 activities of this project. These include:

- Rehabilitation and capital upgrade works targeted at a further five years of operation;
- Operational improvements;
- A recommended preventative maintenance program;
- A contingency plan that provides responses to failures; and
- Estimates of costs associated with the above recommendations.

The recommendations of this report are based upon the technical evaluation of the system that was presented in the Phase 1 report. Many of these Phase 1 findings are based upon a field visit conducted during the week of November 23, 2009. The field activities and preparation of this report has been facilitated by the assistance and information provided by the various representatives of Community and Government Services (CGS) and by the candour of the operating contractor.

1.2 Community Description

Resolute Bay is located on Cornwallis Island at N74°42’ and W94°52’. Resolute Bay has a reported population of almost 250. The climate is especially challenging in this community. Average annual temperature is -16.7°C and average annual wind speed is 21 km/hour. The lowest temperature recorded at this site is -52.2°C and the highest recorded hourly wind speed is 142 km/hr. Wind chill as low as -72°C has been observed. The extremely low temperatures are combined with a protracted period of dark during the winter. The sun does not rise above the horizon between early November and early February. The combination of

temperature, high wind and lack of daylight create challenging operating conditions for much of the year.

The current water system was constructed as part of the relocation of the town site in the late 1970's. The system has encountered some operating challenges, including freeze of some of the piping and high rates of water bleeding. The question of replacement of the existing piped systems with trucked delivery of services has previously been examined. There is a strong sentiment within the community that the piped delivery of water and sewer services should continue.

The water system includes a supply from Char Lake, a pump house at Char Lake, a water treatment plant at Signal Hill, a transmission main connecting the pump house and the treatment plant, and a system of underground piping. The sewage system includes a collection network of underground piping, an outfall sewer and a macerator. The following report examines each of these system elements.

2 Summary of Phase 1 Findings

2.1 General

The first phase of the project entailed the evaluation of the existing water and sewage systems. The Phase 2 report presents the findings of Phase 1 of this project. These include:

- A technical assessment of the water and sewer system;
- A review of improvements carried out since 1996;
- A review of preventative maintenance practices, and
- A review of capacity to maintain the system.

The following summarizes the findings of the Phase 1 report.

2.1.1 Water License

A Water License for the period July 1, 1996 to June 30, 1999 has been located. A renewal for this water license has not been identified. This license governs the ongoing operation of the water and sewer system. The stipulations of the license include the following:

- The maximum permitted water consumption is 60,000 m^3 per year.
- Five surveillance locations that include raw water, treated water and treated sewage are identified.
- Sewage discharge parameters include:
    - BOD_5 < 120 mg/L
    - Suspended Solids < 80 mg/L
- Annual reports must be filed with the Nunavut Water Board.

2.1.2 Water Consumption

It appears that water consumption has risen dramatically in the recent past. Annual water use in the mid 1990's was reported as approximately 48,000 m^3, with 80% of this volume lost to bleeds. Records of water consumption are limited and there are some questions relating to the reliability of measuring equipment. Despite these questions it appears that there has been a substantial increase in water consumption. Current annual water use is reportedly

approaching 300,000 m^3, which is substantially higher than the amount permitted in the July 1996 Water License. There has been a modest growth in population over this period.

Much of the current water consumption is likely the result of numerous water bleeds. Water is bled from the water system into the sewers at several locations to promote flow, input heat into the sewers and reduce the risk of freeze of the sewer system. Water is bled directly into the bases of many of the concrete Access Vaults (AV's) in an effort to offset heat loss from these structures. Water bleeds are active on almost all of the sanitary sewer connections in Resolute Bay.

High rates of water consumption raise several concerns. The system is experiencing increased operating costs due to the cost of water heating at the Char Lake Pumping Station House and at the water treatment plant. A greater concern arises from average water consumption rates approaching the capacity of the supply pumps. A further increase in water demand could place the systems at risk of cross contamination and system wide freeze, depriving the community of water supply and sewage disposal.

2.2 Condition of Civil Works

The current Resolute Bay water and sewer systems were installed approximately 30 years ago. These systems reflect the design thinking of that era. The systems may be described as shallow bury installations. The selection of shallow bury may have contributed, to some degree, to more rapid than normal aging of the water and sewer systems. These systems appear to be at greater risk of freezing. There has been an ongoing requirement for repairs to the system piping, especially within the initial phase of installation. The recent increase in water consumption appears to be an effort to reduce the risk of freeze of systems that are becoming increasingly challenging to operate.

Much of the system has also been subject to annual thaw and refreeze of the surrounding soil. It is suspected that ongoing refreeze pressures have reduced insulation performance and damaged piping. Additionally, the combination of annual and heat loss from the piping has likely caused thaw induced settlement in some locations leading to instability of the piping profile. The combination of all of these behaviours has reduced the reliability of the water and sewer system and increased the vulnerability to freeze, and therefore resulting in a greater effort applied to the avoidance of freeze.

2.2.1 Water Supply Works

There are some water quality questions relating to fuel storage at the Char Lake Pumping Station. Specifically, there is a report of a past fuel spill at Char Lake. There is currently a risk of water supply contamination both from the external storage tank and from the day tank housed within the pumping station.

The current water intake appears to be suitable to meet the community needs for the next 5 years.

The existing pumping equipment within the Char Lake Pumping Station is meeting the current demands of the community. However, this will not continue if there is any substantial increase in community water demand. This equipment, which is part of the original installation, is nearing the end of its useful life.

One of the essential functions of the Char Lake Pumping Station is the injection of heat into the water supply prior to pumping to the town site. The boilers, heat exchanges and pumps related to this service have recently been replaced. The condition of these installations is dealt with in a subsequent section of this report. The current heating arrangement is poorly controlled and the method of heat injection into the transmission main to the town site is ineffective.

The transmission water main between Char Lake and Signal Hill Water Treatment Plant is meeting the current requirements of the community. It appears that external refreeze pressure has reduced the performance of the insulation on this pipeline, but replacement does not appear to be justified at this time. The internal electrical heat trace cable within the transmission water main is operating continuously.

There is a general concern with the Char Lake Pumping Station relating to instrumentation controls and alarms. Several functions such as water heating are poorly or uncontrolled. There are no calibration records for the magnetic flow meter that measures total water consumption and there are some question relating to the reliability of this instrument. In view of the concerns relating to total water consumption, reliable water consumption information is critical. There are only a modest number of parameters that are monitored and very limited alarms are provided from Char Lake.

2.2.2 Water Treatment and Storage

Water treatment, heating, circulation and storage are provided at the Signal Hill Water Treatment Plant, which is located immediately above the town site. Treatment is limited to chlorination. The boilers, heat exchangers and associated pumps were recently replaced at the Signal Hill Water Treatment Plant. The quantity of heat injected into the storage tank is uncontrolled. The controls for heat injection into the water supply to the town site are not currently operating properly.

Circulation of the town site water distribution system is achieved by a pair of circulation pumps at Signal Hill that operate in alternation. These pumps are meeting current community requirements, but they are reaching the end of their service life.

The current water storage tank, with a volume of 570 m^3, was completed in 2009. This tank replaced the original tank that experienced substantial leakage due to pinhole corrosion. The original storage tank has been permanently removed from service. The storage tank does not provide sufficient volume to meet current equalization, fire supply and emergency storage requirements of 873m^3, as reported in the UMA 1996 report.

As in the case of the Char Lake Pumping Station, there is a general concern with the treatment plant instrumentation controls and alarms. Several functions such as water heating are poorly or uncontrolled. The flow meter is no longer in service and circular paper charts for the tank level recorder are difficult to obtain. There are only a modest number of parameters that are monitored and very limited alarms are provided from the Signal Hill Water Treatment Plant.

2.2.3 Water Distribution System

The water distribution system includes water main piping and Access Vaults (AV's). The water distribution piping is laid out as a loop with circulation forced by pumps in the water treatment plant. The system may be described as shallow bury with typically one meter of cover. Shallow bury was typical of the design practices that prevailed at the time this system was designed. The selection of shallow bury facilitates excavation should repairs be required. This installation strategy raises issues with the long term durability of the piping. The current installation depth places the piping within the influence of annual thaw and freeze. The resulting refreeze pressures create issues with damaged piping and deteriorated insulation. It is estimated that current heat loss is at five times the rate that would be expected of modern insulation system. There have been ongoing requirements to replace sections of the water system piping. The potential that a portion of the current high rates of water consumption are the result of leakage cannot be ruled out at this time.

The combinations of shallow bury and high rates of heat loss from the piping can create problems with stability of the buried piping profile. Sags and humps in the profile can arise from thaw settlement and frost heave. This does not normally cause substantial operational problems for water systems, but the heat input into the soil and resulting destabilization of profile can be a significant issue for the adjacent sewer piping.

Water system AV's are shared with the sewer system. Issues with the AV's include heat loss, water infiltration and the risks of cross contamination.

Water is currently bled into many of the AV's as a mechanism to provide heat input and offset heat loss from these concrete structures. Operational personnel report that this practice has been adopted to avoid freeze of equipment within the AV's. This suggests that the AV's are currently experiencing substantial heat loss.

In addition to providing a heat input into the AV's, the water bleeds provide flow and heat input into the sewer system. This operational measure appears to have been applied over the full Resolute Bay water and sewer system as a measure to reduce the risk of freeze for the sewer system. Bleeds are also used as a freeze prevention measure for the two dead-end sections of water main. One specific water system concern arising from the use of bleeds relates to the risk of cross contamination of the water system from the sewer system. With very few exceptions there are no back flow prevention measures in place. In those limited locations where some provision has been made, this has taken the form of check valves. No

approved backflow preventors have been provided. The resulting arrangement represents a substantial risk to public health should the water system become depressurized.

In addition to the bleeds there are several locations within each AV where there is a potential for cross contamination. These include the various uncapped valves and connections within the AV's.

The design of the AV's included covers for the sewer access points (clean-outs). Virtually all of these clean-out covers have been removed to permit drainage of ground water infiltration and to provide a point of introduction for bleed flows into the sewer. Leakage of groundwater into AV's during the summer season has been an ongoing issue with the AV's.

2.2.4 Sewage Collection

The sewage collection system is made up of Access Vaults (AV's) that are shared with the water system and piping. The issues with the AV's, which include heat loss, water infiltration and the risk of cross contamination, are reported above in Section 2.2.3 – Water Distribution System.

During the field visit it was noted that almost all of the clean-out covers had been removed. There was evidence in some AV's of slow flow in the sewer and past sewer back-up. Rocks and debris were observed, both in the AV's and the clean-outs. It is likely that a system wide AV clean up program has not been conducted for some time. The observation of the AV's also suggested that there are issues with the piping that require attention.

The sewer piping was installed as a shallow bury system with a typical cover of one metre. This places the piping within the influence of annual thaw and re-freeze, which raises the concerns of re-freeze pressure and profile stability. Re-freeze pressure can lead to the compression of insulation and crushing of the piping. The profile of the piping may not be reliably maintained due to thaw settlement and frost heave.

Close circuit television (CCTV) information is available for a portion of the Resolute Bay sewer system. The CCTV inspection provided evidence of external pressure that included internal ice and out of round pipe. This external pressure has likely damaged the piping insulation. External pressure is also a cause of piping collapse. The CCTV information also demonstrated sags in the piping profile. There is an increased risk of freeze due to stagnation of flow in the sags.

Evidence of slow flow and back-ups noted during the field visit suggest that there are issues with localized flat piping gradients, accumulation of debris, especially in sags, and piping freeze. One back-up was resolved during the field visit by thawing the downstream piping.

The high rates of bleed flow appear to be a response to avoid piping freeze that is based upon operation experience.

Continuing deterioration of the piping due to annual re-freeze is likely. This deterioration is the result of ongoing damage to the insulation system, which in turn leads to increased heat loss. The increased heat loss leads to a greater impact upon the underlying permafrost and a need for greater operational efforts to offset this heat loss.

2.2.5 Sewer Service Connections

The sewer service connections are one of the most vulnerable parts of the sewer system. The service connections are the shallowest elements of the system, placing them within the greatest influence of annual re-freeze and subjecting them to the lowest temperatures. Many of the service connections have relatively flat gradients due to the elevations of the sewer and connected houses. There are long periods (over night) with little or no flow into the service connections. The risk of freeze during no-flow periods can be exacerbated by the accumulation of hoar frost within the sewer service connection piping due to the venting of warm moist air from the sewer through the plumbing vents of the connected building. The combination of these factors places the service connections at high risk of freeze, and this has been the operational experience in Resolute Bay.

The operational measure instituted to avoid freezing of service connections has been water bleeding. Water bleeds to the sewer service connections have been installed in all of the building that are connected to the sewer system. These bleeds are operated by the building owners with a focus upon maintaining their service connection in operation. It is estimated that between one quarter and one third of the total water consumption is the result of bleeds to service connections.

2.2.6 Sewage Disposal

The current sewage disposal arrangement involves a macerator and a discharge on the beach near the high water mark. The current discharge likely meets the stipulations of the July 1996 Water License largely as a result of dilution due to the high rates of bleed water flow.

Improvements to the sewage treatment works cannot be developed until the question of water consumption is resolved.

2.3 Mechanical Systems

2.3.1 Char Lake Pumping Station

2.3.1.1 Potable Water Systems

Water is drawn by gravity from Char Lake into a pumping well below the pump station floor. Heated water is injected into the pumping well to raise the temperature of the incoming water. The water is then pumped to the Signal Hill Water Treatment Plant through a 1.8 kilometre long, 150mm diameter, insulated and electrically heat traced, high density polyethylene transmission main.

Two pumps, operating in alternation, are used to refill the storage tank at the Signal Hill Water Treatment Plant. Between tank fill cycles, a pair of jockey pumps operates to maintain minimum flow in the transmission main.

The main transfer pumps dates to the original installation in the 1970's and the jockey pumps were installed in 1994.

2.3.1.2 Fuel Systems

The fuel system at the Char Lake Pumping Station consists of three holding tanks: a 9090 L (2000 imp. gal.) tanks installed outside, 1135 L (250 imp. gal.) day tank installed inside the building as well as a 115 L (25 imp. gal.) generator day tank. All tanks are interconnected. The system is used to feed the oil fired equipment that includes the emergency generator, two hot water boilers and one unit heater.

Many code violations have been observed with the diesel fuel systems in place. The present set up represents a great risk of contamination of the ground and Char Lake, which is the source of potable water for the community. The same code violations can be observed at the water treatment plant, but would not represent a risk of contamination of the potable water.

The following code violations have been observed and require immediate attention:

- A single-wall 9090 L (2000 imp. gal.) above-ground fuel storage tank is installed outside the building, across the road from the pump station. Single-wall black steel pipes installed underground, passing under a road, feed by gravity a 1135 L (250 imp. gal.) day tank and a smaller 1135 L.(25 imp. gal) installed inside the pump house. There is no leak detection installed between the main tank and the day tank. In the event of failure of the buried piping, fuel could contaminate the ground and eventually the water of the lake before the leak is noticed.

- The larger day tank is a single wall tank, installed directly next to the potable water wet well. The tank is gravity fed from the main tank outside. The tank has no ULC Label, no secondary containment, no leak detection, no overflow, no overfilling protection and is vented directly to the exterior. The termination of the vent line is higher than the vent of the main tank installed outside, in order to prevent a spill in case of overfilling.

All tanks are interconnected and gravity fed. In the current configuration, a failure of one of the tanks installed in the building would mean that the entire volume of fuel contained in the day tank, the main storage tank and the piping, representing over 10,230L (2250 imp. gals) could flow in the pump house, potentially contaminating the water in the wet well, Char Lake and/or cause a fire.

2.3.1.3 Boilers, Heat Exchangers and heating pumps

Two oil fired boilers provide most of the heating capacity for the building. Through a pair of heat exchangers, potable water is heated for injection into the wet well and to the outgoing pipe to Signal Hill water treatment plant. There is no controller to allow sequential operation and no means to control the potable temperature in the well or in the piping between Char Lake Pumping Station and the Signal Hill Water Treatment Plant. There is also no make-up water to the boilers. In the event of a leak, the boilers would shut-down until someone comes to fill the system back up.

Two hot water unit heaters and one oil fired unit heater are used for heating the building. The entire hydronic heating system at Char Lake uses water. To reduce the risk of freezing, 50% non-toxic propylene-glycol solution should be used, in accordance with Good Building Practice Guidelines.

The boilers, hot water pumps and heat exchangers were installed in 2009, the oil fired unit heater was installed in 2003 and the rest of the mechanical equipment dates to the original installation in the 1970's.

2.3.1.4 Ventilation and building heating

The Char Lake Pumping Station has minimal ventilation. The only mechanical ventilation in the building is a supply fan that starts when the emergency generator starts.

The suction side of the fan is connected to a set of motorized dampers. The dampers are not operational, the outside air damper remains fully opened and the recalculating air damper remains closed. The discharge of the generator supply fan is directly aimed in the direction of water piping which creates a risk of freezing the pipes.

In the event of a power failure, the operator has to open the door of the building to prevent overheating of the generator engine which could cause a failure of the equipment.

There are two hot water unit heaters and one oil fired unit heater to maintain the building's indoor air temperature. The oil fired unit heater was not operational at the time of the visit.

2.3.1.5 Controls

Controls are very limited at the pumping station. Most of the control devices are original to the building and are either de-commissioned or not operational. Presently, the only alarm from the building's controls is a low building temperature alarm. There is no alarm for failure of the boilers or for low water temperature.

The hot water injection into the flows to the Signal Hill Treatment Plant is a passive system, dependent upon pressure differences between the supply point to the heat exchanger and the injection point. The current arrangement does not provide a meaningful quantity of heat injection due to the piping arrangement. As the injection of hot water is on the discharge side

of the of the potable water pumps, which are the same pumps that are used to circulate water through the heat exchangers, the injection of hot water into the supply main is not possible, leaving the electrical heat tracing as the only source of heat between the Char Lake Pumping Station and the Water Treatment Plant.

2.3.2 Signal Hill Water Treatment Plant

2.3.2.1 Potable Water System

Water treatment is limited to chlorination. A chlorine solution is injected into the water supply to town, immediately prior to point where the piping leaves the building.

The water pressure for distribution to the town site is boosted by a pair of pumps that operate in alternation. The pressure boost, provided by the pumps, is intended to assure circulation of the water supply and return flow to the water treatment plant. With a system of butterfly valves and check valves, it is possible to by-pass the pumps installed at the water treatment plant and rely only on the pumps installed at Char Lake to circulate water through town. There is also a possibility to rely on gravity to pressurize the potable water supply to town, however, in this arrangement, there would be no circulation of water in the return line so the system would therefore be subject to freezing.

A portion of the water pumped is heated by heat exchangers to a temperature measured to be 40^{o}C (115^{o}F). This heated potable water is injected in the storage tank to maintain the water temperature above freezing. There are no automatic controls to maintain this temperature.

A portion of heated water is also injected on the suction side of the circulating pumps to heat the water that is pumped to town. A three way valve installed on the hot water side of the heating system controls the temperature of the water leaving to town. However, at the time of the site visit, the controls were not operational. There is also no means to balance the flow of hot water between what is injected into the storage tank and what is injected into the circulating water.

2.3.2.2 Fuel System

The fuel system at the Water Treatment Plant consists of three holding tanks: a 9090 L (2000 imp. gal.) tank installed outside, a 1135 L (250 imp. gal.) day tank installed inside the building as well as a 115 L (25 imp. gal.) generator day tank. All tanks are interconnected. The system is used to feed the oil fired equipment that includes the emergency generator and three hot water boilers.

The following code violations have been observed and require immediate attention:

- A single-wall 9090 L (2000 imp. gal.) above-ground fuel storage tank is installed outside the building. Single-wall black steel pipes feed by gravity a 1135 L (250 imp. gal.) day tank and a smaller 1135 L (25 imp. gal) installed inside the pump

house. There is no leak detection installed between the main tank and the day tank. In the event of failure of the buried piping, fuel could contaminate the ground.

- The larger day tank is a single wall tank. The tank is gravity fed from the main tank outside. The tank has no ULC Label, no secondary containment, no leak detection, no overflow, no overfilling protection and is vented directly to the exterior. The termination of the vent line is higher than the vent of the main tank installed outside, in order to prevent a spill in case of overfilling.

- All tanks are interconnected and gravity fed. In the current configuration, a failure of one of the tanks installed in the building would mean that the entire volume of fuel contained in the day tank, the main storage tank and the piping, representing over 10,230L (2250 imp. gal) could flow into the treatment plant.

2.3.2.3 Boilers and Heat Exchange

Three oil fired boilers provide all of the heating capacity for the building. Through a pair of heat exchangers, potable water is heated for injection into the suction header of the potable water circulating pumps in order to maintain acceptable temperature and prevent freezing. The boilers, heating pumps and heat exchangers were installed in 2009. Three hot water unit heaters are used for heating the building.

Two boilers were operating at the time of site review, the third boiler was turned off and the valves in a closed position. This is made necessary from the fact that the hot water pumps are sized to provide enough flow for only two boilers. Since no controls are installed, the boilers would all fail on low water flow if they were to all be on line simultaneously.

Hot Water Pumps

Two primary pumps, installed in parallel, ensure flow through two of the boilers and to the heat exchangers. The pumps operate at a constant volume and only one pump operates at a time in a lead/lag configuration. The capacity of one pump is sufficient to operate two boilers and both heat exchangers. The pumps were installed in 2009.

Heat Exchangers

Two stainless steel plate and frame heat exchangers are installed to transfer heat from the heating water to the domestic water. The heat exchangers were installed in 2009. The heat exchangers operate at variable flow. A three-way valve is installed to maintain the water temperature supplied to town. The controls were not operational at the time of the visit.

2.3.2.4 Ventilation

The Water Treatment Plant has minimal ventilation. The only mechanical ventilation in the building is a supply fan that starts when the emergency generator starts. This fan was not operational at the time of the visit.

No combustion air intake is installed for the boilers.

2.3.2.5 Controls

As in the case of the Char Lake Pumping Station, there is general concern with the treatment plant instrumentation controls and alarms. Several functions, such as water heating, are poorly or uncontrolled. The flow meter is no longer in service and circular paper charts for the tank level recorders are difficult to obtain. There are only a modest number of parameters that are monitored and very limited alarms are provided from the Signal Hill Water Treatment Plant.

A three way valve installed on the hot water side of the heating system controls the temperature of the water leaving to town.

There is no balancing valve installed and no way to control the flow of water injected in the potable water holding tank. Since there have been no failures caused by the freezing of the storage tank, it is easy to conclude that there is a waste of energy by injecting hot water in the storage tank even when not required.

2.3.3 Sewage Treatment

The sewage treatment works consist of a treatment plant building and an adjacent macerator facility. There is no equipment within the sewage treatment plant building. A comminutor (macerator) is located in a small bally building adjacent to the treatment plant building. At the time of the visit, the macerator was not operational. When the equipment is in operation, there is no treatment beyond maceration. Sewage flows are then directed to an outfall on the beach above the high tide mark.

The building in which the macerator is installed has no mechanical equipment in operation. There was a wall mounted propeller exhaust fan installed in the past, but the fan is now not operational and the opening is filled with thermal insulation.

2.4 Electrical Systems

2.4.1 Char Lake Pumping Station

The Char Lake Pumping Station is supplied from the Qulliq Energy Corporation with a 300 amp 120/240 volt, 3 phase, 4 wire overhead service and is metered by the Utility.

The voltage between neutral and Phase “B” is 212 volts due to the nature of the service connection. As this is not a typical condition, care must be taken when connecting 120 volt single phase loads to the 3 phase panel supporting the new mechanical boilers. Warning signs are required on this panel and the service to clearly identify this condition.

The service supplies the automatic transfer switch, which in turn supports all of the electrical distribution in the pumping station, with the exception of the heat tracing system on the main water supply piping to the Signal Hill Water Treatment Plant.

There is no Transient Voltage Surge Suppressor (TVSS) on the main service.

2.4.1.1 Secondary Distribution, Starters and Heat Tracing

The electrical distribution splitters fed from the transfer switch feed the reduced voltage starters for the main water distribution pumps, starters for the Jockey Pumps and Branch Circuit Panels that support the new Boiler System and Lighting & Receptacle loads in the Pumping Station.

The Main Water Distribution Pump Starters lock out the pump operation when the power fails and the generator starts and the transfer switch operates to support the loads in the Pumping Station. Manual reset of the pump starter is required to start the lead pump. Investigation of the starter operation is required to verify what causes this condition and failure.

The Jockey Pump starters are in unsatisfactory condition, the starter for Jockey Pump P2 has failed and is no longer in service and the starter for Jockey Pump P1 has been reconstructed from miscellaneous parts.

The heat tracing on the Main Water Distribution Piping to Signal Hill is fed from a step up transformer that is connected on the normal side of the transfer switch so that it only operates when utility power is available.

The feed to the heat tracing transformer runs through the transfer switch and associated splitter. This is a Code violation that requires correction.

The control contactor for the heat tracing system is undersized and the heat tracing is connected so that there is no control and the heat tracing is on continuously. The control sensor for the heat tracing is installed in a typical insulated section of pipe on the exterior of the building.

2.4.1.2 Emergency Power

The 30 kW 120/208 volt diesel generator is original to the building and supports the pumping station through a 300 amp, 120/240 volt automatic transfer switch that was installed in 1995. The generator controller was upgraded in 1995 as part of the heat tracing installation. Based on industry standards, the generator is considered to be at the end of its normal service life.

The generator radiator is not exhausted to the outdoors, and with no exhaust fan to extract the hot air from the pump house, the generator shuts down on high temperatures when operational if operators do not go to site and open doors to the pumping station.

The generator is tested once a month under load for approximately an hour. No logs of generator test or operation are kept. The generator is tested on an annual basis by an independent contractor retained by the GN. Weekly and monthly operational maintenance outlined in the MMS documents are not completed.

The annual generator testing was performed in April 2009. The report indicates that the system is functioning properly and there are no issues with the Generator Operation. There is a question if the report is accurate or if the corrective action notes for the Signal Hill generator repair should be for the Char Lake generator or both, as items reported by the Testing agent are opposite to those identified and raised by the Station operator.

The issues raised by the operator include the Generator water jacket temperature sensor has been disconnected due to operating issue and the ventilation system does not function properly and cause the building and generator to over heat causing it to shut down.

2.4.1.3 Lighting

The interior and exterior lighting at the Char Lake Pumping Station is in good condition, this being said upgrades to the lighting to improve the general lighting levels in the station should be considered.

2.4.1.4 Instrumentation Control and Annunciation

The existing relay based monitoring and Pump Control Panel is original to the building. The monitoring points connected to this panel no longer function due to the lack of available parts. At this time, the only function this panel serves is to alternate the Main Water Distribution Pumps P1 and P2 based on the water level in the Signal Hill Reservoir.

The auto dialer, installed in 1994, for this system is not equipped with battery back up and does not function properly, requiring the operator to use alternate means to verify a malfunction at the Pump House, such as noting that the aviation warning light on the adjacent radio tower means that the power is off at the Pump Station.

The remote display unit for the Mag Flow meter malfunctions on a regular basis, and to reset this unit the power to the unit must be turned on and off numerous times to reset the display.

2.4.2 Signal Hill Water Treatment Plan

2.4.2.1 Main Electrical Service and Distribution System

The Signal Hill Water Treatment Plant is supplied from the Qulliq Energy Corporation with a 100 amp 120/208 volt, 3 phase, 4 wire service and is metered by the Utility.

The supply voltages to the building are not consistent and need to be verified with the Utility.

The service supplies the automatic transfer switch, which in turn supports all of the electrical distribution in the Treatment Plant.

There is no Transient Voltage Surge Suppressor (TVSS) on the services.

2.4.2.2 Secondary Distribution and Heat Tracing

The electrical distribution splitter, fed from the transfer switch, feeds the reduced voltage voltage starters for the Water Distribution Pumps, Branch Circuit Panels that support the new Boiler System, Heat Tracing Cable, Lighting and Receptacle Loads in the Water Treatment Plant.

The starters for the Distribution Pumps are alternated manually by placing the starter control in the HAND position, one pump operates constantly to maintain constant water flow.

2.4.2.3 Emergency Power

The 30 kW 120/208 volt diesel generator is original to the building and supports the Treatment Plant through the original 100 amp 120/240 volt dual contactor type transfer switch. Based on Industry Standards, the generator and the transfer switch are considered to be at the end of their normal service life.

The generator radiator is not exhausted to the outdoors, when the generator is in operation an exhaust fan operates to reject the heat outside.

The generator is tested once a month under load for approximately an hour. No logs of the generator test or operation are kept. The generator is tested on an annual basis by an independent contractor retained by the GN. Weekly and monthly operational maintenance outlined in the MMS documents are not completed.

The annual generator testing was performed in April 2009. The report indicates that the engine High Temperature and Low Oil Pressure alarms and shutdown functions do not function and the GN should consider replacing the original relay based controller with a new Digital Controller similar to Char Lake. The report indicates that the system is functioning properly and there are no issues with the Generator Operation. There is a question if the report is accurate or if the corrective action notes for the Signal Hill generator repair should be for the Char Lake generator or both, as items reported by the Testing agent are opposite to those identified and raised by the Station operator and that the Signal Hill generator functions with out issues.

2.4.2.4 Lighting

The interior and exterior lighting at the Treatment Plant is in good condition this being said upgrades to the lighting to improve the general lighting levels in the station should be considered.

2.4.2.5 Instrumentation Control and Annunciation

The existing relay based monitoring system and associated instrumentation is original to the building. This system monitors operation of the Water Treatment Plant, and a common alarm signal is sent via the Auto Dialer in the event that any of the alarm points are activated.

In the event that water flow is lost, a siren and strobe light on the exterior of the building is activated to notify the Hamlet that immediate action is necessary.

A single chlorination Metering Pump is in place and injects chlorine from the Chlorine Tank directly into the water distribution piping system after the Distribution Pumps.

Mechanical paper flow chart and mechanical temperature recorders are original to the building and no longer record data properly.

2.4.3 Sewage Treatment

There is no sewage treatment equipment. The Macerator Building has an electrical service to support building radiant heat, lighting and power to the macerator.

The macerator was disconnected and not operational.

All electrical equipment within the building is not rated for a hazardous location which may be required.

2.5 Conditions Requiring Urgent Action

The Phase 1 Report identified the following actions that require urgent action based on observations during the site visit to Resolute Bay between November 23rd and 25th. These issues were previously brought to the Government of Nunavut's attention in separate correspondence.

2.5.1 Fuel Storage

During the site visits of the Char Lake pumping station many code violations were observed with the diesel fuel system in place. The present set up represents a great risk of contamination of the ground and Char Lake, which is the only source of potable water for the community.

The following observations were made and require immediate attention:

- A single-wall 9090 L (2000 imp. gal.) above-ground fuel storage tank is installed outside the building, across the road from the pump house. Single-wall black steel pipes installed underground, passing under a road, feed by gravity a 1135 L (250 imp. gal.) day tank and a smaller 1135 L.(25 imp. gal) installed inside the pump house. There is no leak detection installed between the main tank and the day tank.

In the event of failure of the buried piping, fuel could contaminate the ground and eventually the water of the lake before the leak is noticed.

- The larger day tank is a single wall tank, installed directly next to the potable water wet well. The tank is gravity fed from the main tank outside. The tank has no ULC Label, no secondary containment, no leak detection, no overflow, no overfilling protection and is vented directly to the exterior. The termination of the vent line is higher than the vent of the main tank installed outside, in order to prevent a spill in event of overfilling of the main tank.

- All tanks are interconnected and gravity fed. In the current configuration, a failure of one of the tanks installed in the building would mean that the entire volume of fuel contained in the day tank, the main storage tank and the piping, representing over 10,230L (2250 imp. gal) would flow into the pump house, potentially contaminating the water in the wet well and/or cause a fire.

The entire fuel system must be replaced to meet the current codes. Work shall include:

- Provide secondary containment with leak detection, low level and high level alarms for all the tanks, including tanks installed outside and inside, as required by the National Fire Code and CSA B-139.

- Provide fuel transfer pumps in a sump to allow drainage by gravity of all fuel lines without risk of fuel being trapped.

- Replace the underground fuel transfer lines between the main storage tank and the building with double-wall construction piping with leak detection, in accordance with the National Fire Code and CSA-B139 standard.

- The emergency generator has a small day tank gravity fed from the 1135 L (250 imp. gal.) day tank. This small day tank is a single wall tank, directly vented to the exterior with no secondary containment and no overfilling protection. There is a solenoid valve installed on the fill side of the tank. When the generator starts, the solenoid will open and the tank will fill up, including the vent pipe, until the levels between the main tank outside the building and the generator tank are balanced, which will mean that the vent pipe is partially filled with fuel and that the tank is pressurized. This type of tank is not designed to be pressurized therefore the risk of failure is increased.

- As required by the National Fire Code and CSA-B139, provide venting of the day tanks through the main storage tank or provide redundant high level sensors to shut the transfer pumps and prevent the overfilling of the tank.

Fuel storage quantity, according to the Government of Nunavut Good Building Practices Guideline, would be of a minimum of two weeks calculated at continuous maximum

operating load, including heating and emergency power. The rational is that blizzards and storms can make delivery difficult for periods of up to two weeks. Based on a fuel consumption of 3 gal/hr., and one boiler used for redundancy, the minimum required fuel storage capacity would be of 22,275 L (4,900 imp. gal.). The current fuel storage capacity would provide autonomy of 128 hours (5 days and 8 hours) at full load. Fuel storage capacity should be reviewed as part of the overall fuel system upgrade.

2.5.2 Public Health

With regards to public health, there is a significant risk of contamination of the water supply due to current conditions within the access vaults. These vaults are shared by the water and sewer. Their design includes enclosure of the sewers using sealed clean-outs, which provided separation of these systems. Currently, the covers on these clean-outs have been removed. There are several locations where various valved connections to the water system are not capped. There are also several locations where bleed water is directed from the water system into the sewers. At these locations no backflow prevention measures are provided.

2.5.3 Water Consumption Monitoring

Current average day water is approaching the supply ability at the Char Lake Pumping Station. Additional demands, including additional bleeds, may increase water consumption beyond supply capabilities. This will create the risk of water system depressurization. Challenges that would arise from a loss of pressure in the water system include water contamination and system wide water and sewer piping freeze. It is recommended that the GN personnel monitor, on a continuing and ongoing basis, the rates of water use in Resolute Bay.

2.5.4 Worker Safety Observations

With regards to worker safety, we must report concerns relating to confined space entry and fall arrest. Concerns arise in both of these areas in relation to any work within the access vaults. As a participant in this water system, the GN must, as a matter of due diligence, confirm that workers have been provided the prescribed training and that appropriate procedures are followed.

3 Facility Rehabilitation

3.1 General

A program of facility rehabilitation and capital upgrades has been identified. This section deals with the program the recommended facility upgrades. This program targets continuing to meet the current level of service in a safe, effective and reliable fashion for a further 5 years.

3.2 Civil Works

3.2.1 Water Consumption

Current water consumption is approaching the pumping capacity at the Char Lake Pumping Station. The principle opportunities to reduce water consumption are associated with operational changes. The works associated with reduction in water consumption are dealt with in Sections 3.2.4 and 3.2.5 below.

3.2.2 Water Supply, Pumping and Transmission

The water supply, pumping and transmission works include the facilities found at the Char Lake Pumping Station, together with the transmission main connecting the pumping station with the Signal Hill Water Treatment Plant.

There is a report of a historic fuel spill at Char Lake. It is recommended that water samples be gathered in the spring and that these samples be tested for benzene, toluene and xylene. Any required actions would be developed based upon the findings of this testing. Currently no allowance has been carried for the resulting actions.

The rehabilitations required at the Char Lake Pumping Station include improvements to the fuel storage, heat injection, water supply pumping, standby power, instrumentation, controls and alarms. These improvements are addressed in subsequent sections of this report.

No improvements are envisaged as necessary for a further five years of operation of the transmission water main.

3.2.3 Water Storage and Treatment

Chlorination is currently provided using a single chemical metering pump that is not equipped with an alarm. This creates the potential circumstance of a protracted period with no chlorine feed following the failure of the single pump. This chlorination arrangement should be replaced by dual metering pumps with one pump operating as the duty pump and automatic start-up of the second pump upon failure. Failure of the duty pump should also initiate an alarm that is transmitted to the water treatment plant control system.

The rehabilitation requirements at the Signal Hill Water Treatment Plant include improvements to fuel storage, domestic water pumping, standby power, instrumentation, controls and alarms. These improvements are addressed in subsequent sections of this report.

3.2.4 Water Distribution

The recommended improvements to the water distribution system focus upon reduction of risk and reduction of operating costs. The proposed improvements are presented within the context of the maintenance of service for a further 5 years. It has been recognized that the existing system has experienced significant deterioration, especially with the piping insulation system. The risks that have been considered relate to public safety and loss of service.

Public Safety

The principle public safety risk relates to cross contamination between the water and sewer system, and this arises due to conditions within the AV's. The scope of improvements recommended includes:

1. System Wide Cleaning of Access Vaults

    - Pump out, clean up and disinfect the AV's.
    - Cap all unused fittings and connections with the AV's.
    - Remove the various hoses and other equipment within the AV's that is no longer in service.
    - Replace the clean-out covers on the sewers.
    - Pipe bleeds directly to the sewer.

    Opinion to cost: $67,000

2. Provide approved backflow preventors for all points within AV's where water is discharged from the water system.

    Opinion to cost: $32,000

Loss of Service

Generally there is a low risk of freeze for the water system piping as the system is looped and aggressively circulated. A bleed is required to maintain the dead end water mains between AV's 23 and 25. It appears that the various remaining bleed points are largely associated with flow maintenance and heat input for the sewer system. The question of bleeds is examined in Section 3.2.5 below.

A second potential cause for water piping freeze is related to consumption. The situation where consumption exceeds supply pumping places the water system at risk of depressurization and loss of circulation. This could, in turn, lead to system wide freeze. The current high rates of consumption are the result of high bleed rates combined with potential main leaks. In addition to addressing the various bleeds the following are recommended:

1. Conduct a system wide water main leakage detection program.

   Opinion to cost: $25,000

   Leaks identified during the leak detection program should be repaired at the first opportunity. For the purposes of the current estimates it has been assumed that leaks will be repaired at four locations. This budget allowance can be adjusted based upon the findings of the leak detection program.

2. Repair water main leaks identified by the leak detection program.

   Opinion to cost: $80,000

There are reports of freeze of equipment within AV's such as valves due to heat loss from the AV's. This is currently addressed through bleeding of water into the base of the AV's, which eventually overflows into the open sewer clean-outs. The highest rates of heat loss are from the top and that portion of the AV walls that is above grade. Provision of additional insulation will reduce heat loss. Continued heat input into the AV's will be required. There are few viable alternatives other than electric heaters, despite the challenges encountered in the past with these heaters. Installation of electric heaters will also require the provision of electrical power to the AV's. Electrical supply is currently available at 12 of the 31 AV's associated with the water system. In summary the following are recommended:

1. Provide additional wall and roof insulation within the AV's.

   Opinion to cost: $180,000

2. Provide heaters within AV's to offset heat loss and maintain internal temperatures above freezing.

   Opinion to cost: $224,000

3. Provide backflow preventers on any bleed water connections.

Potential reductions in operating costs are tied to reduction in water consumption. Reduction in bleed rates will have a very direct impact upon water consumption. This matter is examined in Section 3.2.5.

3.2.5 Sewage Collection

The principle issue with the sewer system is the high risk of freezing. The current operational response to this risk is high rates of bleed water consumption. The risk of sewer freeze arises from high rates of heat loss combined with slow flow in some sections of the sewer system. The high rates of heat loss are the result, in part, of deteriorated piping insulation. In general, this condition cannot be resolved without replacing much of the sewer piping. Replacement of the piping would reduce, but not remove the requirement for bleeds. A system wide replacement of piping to reduce heat loss can not be justified at this time.

Poor and slow flow in the sewers is the result of several factors including sags in profile, crushed piping and accumulation of materials within the piping. These accumulated materials could include rocks and gravel, sewage solids and sludge, and ice. The extent and degree of profile sags and crushed piping is not fully catalogued as CCTV information is available for only a portion of the sewer system. Flushing and cleaning of the sewer system should precede CCTV inspection. There is currently sewer cleaning equipment in Resolute Bay. This equipment has limited capacity, but the logistics of mobilizing a larger sewer cleaning machine could force a delay of one year for the sewer cleaning and inspection program. The following initial program is recommended:

1. Conduct a clean up of all AV's including the clean-out boxes.

   Opinion to cost: None; cost included with AV clean-up under water system rehabilitations

2. Conduct a sewer system wide flushing and cleaning program.

   Opinion to cost: $65,000

3. Conduct a system wide CCTV inspection of the sewer system.

   Opinion to cost: $100,000

4. Pump out, clean and disinfect the AV's following the flushing and CCTV program.

   Opinion to cost: $20,000

Following the CCTV inspection the full scope of required repairs can be defined. There may be some conditions identified that can not be resolved such as system wide insulation deterioration. For the purposes of the current estimates it has been assumed that 10% of the existing sewer system or approximately 200 metres will require replacement. Better definition of the scope of the required replacement can be better defined after completion of the CCTV inspection program. At that time the budget can be adjusted to reflect better information..

Opinion to cost: $300,000 - $500,000

Repairs to the sewer system piping are not likely to be permanent solutions. Significant changes to piping profiles are not possible do the fixed elevations of the various existing structure such as AV's. This will force the repaired sections of sewer to continue as a shallow bury system subject to annual thaw and re-freeze.

Following the cleaning, inspection and repairs to the sewer system there will be an opportunity to adjust bleed flows to the sewer system. The appropriate rates of flow for these bleeds are challenging to predict due to deterioration of the insulation system. Adjustments to bleed rates should be based upon measured sewage temperatures and operating experience. This operational response is examined in greater detail in section 4.2.1 of this report.

During Phase 1 of this study the sewer service connections were identified as the location of as much as 1/3 of the bleed water flow from the water system. The need for these bleeds is related to a list of factors including unstable piping profiles, low flow at night and deteriorated insulation. The issue of service connections is further complicated by the matter of the responsibility for that portion within the lot lies with the building owner. No capital improvements for the service connections have been identified. The issue of adjustment of bleed rates is examined in section 4.2.1 of this report.

3.2.6 Sewage Service Connections

Bleeding of water into sewer service connections in an effort to avoid freeze represents a significant portion of the total water bleeding. The service connections are especially vulnerable to freeze due to instable profiles, flat gradients, low temperature and lack of over-night flow. It is recommended that a program be conducted with building owners to reduce bleed rates into the service connections. Although this is an operational activity, it is likely that the need to rehabilitate some service connections will be identified. The scope of these rehabilitations can not be defined at this time, but it is proposed that an allowance be established for sewer service connection repairs. For current purposes this allowance will be set at $200,000.

3.2.7 Sewage Disposal

No rehabilitations to the sewage treatment and disposal works are recommended, within the context of those works within the civil discipline. The determination of a long term sewage treatment solution falls outside the scope of this assessment. The determination of this long term sewage treatment strategy will be strongly impacted by efforts to reduce water consumption.

3.3 Mechanical Systems

3.3.1 CHAR LAKE PUMPING STATION

3.3.1.1 Potable water systems

Duty Pumps

The pumps are original to the building and are past their normal service life. During the site investigation, the two pumps were leaking and water was accumulating on the floor of the pump house. In order to improve the reliability of the installation, it is recommended to replace the pumps.

Opinion to cost: $ 65,000

Jockey Pumps

Between tank fill cycles, a pair of submersible jockey pumps operate to maintain a minimum flow in the transmission main. The jockey pumps were installed in 1994. At the time of the site visit, one of the two pumps was not operational. A new pump had been ordered to replace the one that had failed.

Once the new pump is installed, the system will be operational. No improvements are envisaged as necessary for a further five years of operation of the jockey pumps system.

3.3.1.2 Fuel Systems

The entire fuel system must be replaced to meet the current codes. Work shall include:

- Provide secondary containment with leak detection, low level and high level alarms for all the tanks, including tanks installed outside and inside as required by the National Fire Code and CSA B-139.

- Provide fuel transfer pumps in a sump to allow drainage by gravity of all fuel lines without risk of fuel being trapped.

- Replace the underground fuel transfer lines between the main storage tank and the building with double-wall construction piping with leak detection, in accordance with the National Fire Code and CSA-B139 standard.

- As required by the National Fire Code and CSA-B139, provide venting of the day tanks through the main storage tank or provide redundant high level sensors to shut the transfer pumps and prevent the overfilling of the tank.

Fuel storage quantity, according to the Government of Nunavut Good Building Practices Guideline, would be of a minimum of two weeks calculated at continuous maximum operating load, including heating and emergency power. The rational is that blizzards and storms can make delivery difficult for periods of up to two weeks. Based on a fuel consumption of 3 gal/hr and one boiler used for redundancy, the minimum required fuel storage capacity would be of 22,275 L (4,900 imp. gal.). The current fuel storage capacity would provide autonomy of 128 hours (5 days and 8 hours) at full load. Fuel storage capacity should be reviewed as part of the overall fuel system upgrade.

Opinion to cost: $ 120,000

3.3.1.3 Boilers, Heat Exchangers and heating pumps

Boilers

The boilers have been replaced in 2009. No facility rehabilitation are envisaged as necessary for a further five years of operation of this equipment. Recommended capital improvements related to boilers are detailed in Section 4.

Pumps and heat exchangers

Heating pumps and heat exchangers have been replaced in 2009. No improvements are envisaged as necessary for a further five years of operation of this equipment.

Heating Fluid

Heating systems for both buildings currently operate with water only and there is no make-up water to the boilers. In the event of a leak, the boilers would shut-down until the leak is repaired and the system refilled. Hydronic heating systems using 100% water have shown to be prone to freezing. The system should be filled with 50% Dowfrost HD propylene glycol, with automatic injection pump, in accordance with The Building Good Practice Guidelines.

Opinion to cost: $ 15,000

3.3.1.4 Ventilation

The Char Lake Pumping Station has minimal ventilation. The only mechanical ventilation in the building is a supply fan that starts when the emergency generator starts. In the event of a power failure, the operator has to open the door of the building to prevent overheating of the generator engine. This represents a risk of power failure if access to the pump house is not possible, resulting in a loss of flow between Char Lake and the pump house and a loss of heating capacity.

Two hydronic unit heaters, original to the building, provide heating to the building. Although the unit heaters are past their normal service life, their operation is satisfactory. No

improvements are envisaged as necessary for a further five years of operation of this equipment.

There is also one oil fire unit heater installed in the room. This unit heater was installed in 2003 and appears to be in good condition. However, it was not operational at the time of site inspection.

The combustion air intake for the boilers is at floor level. In accordance with Good Building Guidelines, a skirt should be added around the combustion air duct to discharge the air at high level to reduce the risk of freezing pipes.

In order to provide a reliable installation, in accordance with current codes, the following scope of improvements is recommended:

- Provide adequate ventilation for the emergency generator, including the addition of a direct exhaust from the radiator and a system of interlocked dampers to control the fresh air supply and exhaust air flows.
- Ensure proper operation of the oil fired unit heater.
- Discharge combustion air at high level.

Opinion to cost: $ 50,000

3.3.2 WATER TREATMENT PLANT

3.3.2.1 Potable Water System

Water Treatment

Water treatment, heating, circulation and storage are provided at the Signal Hill Water Treatment Plant. Treatment is limited to chlorination and the injection pumps were replaced in 2009. No improvements are envisaged as necessary for a further five years of operation of this equipment.

Pumps

Circulation of the town site water distribution system is achieved by a pair of circulation pumps at Signal Hill that operate in alternation. These pumps are meeting current community requirements but, as these are the original pumps, they have reached the end of their service life. The pumps are not showing any signs of leakage and appear to be performing satisfactorily. If adequate maintenance work is carried out, no improvements are envisaged as necessary for a further five years of operation.

3.3.2.2 Fuel Systems

The entire fuel system must be replaced to meet the current codes. Work shall include:

- Provide secondary containment with leak detection, low level and high level alarms for all the tanks, including tanks installed outside and inside as required by the National Fire Code and CSA B-139.

- Provide fuel transfer pumps in a sump to allow drainage by gravity of all fuel lines without risk of fuel being trapped.

- As required by the National Fire Code and CSA-B139, provide venting of the day tanks through the main storage tank or provide redundant high level sensors to shut the transfer pumps and prevent the overfilling of the tank.

Fuel storage quantity, according to the Government of Nunavut Good Building Practices Guideline, would be of a minimum of two weeks calculated at continuous maximum operating load, including heating and emergency power. The rational is that blizzards and storms can make delivery difficult for periods up to two weeks. Based on a fuel consumption of 3 gal/hr and one boiler used for redundancy, the minimum required fuel storage capacity would be of 38,165 L. (8395 imp.gal.). The current fuel storage capacity would provide autonomy of 90 hours (3 days and 18 hours) at full load. Fuel consumption for the previous years should dictate the amount of fuel storage required.

Opinion to cost: $ 100,000

3.3.2.3 Boilers, Heat Exchangers and heating pumps

Boilers

The boilers have been replaced in 2009. No facility rehabilitation are envisaged as necessary for a further five years of operation of this equipment. Recommended capital improvements related to boilers are detailed in Section

Pumps and Heat Exchangers

Heating pumps and heat exchangers were replaced in 2009. No improvements are envisaged as necessary for a further five years of operation of this equipment.

Heating Fluid

Heating systems for both buildings currently operate with water only and there is no make-up water to the boilers. In the event of a leak, the boilers would shut-down until the leak is repaired and the system is refilled. Hydronic heating systems using 100% water have shown to be prone to freezing.

The system should be filled with 50% Dowfrost HD propylene glycol, with automatic injection pump, in accordance with The Good Building Practice Guidelines.

Opinion to cost: $ 15,000

3.3.2.4 Ventilation and building heating

The Water Treatment Plant has minimal ventilation. The only mechanical ventilation in the building is a supply fan that starts when the emergency generator starts. This fan was not operational at the time of the visit.

Three hydronic unit heaters, original to the building, provide heating to the building. Although the unit heaters are past their normal service life, their operation is satisfactory. No improvements are envisaged as necessary for a further five years of operation of this equipment.

In order to provide a reliable installation, in accordance with current codes, the following scope of improvements is recommended:

- Provide adequate ventilation to for the emergency generator, including the addition of a direct exhaust from the radiator and a system of interlocked dampers to control the fresh air supply and exhaust air flows.
- Provide combustion air intake for the boilers.

Opinion to Cost: $ 50,000

3.3.2.5 Controls

Heat Injection

A three way valve installed on the hot water side of the heat exchanger controls the injection water temperature based on potable water temperature returning from town. The controls for heat injection into the water supply to the town site are not currently operating properly.

There is no means to control the temperature in the water storage tank. Hot water is injected at constant volume into the tank.

The scope of recommended controls improvements for the hot water injection control at the Water Treatment Plant is the following:

- Provide a set of two-way control valves to control the water supply temperature to the town site and water holding tank. Remove the three-way valve on the boiler side of the heat exchangers allowing constant flow on the hot side of the exchangers.

Opinion to Cost: $ 15,000

3.3.3 Sewage Treatment

It is recommended to provide adequate ventilation to remove any noxious gases that could accumulate in the space. Additional heating capacity would also have to be provided to prevent freezing. Macerator should also be repaired and put back into operation.

Opinion to cost: $ 25,000

3.4 Electrical Systems

3.4.1 Char Lake Pumping Station

3.4.1.1 Emergency Power

The generator is at the end of recommended service life but may be able to operate for the next 5 years without any issues. The annual generator testing was performed in April 2009. The report indicates that the system is functioning properly and there are no issues with the Generator Operation. Considering that the annual testing should be scheduled for April of 2010, this timing of the tests should be changed February / March so that conditions can be verified immediately.

As part of the annual testing the GN should arrange for the testing Agent to have all the necessary parts to repair the previously reported issues and to provide and deliver specific replacement parts to address the contingency plans. Opinion to Cost: $15,000. Testing and repair

Replacement cost for a similar generator $130,000.

3.4.1.2 Lighting

Remove and replace all interior lighting in the station with new Fluorescent fixtures with wire guards.

3.4.1.3 Opinion to Cost: $5,000. Instrumentation Control and Annunciation

The instrumentation and control no longer function due to obsolescence, a completely new fully automated PLC based system that can be monitored via the internet in real time with a digital auto dialer backup. As part of this replacement, the flow meter would be replaced and connected to the system.

Opinion to cost: $200,000.

3.4.2 Signal Hill Water Treatment Plan

3.4.2.1 Emergency Power

The generator is at the end of recommended service life but may be able to operate for the next 5 years without any issues. To verify this condition, it is recommended that detailed servicing and testing be completed on the generator to verify condition and to repair any defective components. If the existing generator is maintained for the next 5 years, ventilation configuration must be corrected.

The annual generator testing was performed in April 2009. The report indicates that the engine High Temperature and Low Oil Pressure alarms and shutdown functions do not function. Also the GN should consider replacing the original relay based controller with a new Digital Controller similar to Char Lake.

Considering that the annual testing should be scheduled for April of 2010, this timing of the tests should be changed February / March so that conditions can be verified immediately.

As part of the annual testing the GN should arrange for the testing Agent to have all the necessary parts to repair the previously reported issues and to provide and deliver specific replacement parts to address the contingency plans.

Opinion to Cost: $15,000. Testing and repair

Replacement cost for a similar generator $130,000

3.4.2.2 Lighting

Remove and replace all interior lighting in the station with new Fluorescent fixtures with wire guards.

Opinion to Cost: $5,000.

3.4.2.3 Instrumentation Control and Annunciation

The instrumentation and control no longer function due to obsolescence, a completely new fully automated PLC based system that can be monitored via the internet in real time with a digital auto dialer backup. As part of this replacement, the flow charts and water temperature charts would be replaced and connected to the system.

Opinion to cost: $200,000.

3.5 Summary of Recommended Facility Rehabilitation

The recommended rehabilitation program is summarized in Table 3.1 This table presents the rational, priority, estimated cost and suggested timing for the various works. The following

scale has been used in assigning priorities for the various rehabilitations summarizes the recommended facility rehabilitation.

Urgent – The work should be completed immediately for safety reasons or to ensure the operational integrity of the water and sewer systems.

Required – The proposed work must be completed in 2010 to ensure the operational integrity of the water and sewer systems.

High Priority – The proposed work should be completed in 2010 to improve the operational efficiency of the water and sewer system.

Medium Priority – The proposed work should be completed as soon as possible to improve the operational efficiency of the water and sewer system.

Low Priority – The work is recommended to improve operational efficiency or operational convenience.

Logistics plays an important role in the timing of works in Resolute Bay. Some rehabilitation can be initiated in 2010 due to the modest scope of materials and equipment required. Other works must be delayed for a variety of reasons including mobilization of materials. There are also some works, such as sewer repairs, that are dependent upon the findings of the investigations that are recommended for 2010. Table 3.1 presents the suggested timing for the various rehabilitations.

Table 3.1 – Summary of Recommended Facility Rehabilitation					
System	**Rehabilitation**	**Rational**	**Priority**	**Year**	**Estimated Cost**
Water and Sewer System					
Access Vaults	System wide cleaning of Access Vaults	Public Safety	Urgent	2010	$67,000
Water System	Installation of backflow preventors on water bleeds	Public Safety	Urgent	2010	$32,000
Water System	Conduct system wide leak detection program	Loss of Service	Required	2010	$25,000
Water System	Repair leaks identified in leak detection program (allowance)	Loss of Service	Required	2010/2011	$80,000
Access Vaults	Install additional insulation	Loss of Service	Medium	2011	$180,000
Access Vaults	Install electric heaters	Loss of Service	Medium	2011	$224,000
Sewer System	System wide sewer flushing and cleaning program	Risk of Freezing	Required	2010	$65,000
Sewer System	System wide CCTV inspection	Risk of Freezing	Required	2010	$100,000
Sewer System	Clean out AVs after flushing and CCTV programs	Risk of Freezing	Required	2010	$20,000
Sewer System	Repair sections of Sewer identified in CCTV program (allowance)	Risk of Freezing	High	2010/2011	$300,000 to $500,00
Sewer System	Rehabilitate sewer service connections	Risk of Freezing	High	2010/2011	$200,000

Table 3.1 – Summary of Recommended Facility Rehabilitation					
System	**Rehabilitation**	**Rational**	**Priority**	**Year**	**Estimated Cost**
Char Lake Pumping Station					
Duty Pumps	Replacement of pumps	System Reliability	Required	2010	$65,000
Fuel System	Replace fuel system	Code Violations and Public Safety	Urgent	2010	$120,000
Heating Fluid	The system should be filled with 50% Dowfrost HD propylene glycol, with automatic injection pump	Good Building Practice Guidelines	Required	2010	$10,000
Ventilation	Improvements to the ventilation system	Good Building Practice Guidelines	High	2010	$50,000
Emergency Power	Detailed servicing and testing be completed on the generator	System reliability	Required	2010	$15,000
Lighting	Replace and install new lighting	Good Building Practice Guidelines	Medium	2010	$5000
Instrumentation Control and Annunciation	Installation of a new fully automated PLC based system that can be monitored via the internet in real time	System reliability	Medium	2010	$200,000

Table 3.1 – Summary of Recommended Facility Rehabilitation					
System	**Rehabilitation**	**Rational**	**Priority**	**Year**	**Estimated Cost**
Signal Hill Water Treatment Plant					
Fuel System	Replace fuel system	Code Violations and Public Safety	Urgent	2010	$100,000
Heating Fluid	The system should be filled with 50% Dowfrost HD propylene glycol, with automatic injection pump	Good Building Practice Guidelines	Required	2010	$10,000
Ventilation	Improvements to the ventilation system	Good Building Practice Guidelines	Required	2010	$50,000
Heat Injection Controls	Install a set of two-way control valves to control the water supply temperature to the town site and in the water holding tank	Improvements to the systems efficiency and reliability	High	2010	$15,000
Emergency Power	Detailed servicing and testing be completed on the generator	System reliability	Required	2010	$15,000
Lighting	Replace and install new lighting	Good Building Practice Guidelines	Medium	2010	$5000
Instrumentation Control and Annunciation	Installation of a new fully automated PLC based system that can be monitored via the internet in real time	System reliability	Required	2010	$150,000

Table 3.1 – Summary of Recommended Facility Rehabilitation					
System	**Rehabilitation**	**Rational**	**Priority**	**Year**	**Estimated Cost**
Sewage Treatment Plant					
Ventilation	Install adequate ventilation to remove any noxious gases that could accumulate in the space. Additional heating capacity would also have to be provided to prevent freezing.	Safety	Medium	2010	$15,000
Electrical	Review Code issues for the rating of the area	Safety	Medium	2010	$5,000
Estimated Capital Cost of Facility Rehabilitation					**$2,123,000 to $2,323,000**
				Contingencies (10%)	**$232,000**
				Engineering (15)	**$348,000**
Total Estimated Costs for Facility Rehabilitation					**$2,703,000 to $2,903,000**

4 Capital Upgrades

4.1 General

A program of capital upgrades and facility rehabilitation has been identified. This program targets improvements to the infrastructure which will improve the current level of service. These capital upgrades are on components of the water and sewer systems which are anticipated to have a service life exceeding the 5 year study period of this project.

4.2 Mechanical Systems

4.2.1 CHAR LAKE PUMPING STATION

4.2.1.1 Boilers

Two boilers were installed in 2009 at Char Lake Pumping Station. The boilers were installed without any control to manage their operation. The boilers at the pump house simply operate with different temperature setpoints. In the event of a failure of one of the boilers, there are no automatic controls to start another one and no way of communicating failure alarm to an operator.

It is recommended to provide a controller to manage the operation of the boilers in a sequential manner in order to improve the efficiency and reliability of the installation for the next five years.

Opinion to cost: Refer to controls section of this report (4.2.1.2) for cost.

4.2.1.2 Controls and alarms

To improve the reliability of the installation, the new boiler control system should provide the ability to remotely start and stop the boilers via internet, provide information on the status of the boilers and send alarms for failure

The scope of recommended controls improvements for the Pumping Station is the following:

Heat Injection Controls

- Provide a hot water injection pump and a set of control valves to control the water temperature in the well and in the water line between the pumping station and the treatment plant to control the quantity of hot water required to be mixed to maintain acceptable water temperature between the two buildings.

- Injection of hot water in the water line should be controlled by the water temperature entering the treatment plant. The electric heat trace should remain as a back-up measure only.

Opinion to cost: 17,000

Boiler Controls

- Provide a controller capable of managing pumps and boiler failure alarms. These alarms should be communicated to a remote control station where an operator would be advised.

- To reduce the energy costs by improving the boilers efficiency and increase boiler installation reliability, a controller should be added to sequentially control the operation of the boilers.

- To improve the reliability of the installation, the new boiler control system should provide the ability to remotely start and stop the boilers via internet, provide information on the status of the boilers and send alarms for failure.

Opinion to Cost: $ 13,000

4.2.2 WATER TREATMENT PLANT

4.2.2.1 Boilers

Three cast iron boilers were installed in 2009 at the water treatment plant.

The boilers were installed without any controls to manage their operation. Two boilers operate with different setpoints and the third one is turned off. In the event of a failure of one of the boilers, there are no automatic controls to start another one and no way of communicating failure alarm to an operator.

It is recommended to provide a controller to manage the operation of the boilers in a sequential manner in order to improve the efficiency and reliability of the installation for the next five years.

Opinion to cost: Refer to controls section of this report (3.3.2.5) for cost.

4.2.2.2 Controls and alarms

Boiler Controls

- Provide a controller capable of managing pumps and boiler failure alarms. These alarms should be communicated to a remote control station where an operator would be advised.

- To reduce the energy costs by improving the boilers' efficiency and increase boiler installation reliability, a controller should be added to sequentially control the operation of the boilers.

- To improve the reliability of the installation, the new boiler control system should provide the ability to remotely start and stop the boilers via internet, provide information on the status of the boilers and send alarms for failure.

Opinion to Cost: $ 13,000

4.3 Electrical Systems

4.3.1 Char Lake Pumping Station

4.3.1.1 Main Electrical Service and Distribution System

The service is not equipped with a TVSS Unit and installation will address surges from the Utility supply.

Opinion to cost: $20,000.

4.3.1.2 Secondary Distribution Equipment, Starters and Heat Tracing

Jockey Pumps

The starters for Jockey Pumps P1 and P2 are in an unsatisfactory condition. The starter for P2 is no longer operational. Replacement of combination starters with new equipment and separate supply feeders is recommended.

Opinion to cost: $25,000.

Heat Trace

The feeder for the heat tracing step-up transformer is run through multiple pieces of equipment and violates the Electrical Code. Rerouting of these conductors outside the equipment into a separate conduit is necessary to eliminate this Code Violation.

The control system for the heat tracing does not function and the heat tracing operates year round, 24 hours a day. Upgrades to controls, modifications to the feeder to conform to the code and installation of new heat tracing control contactor and sensor is recommended.

Opinion to cost: $10,000.

4.3.2 Signal Hill Water Treatment Plan

4.3.2.1 Main Electrical Service and Distribution

The service is not equipped with a TVSS Unit and installation will address surges from the Utility supply.

Opinion to cost: $20,000.

4.4 Summary of Recommended Capital Upgrades

Table 4.1 summarizes the recommended capital upgrades. The priority rating for the proposed work is based on the following categories:

Urgent – The work should be completed immediately for safety reasons or to ensure the operational integrity of the water and sewer systems.

Required – The proposed work must be completed in 2010 to ensure the operational integrity of the water and sewer systems.

High Priority – The proposed work should be completed in 2010 to improve the operational efficiency of the water and sewer system.

Medium Priority – The proposed work should be completed as soon as possible to improve the operational efficiency of the water and sewer system.

Low Priority – The work is recommended to improve operational efficiency or operational convenience.

Table 4.1 – Summary of Recommended Capital Improvements

System	Capital Upgrades	Rational	Priority	Estimated Cost
Char Lake Pumping Station				
Boilers	Provide a controller to manage the operation of the boilers	System Efficiency and Reliability	Required	$13,000
Heat Injection Control	Provide a system of injection pumps and automatic control valves to control water temperature.	Improvements to the systems efficiency and reliability	Required	$17,000
Main Electrical Service	Equip with a TVSS Unit	System reliability	Medium	$20,000
Jockey Pumps	Replacement of combination starters with new equipment and separate supply feeders	System reliability	Required	$25,000
Heat Trace	Upgrades to controls, modifications to the feeder to conform to the code and installation of new heat tracing control contactor and sensor is recommended	System efficiency	Required	$10,000

Table 4.1 – Summary of Recommended Capital Improvements

System	Capital Upgrades	Rational	Priority	Estimated Cost
Signal Hill Water Treatment Plant				
Boiler Controls	Provide a controller capable of managing pumps and boiler failure alarms A controller should be added to sequentially control the operation of the boilers	System Efficiency and Reliability	Required	$13,000
Main Electrical Service	Equip with a TVSS Unit	System reliability	High	$20,000
Estimated Capital Cost of Upgrades				**$118,000**
			Contingencies (10%)	**12,000**
			Engineering (15%)	**$18,000**
Total Estimate Cost for Capital Upgrades				**$148,000**

5 Operations and Preventative Maintenance

5.1 General

There are opportunities to improve system reliability, reduce risk and reduce costs through improved operations and more aggressive preventative maintenance. There are also some regulatory requirements that have a bearing upon the operation of the water and sewer systems.

5.2 Regulations

The Water Supply System Regulations under the Public Health Act (SNWT 2007, Ch. 17) contain various stipulations relating to the operation of public water supply systems. The requirements of these regulations include chlorination equipment, maintenance of chlorine residual, reservoir cleaning requirements and disinfection requirements following repairs and certification obligations for system operators. These requirements must be integrated into the ongoing operating practices.

5.3 Operational Improvements

The areas of potential operational improvement include reduction of water consumption, training and lowered water temperature.

5.3.1 Water Consumption

5.3.1.1 General

Current water consumption is approaching the pumping capacity at the Char Lake Pumping Station. This high rate of water consumption gives rise to higher operating costs due to high power and heat consumption. This financial consideration is currently less important than the risk to ongoing service and public health. The system can not support ongoing demands beyond the pumping capacity at Char Lake. An increase in demand to beyond pumping capacity will lead to depressurization of the water system and a loss of circulation. Depressurization places the system at high risk of contamination from the sewer due to conditions within the AV's. Loss of circulation will lead to freeze of piping, places the system out of service for an extended period of time.

5.3.1.2 Consumption Monitoring

In the short term, ongoing monitoring of water consumption should be undertaken. This should include weekly reporting of daily water consumption to CGS. In the longer term improvements to instrumentation can provide remote surveillance of water consumption. The capital improvement required to provide for remote monitoring of consumption are examined in Section 3.4.2.3 of this report. Appropriate organizational responsibility should be established with CGS to assure ongoing monitoring of demand

5.3.1.3 Water Main Leakage

A water main leak detection and repair program have been recommended in Section 3.2.4 of this report. The findings of this program will provide guidance regarding the ongoing need to repeat this leak survey.

5.3.1.4 Water Bleed Controls

Water bleeds are currently in operation for the following purposes:

- Provision of heat input into AV's.
- Freeze protection for dead end water mains.
- Freeze protection for sewer mains.
- Freeze prevention for service connections.

Regarding heat input into AV's, improved insulation and a more sophisticated method of heat input have been recommended as capital improvements in Section 3.2.4 of this report. Ongoing monitoring of internal temperatures within AV's should be instituted.

Freeze protection for dead end water mains will require continued bleeds. Bleed water temperatures should be monitored and flow rates adjusted to assure a water temperature of 5°C during low flow (night) periods.

Freeze prevention for sewer mains will require ongoing bleed flows to offset heat loss into the surrounding soil. Precise estimates of the required bleed flows can not be made for a list of reasons including the deteriorated state of the piping insulation. Bleed rates should be adjusted to achieve a minimum temperature of 5°C at these locations.

The control of bleeds into service connections as a freeze prevention measure represents some substantial challenges and significant opportunities. It is estimated that as much as 1/3 of total water consumption is the result of bleeds within the connected buildings. These bleeds are currently operated by the building owners with the intent of maintenance of service to the building outside of broader concerns for water consumption. Unfortunately, the service connections operate under the most challenging conditions that include lowest system temperatures, sagged profiles, flat gradients and a lack of heat input overnight. Reduction in service connection bleed rates will be a trial and error process that will include the need to thaw some frozen services. The cooperation of the building owners will be required. There may be some merit in reconsidering the reconnection point for the water supply to the bleeds. The supply point could be move to the served side of the water meter and a billing credit provided for a reasonable quantity of bleed flow.

Ongoing monitoring of the performance of the various water bleeds should be instituted. It is recommended that various water and sewer temperatures at the monitoring points be reported

to CGS on a weekly basis. This weekly reporting should also include comments regarding ongoing operational adjustments.

5.3.2 Training

Appropriate operator training is required to assure the ongoing safe operation of the water supply system. This training focuses upon operating issues that have a bearing upon public health. This includes the risk of contamination of water mains during the course of repairs, water treatment practices and ongoing operating measures to assure that appropriate water quality is provided to all users of the system. A program of operator training targeted at securing the required certification should be undertaken.

The day to day to operation of the water and sewer systems entails some workplace risks and hazards that must be addressed. These risks include falls, confined space entry and chemical hazards. Appropriate workplace safety training must be provided to all workers exposed to these risks.

5.3.3 Potable Water Temperature

There is a potential for operating cost reduction through reducing the potable water temperature. Although the opportunity to save operating costs may be attractive, this strategy is not recommended for the following reasons.

- The system is currently operating near the temperature recommended in the original Operations and Maintenance Manual.
- The insulation system on the existing system has experience substantial deterioration. Lower temperatures may increase the risk of freeze.
- Freeze of many sections of the water system will disrupt circulation raising the risk of system wide freeze.
- There are greater opportunities for operating savings through reduction in consumption.

5.4 Electrical Systems

During the review of the three facilities, the following items were noted that require attention to ensure the safety of operating staff and continued reliable operation of the systems.

5.4.1 Char Lake Pumping Station

- Adjustment to primary transformer service tap setting and verify supply voltage from Qulliq Energy Corporation should be considered to correct secondary voltage on the system.

- Confirm availability of replacement transformers for the service should be reviewed with Qulliq Energy Corporation.

- Verification of utility metering and associated connection in the CT cabinet to the utility meter.

- Add sign to main service breaker and 120/208V, 3 phase panel installed for boilers. "VERIFY VOLTAGE LINE TO NEUTRAL BEFORE INSTALLING AND CONNECTION OF SINGLE PHASE 120 VOLT LOADS.

- Complete a thermographic scan of all feeders, terminating points and equipment to correct any issues.

- Clean and label all equipment and update panel schedules. Prepare an as-built single line diagram and post in the building.

5.4.1.1 Secondary Distribution Equipment, Starters, Heat Tracing

- Conduct a detailed inspection and operation of controls on pump starters for Main Water Circulation Pumps P1 and P2 to determine why they do not automatically restart during power fails and the generator is running and is supporting the building. Modify control wiring to ensure systems automatically start during power failure.

5.4.1.2 Emergency Power

- Detailed record keeping procedures for monthly load testing should be put in place.

- Clean fixtures; replace lamps and ballasts as required.

5.4.2 Signal Hill Water Treatment Plan

- Confirm availability of replacement transformers for the service should be reviewed with Qulliq Energy Corporation.

- Adjustment to primary transformer service tap setting and verify supply voltage from Qulliq Energy Corporation should be considered, to correct secondary voltage on system.

- Clean and label all equipment, update panel schedules. Prepare an as-built single line diagram and post in the building.

- Detailed record keeping procedures for monthly load testing should be put in place.

- Clean fixtures; replace lamps and ballasts as required.

5.5 Preventative Maintenance

Preventative maintenance programs are required to maintain system functionality, protect capital assets and minimize overall costs. In the case of the Resolute Bay water and sewer systems, continued reliable functionality with public health risks is the first priority. A preventive maintenance program has been developed around the target of reliable and safe continuing operation for a further 5 years.

The Government of Nunavut has developed a comprehensive and detailed Maintenance Management System (MMS). The MMS provides maintenance activities and frequency for these activities for a broad range of assets including piped water and sewer systems. Piped water and sewer systems, together with supporting assets such as boilers, heat exchange and standby power, are included in the MMS. The maintenance schedules contained in MMS appear to be comprehensive in terms of the scope and frequency of activities directed.

As a general direction, it is recommended that all of the work contained within the MMS, as it applies to the water and sewer system, should be conducted on a continuing basis. There are some activities that are especially important, and these are summarized in the attached Tables 5.1 through 5.4. The MMS sections referenced in the tables are included in Appendix A.

Due to the age and condition of the systems, some of the recommendations put forth in Sections 5.5.1 through 5.5.3 recommended a more frequent performance of the preventative maintenance activity due to the age and condition of the system. These activities, which represent a modification of the recommendations of the MMS, are also summarized in the tables.

5.5.1 General Operations

Due to the age and condition of the Resolute Bay water and sewer system the following additions or modifications to the MMS are recommended.

- It is recommended that the calibration and operation of the various instruments and controls be verified on an annual basis. Earlier in this report, it was recommended that a more sophisticated instrumentation, control and alarm system be provided in response to high water consumption and poor existing alarms. The ongoing ability to monitor water consumption and alarm status requires a control system that is reliable on an ongoing basis.

- Logging of the water temperature leaving the Char Lake Pumping Station has been added as a daily activity. This added requirement is a reflection of some of the unique nature of the systems in Resolute Bay.

- The MMS suggests that bleed rates and sewage temperatures be monitored on an "As required," basis. It is suggested that this be amended to a fixed interval of at least once monthly.

- MMS Activity 100-5 has been amended to remove those activities that are not applicable because certain water treatment equipment and processes are not found in the water treatment plant in Resolute Bay.

- Measurement of the internal temperature of the AV's has been added as a monthly activity. This should improve the likelihood of a timely response to low temperatures within the AV's.

5.5.2 Mechanical Systems

Most of mechanical systems installed require little preventative maintenance, with the exception of regular inspections to ensure proper operation and occasional lubrication of bearings, as described in the MMS.

However, boilers will require regular preventative maintenance to reduce operating costs and increase service life and reliability of installations.

The MMS document provides a detailed list of preventative maintenance activities for each type of equipment. Table 5.3 provides a summary of the MMS document and should not be considered as exhaustive. The following is a summary of the minimal preventative maintenance work that must be made on the mechanical equipment installed at the pumping station and the treatment plant. The operation and maintenance manuals of the equipment and the complete MMS will provide additional details.

5.5.2.1 Pumps

Regularly check operation for abnormal noise and leaks. Replace mechanical seals when leaking.

5.5.2.2 Boilers and Heat Exchange

Based on discussions with technical staff of the Government of Nunavut, it was noted that people in charge of the maintenance of the boilers have not had sufficient training on the operation and maintenance of the Riello burners that equip the newly installed boilers. It is recommended that training be provided to maintenance personnel on the Riello burners. The company has personnel based in Toronto that will provide such training.

As a minimum, the following preventative maintenance work should be performed on the boilers twice a year:

- Perform combustion test analysis and make minor adjustments required to ensure efficient burning rate;

- Check igniters with gauge provided with the burners.
- Open the boilers to remove soot with the brush that was provided with the boilers.
- Check chimney and remove any debris.

Once a year, the UV scanner should be replaced.

Fans:

Three times a year lubricate the bearings. Check belt tension for belt driven fans.

5.5.2.3 Fuel Systems

Once a year, check all piping systems and accessories for leaks and repair as required, replace filters and clean strainers.

5.5.3 Electrical Systems

The electrical systems in the Pumping Station, Water Treatment Plant and Sewage Treatment Plant all require ongoing preventative maintenance.

The detailed preventative maintenance schedules for all electrical equipment are clearly prescribed in the MMS Manual. In addition to the MMS, the Operations and Maintenance Manuals for the starters, generator, transfer switches and heat tracing systems should be consulted to ensure that all necessary manufacturers' recommendations are completed in addition to the MMS.

Presently there is limited or no preventative maintenance conducted on the electrical systems as the contract in place only describes that the generator should be load tested monthly in accordance with MMS 440-51 which does not include reference to load testing of the generator. The MMS standard should be reviewed and considered be given to updating to include the inspection and testing outlined in the CSA C282 Emergency Power Supply for Building (copy of tables included in Appendix B).

5.5.4 Summary of Preventative Maintenance

The following tables summarize the recommended preventative maintenance program. The recommendations are based on the MMS program. It is recommended that the requirements of the MMS be followed and the following tables are intended as a guide to major requirements under the MMS or to recommended additional activity or increased frequency to the MMS.

Table 5.1 - Water System Preventative Maintenance Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
1.0 Char Lake							
1.1 General							
Remove garbage	100-1; 5			✓			
Bacteriological sample	100-1; 7			✓			
Raw water quality sample	100-1; 8				✓		
2.0 Char Lake Pumping Station							
2.1 Intake							
Check flow rates	100-3; 1	✓					
Check freeze prevention and alarm	100-3; 3		✓				
Check intake structure. Clean as required	100-3; 4					✓	
2.2 Pumps							
Check operation	100-10; 1	✓					
Check for leaks and abnormal noise	100-10; 2,3,7	✓					
Log flow rate and daily flow. Report abnormal flow	100-10; 4	✓					
Log suction and discharge pressure	100-10; 5	✓					
Confirm controls	100-10; 6	✓					
Confirm controls, alarms and instrument calibration						✓	
See also Mechanical and Electrical							
2.3 Boilers and heat exchange							
Log wet well temperature	100-5; 3	✓					
Log temperature of water leaving pumping station	100-5;	✓					
See also Mechanical and Electrical							

Table 5.1 - Water System Preventative Maintenance Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
3.0 Transmission Water main							
3.1 General							
Exercise valves	100-8; 3					✓	
Check for ground settlement along line	100-8; 4					✓	
Check for indications of leakage	100-8; 5					✓	
Check and load test electrical heat trace	100-8; 7					✓	
4.0 Signal Hill Water Treatment Plant							
4.1 General							
Walk-through the entire facility	100-5; 1	✓					
Recalibrate instrumentation and confirm controls						✓	
4.2 Water Storage							
Log water level. Log all instrument readings	100-6; 1, 5	✓					
Check for leaks	100-6; 3	✓					
Check and log residual chlorine	100-6; 4	✓					
Confirm al screens and covers in place and locked	100-6; 8		✓				
Confirm operation of freeze prevention	100-6; 9			✓			
Drain, clean and inspection tank interior lining; disinfect	100-6; 17, 18					✓	
Check insulation, exterior cladding	100-6; 14, 19					✓	
Check drains, screens, overflows, vents, ladders	100-6; 12, 16					✓	
4.3 Water Treatment							
Check and clean-up all leaks	100-5; 1	✓					
Log all water temperatures (raw, treated, stored)	100-5; 3	✓					

Table 5.1 - Water System Preventative Maintenance Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
Check and log all pressure gauges	100-5; 7	✓					
Check alarms	100-5; 8	✓					
Test treated water free chlorine	100-5; 9	✓					
Confirm chlorine feed system, replenish feeders	100-5; 10	✓					
Check and secure buildings	100-5; 14	✓					
Confirm chlorine injection rate	100-5; 16		✓				
Check controls, confirm alarm operation	100-5; 18, 19		✓				
Clean chlorine mixing tank and pump head	100-5; 22, 23			✓			
Service controls and valves per manufacturer	100-5; 24, 27			✓			
Confirm operation of all valves	100-5;			✓			
Bacteriological sample of raw and treated water	100-5; 29			✓			
Clean-up; wash floor	100-5; 26			✓			
Sample treated water and submit	100-5; 36					✓	
Re-order chemicals; verify parts stock;	100-5; 39, 41					✓	
4.4 Pumping							
Check operation	100-10; 1	✓					
Check for leaks and abnormal noise	100-10; 2,3,7	✓					
Log flow rate and daily flow. Report abnormal flow	100-10; 4	✓					
Log suction and discharge pressure	100-10; 5	✓					
Confirm controls	100-10; 6	✓					
Confirm instrument calibrations						✓	
See also Mechanical and Electrical							

Table 5.1 - Water System Preventative Maintenance Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
5.0 **Water Distribution**							
5.1 General							
Sample for total and free chlorine	100-8; 1	✓					
Exercise all valves	100-8; 3					✓	
5.2 Watermains							
Check for ground settlement over mains	100-8; 4					✓	
Check for indications of leakage	100-8; 5					✓	
5.3 Access Vaults							
Check for water in bottom; remove water and repair leaks	100-12; 1		✓				
Confirm that fittings are tight and secure	100-12; 3			✓			
Confirm that clean-out covers are secure (with gaskets)	100-12; 4			✓			
Confirm that valves are not submerged	100-9; 1			✓			
Service and exercise valves	100-9; 3				✓		
Confirm valve position	100-9; 2				✓		
Confirm bleed flow temperature and flow; adjust as required	100-8; 11			✓			
Check condition and operation of backflow preventers	100-8;					✓	
Check interior and exterior for structural deterioration	100-12; 5					✓	
Measure and log internal AV temperature				✓			

Table 5.2 - Sewer System Preventative Maintenance Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
1.0 Sewage Collection System							
1.1 Sewer Mains							
Clean and flush mains	110-1; 2					✓	
Service and exercise valves	110-1; 3					✓	
Monitor sewage temperatures; adjust bleeds	110-1; 6, 7			✓			
CCTV inspection (As required)	110-1 5						
2.0 Access Vaults							
2.1 General							
Confirm operation of internal equipment	110-2; 2				✓		
Confirm heating systems	110-2; 3				✓		
Check for obstruction in vicinity of clean-out	110-2; 5				✓		
Confirm that clean-out is closed and sealed	110-2; 6				✓		
Confirm frost cover is in place	110-2; 8				✓		
Check for groundwater infiltration; respond as required	110-2; 10				✓		
Remove accumulated water and debris, clean interior	110-2; 10, 14				✓		
Check and report shifting or structural damage	110-2; 11				✓		
Confirm condition of insulation	110-2; 12				✓		
Check ladder security	110-2; 13				✓		

Table 5.2 - Sewer System Preventative Maintenance Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
3.0 Macerator							
3.1 General							
Check for excessive noise, heat or vibration	110-8; 1	✓					
Flush basin	110-8; 3					✓	
Clean combs	110-8; 4					✓	
Inspect cutting edges; replace if required	110-8; 5					✓	
Inspect and overhaul cutters	110-8; 6					✓	
Lubricate per manufacturer's directions	110-8; 7					✓	
Service motor per manufacturer's direction	110-8; 8					✓	

Table 5.3 - Building System Preventative Maintenance – Mechanical Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
1.0 Char Lake							
1.1 General							
See civil							
2.0 Char Lake Pumping Station							
2.1 Heating Pumps							
Check operation, gauges, leaks and abnormal noise	440-16; 1,2	✓					
Check lubrication and replenish as required	440-16; 7			✓			
Install new seals and gaskets as required	440-17; 6					✓	
Confirm controls	100-10; 6	✓					
2.2 Boilers							
Log wet well temperature	100-5; 3	✓					
Log temperature of water leaving pumping station	100-5;	✓					
Check boiler and pumps for leaks and noise	440-3D; 1,3,4	✓					
Check controls, gauges and alarms	440-3D; 2,5-8	✓					
Combustion tests and re-adjustments	440-3M			✓			
Verify operation and low-water cut-off	440-3M			✓			
Check and calibrate gauges and limit switches	440-3A					✓	
Clean interior and exterior of stack	440-3A					✓	
Add chemical treatment	440-3A					✓	
Clean and service all oil valves, nozzle, oil filter. Replace as required.	440-3A					✓	

Table 5.3 - Building System Preventative Maintenance – Mechanical Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
2.3 Heat exchangers							
Check temperatures and pressure readings and record	440-8; 1	✓					
Check for leaks	440-8; 2	✓					
2.4 Fuel Supply							
Change filters and clean strainers	440-10; 2					✓	
Check all lines and repair any leaks	440-10; 3					✓	
Check and calibrate gauges	440-10; 4					✓	

Table 5.4 - Building System Preventative Maintenance – Electrical Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
1.0 Char Lake							
1.1 General							
See civil							
2.0 Char Lake Pumping Station							
2.1 Lighting	440-42; 1,2,3						✓
2.2 Motor Controllers	440-46; 1 - 20					✓	
2.3 Secondary Transformers	440-48; 1, 16					✓	
2.4 Battery Chargers	440-49; 1 - 13					✓	
2.5 Batteries	440-50; 1 - 7			✓			
2.6 Generators - Standby Usage	440-51; 1 - 18		✓				
Generators - Standby Usage	440-51; 3 - 33					✓	
Generators - Standby Usage	440-51; 1						✓
Stand By Generator	110-14; 1 - 3		✓				
Stand By Generator	110-14; 4,5			✓			
Stand By Generator	110-14; 6,7					✓	
Stand By Generator	110-14; 8,9						✓
2.7 Automatic Transfer Switch	440-54; 1,2			✓			
Automatic Transfer Switch	440-54; 1 - 6					✓	
Automatic Transfer Switch	440-54; 1 - 6						3 years
2.7 Heat Trace and Cable	440-74; 1					✓	
3.0 Springhill Water Treatment Plant							
3.1 Lighting	440-42; 1,2,3						✓
3.2 Motor Controllers	440-46; 1 - 20					✓	
3.3 Secondary Transformers	440-48; 1, 16					✓	

Table 5.4 - Building System Preventative Maintenance – Electrical Summary

Activity	MMS Ref.	Daily	Weekly	Monthly	Semi-Annual	Annual	As required
3.4 Battery Chargers	440-49; 1 - 13					✓	
3.5 Batteries	440-50; 1 - 7			✓			
3.6 Generators - Standby Usage	440-51; 1 - 18		✓				
Generators - Standby Usage	440-51; 3 - 33					✓	
Generators - Standby Usage	440-51; 1						✓
Stand By Generator	110-14; 1 - 3		✓				
Stand By Generator	110-14; 4,5			✓			
Stand By Generator	110-14; 6,7					✓	
Stand By Generator	110-14; 8,9						✓
3.7 Automatic Transfer Switch	440-54; 1,2			✓			
Automatic Transfer Switch	440-54; 1 - 6					✓	
Automatic Transfer Switch	440-54; 1 - 6						3 years
3.7 Heat Trace and Cable	440-74; 1					✓	

6 Contingency Plan

6.1 General

All piped water and sewer systems experience conditions that require an immediate response to these unusual conditions. In Resolute Bay, the need for these sorts of responses will continue following rehabilitation of the existing systems and the implementation of improved operations. Successful resolution of abnormal conditions requires access to materials, resources that include equipment and labour, and a plan of action. The following sections provide some direction regarding these requirements.

The most common events that must be responded to in Resolute Bay include:

- Watermain leaks,
- Frozen watermains,
- Frozen sewer mains,
- Crushed or collapsed sewers, and
- Frozen service connections.

6.2 Materials

The availability of a suitable stock of materials and spare parts will facilitate and expedite the responses to unusual conditions. A stock of the following materials should be continuously on-hand. Replacement materials should be acquired as the stock is consumed during the course of routine operations and in response to emergency repairs.

- Water treatment
    - Service parts for chlorinator
    - Spare chlorine metering pump
    - Spare chemical feed tubing and fittings
- Underground piping repairs
    - 150 mm and 200 mm preinsulated polyethylene piping to match existing diameters and pressure classes.
    - Repair clamps (Robar style)
    - Electro-fusion couplings (150mm and 200mm)

  - Flange stub ends suitable for electro-fusion, back-up rings, bolts and gaskets
  - Insulation half shells
  - Polyurethane spray foam
  - Heat shrink wraps

- AV repairs
  - Valves – 200 mm butterfly to match existing
  - Fittings including tees, elbows, 45° bends, bolts, gaskets, Vic-flanges, etc
  - Fire hydrant
  - Electric heater

- Service connections
  - Water and sewer service saddles, including corporation stops
  - 100 mm polyethylene piping (water duct and sewer service piping)
  - 25 mm water service tubing
  - Water service shut off valves (building end)

- Excavation and backfill materials
  - Well graded 20 mm minus granular material
  - Well graded sand

6.3 Resources

Appropriate resources must be available to assure that unusual conditions are expeditiously dealt with. The following should be among the equipment that is continuously available:

- Sewer cleaner (blaster)
- Hot water thawing machine (steamer) with hose, dedicated to water thawing
- Hot water thawing machine (steamer) with hose, dedicated to sewer thawing
- Excavator

- Electro-fusion equipment
- Butt fusion equipment
- Small backhoe
- General earth moving equipment including loaders, dump truck and compactor
- Small trench compactor
- Safety equipment including fall arrest, gas detection and ventilation equipment
- Portable generators, heaters, temporary enclosures and ventilation.

The personnel responsible for emergency responses and repairs to the water and sewer system must be appropriately trained. In addition to the training typical of trades persons there are specific training needs associated with the operation of a water and sewer system. These include:

- Worker safety training related to fall arrest and confined space entry. There are several areas within the water and sewer system that are considered to be confined spaces. These include the AV's and any tanks that have been emptied for inspection or cleaning. Access to many locations within the water and sewer system, including AV's and tanks requires the use of ladders. Appropriate awareness of the hazards associating with climbing should form part of worker training.

- The personnel undertaking water and sewer system operations must be trained in the safe operation of these systems.. This focus of this training should be upon the assurance of the ongoing supply of uncontaminated water. This is an especially sensitive issue in view of the significant risks of cross contamination between the sewer and water system associated with work within the AV's.

- There is an ongoing requirement for chemical handing during the course of both routine operations and during the response to unusual conditions. The principle chemical of concern is chlorine, which is a corrosive oxidizer. Additionally there are various toxic and flammable materials in use at the pumping station and water treatment plant. Operating personnel should be trained in the proper handling of these materials, the response to chemical spills and the appropriate first aid responses for accidents with these chemicals.

6.4 Responses to Unusual Conditions

Section 6.1 of this report lists events for which recommended courses of action have been prepared. Detailed response plans for these issues are provided in Appendix C.

7 Summary and Conclusions

7.1 Summary

The findings of the preceding report may be summarized as follows:

7.1.1 Technical Status

The current technical status of the water and sewer systems in Resolute Bay is presented in the Phase 1 report prepared during the course of the project. The principal findings of the Phase 1 report are summarized with this report. These include:

1. Very high water consumption, which is approaching the capacity of the supply pumps, is currently being experienced in Resolute Bay. In addition to raising concerns regarding system efficiency, high water consumption is causing concerns with increased risk of cross contamination and system wide freeze.

2. A substantial quantity of water is consumed in an effort to avoid freeze. This takes the form of bleeds into the access vaults (AV's), the sewer system, the sewer service connections and from water main dead ends.

3. The fuel systems at the Char Lake Pumping Station and Signal Hill Water Treatment Plant have substantial deficiencies and do not comply with codes. The system at Char Lake represents a risk of fuel contamination for the water source.

4. There is a significant risk of cross contamination between the water and sewer system due to conditions within the existing (AV's).

5. The water and sewer system piping was installed with shallow bury. As a result the piping has been exposed to annual freeze effects that include heave, thaw settlement, pipe squeeze, insulation crushing and insulation deterioration. These effects give rise to sags in the sewer profiles, increased rates of heat loss, increased risk of freeze and collapsed piping.

6. The current methods of heat injection and freeze prevention at Char Lake are functional but poorly controlled and inefficient.

7. The control systems at Char Lake and Signal Hill are largely ineffective. These systems currently provide few alarm indications. In general there is poor reporting of the ongoing operation of the systems at these sites.

8. The current ventilation arrangements at both Char Lake and Signal Hill do not support unattended operation of the standby generators.

9. The water supply pumps at Char Lake are near the end of their service lives.

10. Maintenance of the water and sewer system is currently provided by a service contractor. This contractor has access to suitable equipment. There is a concern that the personnel be trained in the operation of water and sewer systems.

11. Items requiring urgent action were identified. These included improved fuel storage, reduction in risk of cross contamination and monitoring of water consumption.

7.1.2 Facility Rehabilitation

Based upon the current technical status of the water and sewer systems, a program of rehabilitations has been identified. This program includes the following:

1. Replacement of the fuel storage and handling systems at Char Lake and Signal Hill facilities has been identified as an urgent requirement.

2. The program of recommended rehabilitations at the Char Lake Pumping Station includes replacement of the supply pumps and improvements to the heat injection arrangement. In addition it is recommended that the control systems, including the boiler controls, heat injection control, system monitoring and alarms be improved and means for off site monitoring be provided.

3. The recommended rehabilitations at the Signal Hill Water Treatment Plant include provision of a duplicate chlorinator with automatic transfer of service upon failure. In addition, it is recommended that the control systems, including the boiler controls, system monitoring and alarms be improved and means for off site monitoring be provided.

4. Some of the recommended improvements to the water distribution system target increasing public safety. With regards to public safety the focus is upon conditions within the AV's. The proposed works include a general clean up and disinfection of AV's, capping of unused fittings, replacement of clean-out covers and provision of backflow prevention.

5. A group of the recommended improvements to the water distribution system relate to reduction in the risk of loss of service through the reduction of the risk of freeze. The current high rate of water consumption increases the risk of system wide freeze. A system wide leak detection program, followed by repairs of identified leaks is proposed.

6. Water is currently bled into most of the AV's as a means of introducing heat. It is recommended that this practice be discontinued and that additional insulation and electric heaters be provided.

7. The full extent of required sewer system rehabilitations cannot be defined at this time. It is recommended that a system wide cleaning, followed by internal CCTV inspection be conducted. An allowance has been presented for repairs identified

during the CCTV inspection. The system wide cleaning program should also reduce the risk of sewer back-up and freeze.

8. No rehabilitation works have been defined for the sewage disposal works at this time. There are broader questions relating to the long term management of sewage that falls outside the scope of this study.

9. Ventilation improvements are required both at Char Lake and Signal Hill. These improvements are required to permit unattended operation of the standby generators. Improvements are also required to the combustion air supply arrangements.

10. Table 3.1 presents a tabulation of the proposed improvements, including suggested priorities, the date for implementation of these works and an estimate of the costs. The value of the rehabilitations, including an allowance for contingencies and engineering totals between $2.7 and $2.9 million.

7.1.3 Capital Upgrades

In addition to facility rehabilitations a program of recommended capital upgrades has been developed. This program may be summarized as follows:

1. The control systems at Char Lake and Signal Hill are largely ineffective. It is proposed that these systems be replaced by systems that better control the various systems, while providing better surveillance and reporting of system operations. This includes better reporting of alarm conditions and off-site monitoring of system status.

2. Improvements to the freeze prevention system provided at Char Lake for the transmission water main are proposed. These improvements should reduce the reliance upon the electrical heat tracing within the transmission main.

3. TVSS protection is recommended for the electrical services at both Char Lake and Signal Hill to reduce the risk of damage to equipment due to electrical surges.

4. Table 4.1 summarizes the scope of the proposed improvements. The value of the rehabilitations, including an allowance for contingencies and engineering totals $148,000.

7.1.4 Operations and Preventative Maintenance

A program of improved operations and preventative maintenance has been proposed. This program includes the following:

1. With regards to operations it is recommended that:

    a. Water consumption must be more closely monitored.

b. Greater control should be exercised over water bleeds. This includes monitoring of water and sewage temperatures, together with adjustment of bleed rates in response to the measured temperatures.

c. Bleed rates into sewer service connections require greater surveillance. This will entail a trial and error process to determine the required bleed rates. The cooperation of the building owners will be required to achieve a reduction in water use due to bleeds to the sewer system.

d. Improved operator training must be provided. One focus of this training must be upon the public safety related issues associated with operation and repairs to a water supply.

e. A reduction in water system operating temperatures is not recommended at this time.

f. Improvements to the management of standby power including more detailed record keeping and monthly load tests are recommended for both Char Lake and Signal Hill.

2. A more exhaustive program of preventative maintenance is recommended.

    a. The current MMS system that is managed by the Government of Nunavut provides a sound basis to develop a preventative maintenance program for the Resolute Bay water and sewer system. In some instances the program recommended in the MMS has been adjusted and some tasks have been added. In general, the full scope of work within MMS should be conducted.

    b. Table 5.1 summarizes the more important preventative maintenance activities recommended for the Resolute Bay systems.

7.1.5 Contingency Plan

The need for response to unusual and abnormal conditions will continue into the future. A contingency plan has been prepared to assist with this response. This plan incorporates the following:

1. The most likely abnormal events include water main leaks, frozen water and sewer mains, crushed or collapsed sewers and frozen service connections. A response plan for these events has been developed and this plan is presented in Appendix C. This response plan presents both the indications of problems and suggested actions.

2. General recommendations are provided regarding the materials that should be held in stock in Resolute Bay. A suitable stock of repair materials will expedite the response to unusual situations.

3. Suitable resources must be available to execute emergency repairs when such a need arises.

    a. A list of equipment is presented in section 6.3 of this report.

    b. Appropriate personnel must be available to affect required repairs. This staff should be appropriately trained. This training should recognize the public risks associated with water system operation

7.2 Conclusions

It is intended that the current water and sewer system remain in operation for a further five years, while an updated water supply and sewage disposal solution is developed for Resolute Bay. The preceding report provides the following to facilitate the continued operation of the existing systems.

- A program of recommended facility rehabilitations.
- A program of recommended capital upgrades.
- Recommend improvements to operating methods.
- Recommendations regarding enhanced preventative maintenance.
- A contingency plan that provides responses for unusual events.

Appendix A: Maintenance Management System (MMS)

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - OPEN RESERVOIRS	**Activity # :** 100-1
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
D	1	Check water level as indicated by monitoring equipment. Record reading.
D	2	Check water quality as directed by the O&M Manual or in accordance with activity #100-5. Record hours under activity #100-5.
W	3	Check that fence is secure and locked.
M	4	Measure water level and compare results to level monitoring equipment. Record levels and any incidents.
M	5	Check for and remove garbage in and around reservoir. Check that warning/information signs are in place.
M	6	Check for animal burrows, control as necessary. Check vegetation growth in and around reservoir. Control as necessary. Visually check for algae, disturbed sediment and any other condition that could be increasing turbidity and creating an excessive chlorine demand. If the problem persists contact Environmental Health Officer.
M A/R	7	Sample raw water and submit for bacteriological analysis. Frequency of sampling shall be in accordance with the *Public Water Supply Regulations p-23* unless otherwise directed by Environmental Health Officer or the O&M manual. The procedures for bacteriological testing vary by location. If no process is established contact the Medical Health Officer to determine who should receive the samples for testing. A sample should always be taken in the spring when ice is at its thickest and water quality is at its worst.
Sa	8	Check raw water quality - spring and fall. Test for the following: ph, colour, turbidity, iron, manganese, alkyl benzene sulfonate (abs), arsenic, chloride, copper, carbon chloroform extract (cce), cyanide, fluoride, nitrate, phenols, sulfate, total dissolved solids (tds), zinc, barium, cadmium, chromium, lead, selenium, silver and any other parameters identified by the *Public Water Supply Regulations p-23.*
A	9	Check subdrain system for blockages and accumulation of water.
A	10	Check freeze protection system for proper operation. Check system failure alarms - fall.
A	11	Check exposed liners for leaks or damage.
A	12	Check drain valves, drains, pump inlet screens, reservoir over flows and piping for damage and proper operation. Clean as required.
A	13	For liners covered with gravel or earth, check for areas of uncovered liner.
A	14	Check aerator equipment, airlines and diffusers for damage.
A	15	Check berms for signs of erosion or failure. Repair immediately.
A/R	16	Clean reservoir by flushing and cleaning exposed areas of reservoir walls. On open reservoirs this is not usually practical but may be required in special circumstances.
A/R	17	Note or photograph any problems and initiate corrective action as required.
A/R	18	De-silt reservoir
A/R	19	Fluoridate water supply during refill of reservoir if required. Follow O&M manual procedures and check/monitor/record fluoride levels.

continued

Note: Charge repair as activity #101

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - OPEN RESERVOIRS	**Activity # :** 100-1
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Note: Items 9 through 19 (not 16) are best done just prior to filling the reservoir if it is an annual event.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SM	0.5	0.5	Reservoir
1	W	SM	0.5	0.5	Reservoir
1	M	SM	5.5	5.5	Reservoir*
1	Sa	SM	4.0	4.0	Reservoir
2	A	SM/HL	4.0	8.0	Reservoir*
1	A	SM	2.0	2.0	Reservoir
1	M	SM	1.0	1.0	Reservoir - item 7 only

Special tools/materials: safety equipment, tape measure or stick, water truck and hose, camera, compressed air, record forms. **Depends on reservoir size, construction and climate and water source.*

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - INTAKE STRUCTURES	**Activity # :** 100-3
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
D	1	Check flow rates.
M	2	Backwash intake . Where feasible.
M	3	Check freeze protection systems for proper operation and check system failure alarms.
A	4	Check intake structure, protective equipment, wet well, screen and intake valves. Clean as required.
A	5	Check condition of intake. (May require divers).
A	6	Check intake pump and piping removal mechanism.
A	7	Check operation of level sensors, alarms and low level shut offs.
A/R	8	Note any problems and initiate corrective action as required.

Note: Charge repair as activity #101.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SM	0.25	0.25	Intake
1	M	SM	8.0	8.0	Intake
2	A	SM/HL	8.0	16.0	Building
	A	Contr.			Contract for divers
Special tools/materials: Safety equipment and practices, record forms, winch.					

Activity Name: PREVENTIVE MAINTENANCE - WATER TREATMENT	Activity # : 100-5
Date Issued: 2008-08-01	System: COMMUNITY WATER SUPPLY

Prior to performing any maintenance ensure equipment is in a safe condition for this work. This may include:
- Disconnecting power source and ensure it cannot be reconnected accidentally.
- Equipment is isolated from pressure sources then depressurized.
- Harmful chemicals are removed and flushed from equipment.
- Protective shields are in place.
- Fire extinguishers are available.
- Sources of ignition are removed from the area or turned off.
- Personnel safety equipment and clothing is at the site and used appropriately in accordance with WHIMS and the GNWT Safety Act and General Safety Regulations.
- All safety procedures in the GNWT Safety Act and General Safety Regulations and O&M manual or manufacturer's instructions are followed.
  Follow O&M manual and equipment manufacturer's recommended procedures where manuals exist.

Frequency		Task
		General
D	1	Perform walk through of entire facility, check operation of **all** equipment, note any problems, initiate corrective action as required.
D	2	Check all equipment for leaks and clean up any spilled fluid.
D	3	Check temperature of raw water into the building (when raw water pump is running). Record results.
D	4	Check reading of meter for raw water entering the facility. Record results.
D	5	Check reading of meter for treated water leaving facility. Record results.
D	6	Check wet well level.
D	7	Check all pressure gauges and site gauges, and record all readings.
D	8	Check control panels for alarms and perform lamp test for all lamps.
D	9	Test treated water for total and free chlorine residual and record readings.
D	10	Check all water treatment chemical feed systems, including flexible chemical injection tubing, connections and injectors, for leaks, blockages and proper operation. Clean or repair as required.
D	11	Maintain water test equipment in clean operable condition in accordance with manufacturer's instructions.
D	12	Check and record levels in chemical solution tanks and prepare more solution as required.
D	13	Check chlorine gas cylinders are properly secured with safety chains.
D	14	Check that building is secure and locked.
D	15	Check all floor and equipment drains.
W	16	Check chlorine system injection rate (pulse and stroke for liquid solution type; gas is by unit volume); record readings and chemical solution strengths.
W	17	Check all chemical feed pumps for proper operation. Service when required. Record pump settings and reasons for changing settings.
W	18	Check automatic control systems, ensure proper operation of all equipment.
W	19	Check all alarms for proper operation.
W	20	Check all safety guards are securely in place.

CONTINUED…

Frequency	Task

Activity Name: PREVENTIVE MAINTENANCE - WATER TREATMENT	**Activity # :** 100-5
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

W	21	Check operation of pump control valves, air relief valves, pressure gauges, etc.
M	22	Clean chlorine chemical mixing tank.
M	23	Clean chemical pump heads by flushing with clean, warm water.
M	24	Check all gauges, sensors, control switches and recording devices for proper operation.
M	25	Check all flow control systems (electronic, mechanical, hydraulic, pneumatic) for proper operation.
M	26	Wash floor and clean equipment, piping and tanks, etc.
M	27	Service all control valves in accordance with manufacturer's maintenance procedures.
M	28	Check and replace all burned out lights.
M	29	Sample raw water and submit for bacteriological analysis. Frequency of sampling shall be in accordance with the *Public Water Supply Regulations p-23* unless otherwise directed by Environmental Health Officer. The procedures for bacteriological testing vary by location. If no process is established contact the Medical Health Officer to determine who should receive the samples for testing..
M	30	Check valves to ensure they are in the proper position - normally open, normally closed, or modulating properly (use a check list and record positions).
M	31	Check, service and operate all valves (isolation, modulation, flow control) for proper operation.
M	32	Check for proper storage of treatment chemicals.
M	33	Check that WHMIS sheets are available for all chemicals, are complete and are in a visible location.
SA	34	Clean deposits from orifices, valves and strainers. Inspect and repair injectors.
SA	35	Check safety equipment, note expiry date, replace as necessary.
A	36	Sample treated water and submit to approved laboratory for testing of the substances listed in the water licence and the *Public Water Supply Regulations p-23.* These substances include: alkyl benzene sulfonate (abs), arsenic, chloride, copper, carbon chloriform extract (cce), cyanide, fluoride, iron, manganese, nitrate, phenols, sulphate, total dissolved solids (tds), zinc, barium, cadmium, chromium, lead, selenium, silver, ph, hydrogen sulphide, turbidity, colour, total hardness and any other parameters identified by the *Public Water Supply Regulations p-23.* The water should contain no impurity which exceeds GCDWQ levels or limitations of the water license or the *Public Water Supply Regulations p*-23. Record results.
A	37	Contact the Office of the Fire Marshal to review fire prevention practices for the facility.
A	38	Inspect and replace gaskets/seals as necessary.
A	39	Verify stock of essential replacement parts.
A	40	Pump out clear well and clean out.
A/R	41	Re-order chemicals. Record on log sheet.
A/R	42	Check and restock first aid kit and keep in visible location.
A/r	43	Notify the Water Board, in writing, of any changes to the water treatment system which would affect the community's water licence.
A/r	44	Clean plant and equipment.
A/R	45	Perform general outside clean-up and maintenance. Cut grass or remove snow.

CONTINUED…

Note: Charge all chemical usage to this activity.

Frequency — Task

Filtration System

D	1	Collect and test sample of raw and treated water for iron, manganese, ph, hydrogen sulphide. The treated water should contain no impurity which exceed GCDWQ levels or limitations of the water licence. Record results.
D	2	Maintain water test equipment in clean operable condition in accordance with manufacturer's instructions.
D	3	Check backwash waste sump level.
D	4	If potassium permanganate ($kmno_4$) is used, check treated water for pink tinge. Reduce pump injection rate if pink tinge is observed.
D/W/AR	5	Backwash filters in accordance with the O&M manual if not done automatically. Record day, time, flow rate, inlet and outlet pressures, and duration of backwash.
W	6	Drain moisture from air receiver of air compressor system.
M	7	Initiate a filter backwash by manually selecting valves . Follow the directions in the O&M Manual for the system installed.
M	8	Service air compressor as outlined by activity #440-61.
A	9	Inspect water treatment filter media and check for cracking, unevenness, sludge buildup or mud-ball formation.
A	10	Check interior surfaces of all water treatment filters. Repair or replace as necessary.
A	11	Check filter media depth - top-up as necessary.
A	12	Clean out wastewater sump.
A/R	13	Service pumps according to manufacturer's recommended procedure and record on log sheet.
A/R	14	Replace filter media when required or as recommended. Backwash twice before putting into operation.

Coagulation, flocculation, sedimentation and filtration system

D	1	Collect and test sample of raw and treated water for iron, aluminum, manganese, ph, turbidity and colour. The treated water should contain no impurity which exceed GCDWQ levels or limitations of the Water Licence. Record results.
D	2	Maintain water test equipment in clean operable condition in accordance with manufacturer's instructions.
D	3	Check daily plant run time. Record results.
D	4	Check backwash waste sump level.
D	5	If potassium permanganate ($kmno_4$) is used, check treated water for pink tinge. Reduce pump injection rate if pink tinge is observed.
D/W/AR	6	Backwash in accordance with the O&M manual if not done automatically. Record day, time, flow rate, inlet and outlet pressures, and duration of backwash.
W	7	Drain moisture from air receiver of air compressor system.
W	8	Check operation of static mixer and flocculator motors.
W	9	Check operation of air scour and surface wash components.
W	10	Check turbidity level for each treatment unit. Record results.

Frequency		**Task**
M	11	Perform jar test, confirm chemical feed rate and record results. Additional jar tests shall be performed when significant changes in raw or treated water occur.
M	12	Service air compressor as outlined by activity #440-61.
M	13	Initiate a filter backwash by manually selecting valves. Follow the directions in the O&M Manual for the system installed.

Activity Name: PREVENTIVE MAINTENANCE - WATER TREATMENT	**Activity # :** 100-5
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

A	14	Inspect water treatment filter media and check for cracking, unevenness, sludge buildup, mud-ball formation or carryover of floc.
A	15	Check interior surfaces of all water treatment filters, flocculators, settling tubes etc. Repair or replace as necessary.
A	16	Check filter media depth - top-up as necessary.
A	17	Clean out wastewater sump.
A/R	18	Service pumps according to manufacturer's recommended procedure and record on log sheet.
A/R	19	Clean flocculators, settling tubes, etc.
A/R	20	Replace filter media when required or as recommended. Backwash twice before putting into operation.

General

Crew	Freq	Trades	Hours	Total	Work unit
1	D	SM	5.0	5.0	Full treatment system
1	W	SM	5.0	5.0	Full treatment system
1	M	SM	20.0	20.0	Full treatment system
1	Q	SM	2.0	2.0	Full treatment system
1	SA	SM	6.0	6.0	Full treatment system
2	A	SM/HL	8.0	16.0	Full treatment system
1	A	SM	20.0	20.0	Full treatment system
1	A/R	SM	14.0	14.0	Per sampling

Special tools/materials: WHMIS training & compliance all chemical use, safety equipment and practices, gaskets, feeder parts, injector parts, water test equipment, water sample equipment, hand tools, snow shovel, grass cutter, record forms, measuring stick.

Filtration System

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - WATER TREATMENT	**Activity # :** 100-5
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Crew	Freq	Trades	Hours	Total	Work unit
1	D	SM	1.5	1.5	Full treatment system
1	W	SM	0.25	0.25	Full treatment system
1	M	SM	2.0	2.0	Full treatment system
1	A	SM	2.0	2.0	Full treatment system
2	A	SM/HL	10.0	20.0	Full treatment system
2	A/r	SM/HL	44.0	88.0	Full treatment system
Special tools/materials: WHMIS training & compliance all chemical use, safety equipment and practices, gaskets, feeder parts, injector parts, water test equipment, water sample equipment, hand tools, record forms.					

Coagulation, Flocculation, Sedimentation and Filtration System

Crew	Freq	Trades	Hours	Total	Work unit
1	D	SM	2.5	2.5	Full treatment system
1	W	SM	6.0	6.0	Full treatment system
1	M	SM	16.0	16.0	Full treatment system
1	A	SM	6.0	6.0	Full treatment system
2	A	SM/HL	8.0	16.0	Full treatment system
2	A/R	SM/HL	52.0	104.0	Full treatment system
Special tools/materials: WHMIS training & compliance all chemical use, safety equipment and practices, gaskets, feeder parts, injector parts, water test equipment, water sample equipment, hand tools, record forms.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - TREATED WATER STORAGE	**Activity # :** 100-6
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
		NOTE: *The water storage tank may be considered a "confined space" by the GNWT Safety Act and General Safety Regulations. Precautions in accordance with this document shall be taken prior to entering a storage tank*.
D	1	Read and record level monitoring device reading.
D	2	Read and record flow-meter. Note abnormal flows.
D	3	Check for leaks.
D	4	Check residual chlorine levels in storage tank, record results. Minimum residual free chlorine shall be 0.2 mg/liter.
D	5	Check water quality as directed by O&M manual and record results.
D	6	Check fittings and gauges, record gauge readings.
W	7	Check for ice inside the reservoir tank. (Winter)
W	8	Check that covers, caps and screens over openings are securely in place and locked.
M	9	Check freeze protection systems for proper operation and check system failure alarms.
A	10	Check water level by measuring and read level monitoring device. Note any significant variation and determine cause.
A	11	Check, exercise and service valves for ease of operation.
A	12	Check supports and ladders for condition and safety problems.
A	13	Ensure positive drainage away from site.
A	14	Check tanks for deformation or damage and condition of exterior coating or cover.
A	15	Check condition of concrete in concrete reservoirs.
A	16	Check drain valves, drains, pump inlet screens, tank overflows, piping, breather caps and vents for damage and proper operation. Clean as required.
A	17	Drain, clean and inspect tank liner or interior coating and surfaces. Remove rust and other foreign matter.
A	18	Disinfect tanks by cleaning, chlorinating and flushing, then sample water for bacteriological analysis after cleaning and filling. The procedures for bacteriological testing vary by location. If no process is established contact the Medical Health Officer to determine who should receive the samples for testing.
A	19	Check insulation. Initiate repair.
A/R	20	Re-apply/repair coating if necessary.
A/R	21	Note any problems and initiate corrective action as required.

Note: charge repair as activity #101.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SM	2.0	2.0	Each tank
1	W	SM	1.0	1.0	Each tank
1	M	SM	2.0	2.0	Each tank
1	A	SM	14.0	14.0	Each tank*
2	A	SM /HL	16.0	32.0	Each tank*
1	A/R	Contr.	40.0	40.0	Each tank*
Special tools/materials: Disinfectant, safety equipment and training; coating application training, record forms, camera, water truck and hose, tape measure or stick.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - HEATING SYSTEMS	**Activity # :** 100-7
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task

Note: Building heating is not required during summer.
Water tempering of domestic water may not be required part of the year depending on treatment requirements, location; ground temperature for piped systems, etc. This is site specific.

D	1	Check boiler for proper operation as outlined by activity #440-3d.
D	2	Check operation of circulating pumps as outlined by activities #440-16 or #440-17.
W	3	Check fuel storage tank level (seasonal), check tank and piping for leaks.
M	4	Service boilers as outlined by activity # 440-3m.
M	5	Check alarm system for proper operation.
M	6	Check and clean or replace furnace air filters.
A	7	Service boiler as outlined by activity # 440-3a.
A	8	Service boiler pumps as outlined by activities # 440-16 and # 440-17.
A	9	Check heat exchanger as outlined by activity #440-08.
A	10	Check, service and exercise valves for proper operation.
SA	11	Check operation and set points of backup building heating system.
A/R	12	Check ventilation and combustion air supply as outlined by activity #440-3d.
A/R	13	Service building heating furnace as outlined by activity #440-01.
A/R	14	Check fuel supply systems as outlined by activities #440-10 and #440-67.
A/R	15	Note any problems and initiate corrective action as required.

Note: Charge repair as activity # 101.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SM	Nil	Nil	Time included activities #440-3d, #440-16 or #440-17
1	BW	SM	0.25	0.25	Tank
2	M	SM/OB	Nil	Nil	Time included activity #440-3m
1	M	SM	1.5	1.5	Boiler
2	A	SM/OB	Nil	Nil	Time included activities #440-3a, #440-16, #440-17 and #440-08
1	SA	SM	0.5	0.5	Facility
2	A/R	OB/PL	Nil	Nil	Time included activities #440-3d, #440-01, #440-10 and #440-67.
Special tools/materials: Safety equipment and practices, lubricants, packing, seals.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - WATER MAINS	**Activity # :** 100-8
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
W	1	Sample treated water from the most remote point on small distribution systems and from various locations in a set pattern for larger distribution systems and test for total and free residual chlorine. A minimum free chlorine residual of 0.2mg/l must be maintained in all parts of the system.
M	2	Sample raw water and submit for bacteriological analysis. Frequency of sampling shall be in accordance with the *Public Water Supply Regulations p-23* unless otherwise directed by Environmental Health Officer or the O&M Manual. The procedures for bacteriological testing vary by location. If no process is established contact the Medical Health Officer to determine who should receive the samples for testing.
A	3	Check, service and exercise all valves in accordance with activity #100-10.
A	4	Check for ground settlement over mains.
A	5	Check for signs of leakage along line.
A	6	Check all supports and insulation on above ground piping.
A	7	Check all freeze protection and recovery systems including heat trace and bleeder systems.
A	8	Check all pipe corrosion protection systems and replace when necessary.
A	9	Check condition and operation of backflow preventer valves.
A	10	Flush water mains.
A/R	11	Bleeder flows should be adjusted according to water temperatures and minimum flows required.
A/R	12	Note any problems and initiate corrective action as required.

Note: Charge repair as activity # 101.

Note: Items 4 through 7 should be subject to a thorough annual inspection, but should also be checked visually by the maintainer while carrying out all other duties.

Crew	Freq	Trades	Hours	Total	Work Unit
1	W	SM	1.0	1.0	100 m pipe
1	A	SM	15.0	15.0	100 m pipe
2	A	SM/HL	4.0	8.0	Per 100 m flush
1	A/R	SM	0.25	0.25	Per location - item 10 or 12
2	A/R	SM/HL	8.0	16.0	Per 100 m pressure test
Special tools/materials: Safety equipment and practices, water main flushing equipment, water test equipment, water sampling kit.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - BURIED VALVES	**Activity # :** 100-9
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
M	1	Ensure that no valves within an access vault are submerged under water.
SA	2	Check that valve position (opened or closed) is correct.
SA	3	Service and exercise all valves, full open to full closed.
A	4	Check for leaks.
A	5	Clean valves. Remove rust from operating parts and paint as necessary.
A	6	Clean dirt or debris from valve box. Check elevation. Grease valve stem.
A	7	Ensure that all protective enclosures for valves are maintained to prevent freezing and vandalism.
A	8	Ensure that all insulation is properly installed and in good condition.
A	9	Check bollards around valve operators or valve boxes are properly anchored and structurally undamaged.
A/R	10	Note any problems and initiate corrective action as required.

Note: Charge repair as activity # 101.

Crew	Freq	Trades	Hours	Total	Work Unit
1	Sa	SM	1.0	1.0	Valve
1	A	SM	1.5	1.5	Valve
Special tools/materials: Safety equipment and practices, lubricants, packing, record forms.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - WATER PUMPS	**Activity # :** 100-10
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
D	1	Check operation of pump(s).
D	2	Check pumps and fittings for leaks.
D	3	Listen for abnormal noise while equipment is operating.
D	4	Check flow meters, record flow, and abnormal flows.
D	5	Check pump suction and discharge pressure gauges and record results.
D	6	Check operation of all controls.
D	7	Check pump packing glands & mechanical seals for abnormal leaks & adjust as necessary.
W	8	Check lubrication reservoir if applicable, top up as required.
W	9	Check freeze protection devices for proper operation.
M	10	Check pump anchor bolts and pump base.
M	11	Switch primary duty (lead) and standby (lag) pump.
Q	12	Manually run standby pump(s) if the standby pumps are not regularly run as duty pump.
Q	13	Check all electrical components and controls for operation, motor amperage draw and voltage, and record.
Q	14	Check pump alarms.
Q	15	Clean pipeline strainers as required.
A	16	Check ancillary equipment such as foot valves, check valves, and control valves.
A/R	17	Test run and check engine driven standby pump as outlined in activity # 440-52.
A/R	18	Service pumps as outlined by activities #440-16, #440-17 & #440-18.
A/R	19	Note any problems and initiate corrective action as required

Note: Charge repair as activity # 101.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SM	1.0	1.0	Per pumping station
1	W	SM	1.0	1.0	Per pumping station
1	M	SM	1.0	1.0	Per pumping station
1	Q	SM/EL	2.0	2.0	Per pumping station
1	A	SM	1.0	1.0	Per pumping station
2	A/R	SM/HL	Nil	Nil	Time included in activities #440-52, #440-16, #440-17 and #440-18.

Special tools/materials: Safety equipment and practices, lubricants, recording form (flow, pressure, temperature, maintenance), hand tools.

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - ACCESS VAULTS	**Activity # :** 100-12
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
W	1	Check for water in bottom of access vaults. Remove water and fix source of leak.
W	2	Check that locking devices are securely fastened.
M	3	Check that water and sewer piping and fittings are tight and secure.
M	4	Check covers over sewer cleanouts are properly installed with gaskets in place.
A	5	Check interior and exterior surfaces of access vaults for signs of structural damage.
A	6	Check coatings on interior and exterior. Repair damaged coatings.
A/R	7	Note any problems and initiate corrective action as required.

Crew	Freq	Trades	Hours	Total	Work Unit
1	W	SM	0.25	0.25	Per vault
1	M	SM	0.5	0.5	Per vault
1	A	SM	0.5	0.5	Per vault
Special tools/materials: Safety equipment and practices, hand tools.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - HYDRANTS	**Activity # :** 100-13
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
SA	1	Check for leaks (seals, joints) and signs of damage.
SA	2	Check operating nut for wear, rounded corners and function. Lubricate threads.
SA	3	Check connection caps, threads, and chains. All caps shall be in place. Caps with rusted, damaged or worn threads that prevent easy removal shall be repaired or replaced. Ensure chains are in place and do not prevent cap removal.
SA	4	Check all valves for proper operation and exercise.
SA	5	Drain to the ground or pump out hydrant barrel. For self draining hydrants make sure they drain completely. Repair main valve or drain valve if water is present prior to draining or pumping out.
SA	6	Check glycol level and concentration (for non self-draining units). Ensure glycol is food grade. Adjust or replace as necessary.
SA	7	Check that hydrant locations are clearly identified under all conditions.
A	8	Flush hydrant with main valve and any outlet valves fully opened until water runs clear.
A	9	Contact the Office of the Fire Marshal to confirm required fire flow requirements for the community, fire code updates that affect hydrant maintenance, and arrange for flow testing of fire hydrants. Record test results.
A	10	Inspect breakaway component of hydrant if possible.
A/R	11	Check for access obstructions. Remove or minimize obstruction.
A/R	12	Note any problems and initiate corrective action as required.
A/R	13	Records of inspections and tests shall be retained for examination by the Office of the Fire Marshal.
6 YR.	14	Clean and paint hydrant.

Note: Charge repair as activity # 101.

Crew	Freq	Trades	Hours	Total	Work Unit
1	SA	SM	0.25	0.25	Hydrant
1	A	SM	6.0	6.0	Hydrant
1	6 yr.	PT/SM	2.0	2.0	Hydrant

Special tools/materials: Safety equipment and practices, lubricants, paint, food grade glycol, Flow testing equipment and documentation forms.

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - STANDBY GENERATOR	**Activity # :** 100-14
Date Issued: 2008-08-01	**System:** COMMUNITY WATER SUPPLY

Frequency		Task
W	1	Test standby generator and transfer switch as outlined in activity #440-51 record test data in log book.
W	2	Check all controls and alarms for proper operation.
W	3	Check fuel tank level.
M	4	Service batteries as outlined by activity #440-50.
M	5	Check fuel supply systems as outlined by activities #440-10 and #440-67.
A	6	Service generator as outlined by activity #440-51a.
A	7	Service battery charger as outlined by activity #440-49.
A/R	8	Service engine as outlined by activity #440-51e.
A/R	9	Note any problems and initiate corrective action as required.

Note: Charge repair as activity # 101.

Crew	Freq	Trades	Hours	Total	Work Unit
2	W	EL/MC	Nil	Nil	Time included in activity #440-51.
1	W	SM	0.50	0.50	Per generator
2	M	SM/PL	Nil	Nil	Time included in activities #440-50, #440-10 and #440-67.
2	A	EL/MC	Nil	Nil	Time included in activities #440-51a and #440-49.
2	A/R	EL/MC	Nil	Nil	Time included in activity #440-51e.
Special tools/materials: Safety equipment and practices.					

M.M.S. Standards

Activity Name: PREVENTATIVE MAINTENANCE - SEWAGE SERVICE MAINS	**Activity # :**110-1
Date Issued: 2008-08-01	**System: COMMUNITY SEWAGE SYSTEM**

Frequency		Task
A	1	Where sewer main is exposed to the surface, check that the exterior cladding insulation and marking is not damaged or deteriorating.
A	2	Following inspection, clean and flush sanitary sewer mains as necessary.
A	3	Service and exercise all valves (full open to full closed) in the sewer line. Verify correct position of each valve (open or closed). Maintain concise records (forms) for each valve and drawings for each location.
A	4	Check operation of check valves in force mains.
A/R	5	Inspect mains using a pipeline video camera system. Check for blockages, sediment buildup, service pipe protrusions, infiltration, exfiltration, irregularities in grade, and collapsed/ovalled pipe.
A/R	6	Monitor sewage temperature in mains to determine when to activate freeze protection systems. Record temperatures on a daily basis at the start of winter and in spring, depending on the system and location.
A/R	7	Where historical operation dictates the need to operate bleeders to prevent sanitary sewer mains from freezing, the bleeding should be operating as follows: 1. Starting bleeding as required by local conditions. 2. Adjust bleeders to optimize flow. 3. Discontinue bleeding as determined by local conditions.
A/R	8	Check if freezing is a problem (at designated areas) during winter months.

(Refer to Activity #110-5, Force Mains for Preventative Maintenance for Force Mains)

Crew	Freq	Trades	Hours	Total	Work Unit
2	A/R	PL/HL	0.5	1.0	Per temperature reading
1	A/R	PL	1.0	1.0	Per bleeder
2	A	PL/HL	1.0	2.0	Per Valve
2	A	PL/HL	3.0	6.0	Per 100 metres of main flushed
1 1	A A	By Contract - Camera Work HL	2.5 2.5	2.5 2.5	Per 100 metres of main video inspected. As above.
SPECIAL TOOLS/MATERIALS: Sewer blaster, safety gear and practices/training, record forms.					

Activity Name: PREVENTATIVE MAINTENANCE - MANHOLES/ACCESS VAULTS	**Activity # :**110-2
Date Issued: 2008-08-01	**System: COMMUNITY SEWAGE SYSTEM**

Frequency		Task
SA	1	Check if dangerous gases are present before entering manhole. Allow gases to dissipate, or ventilate manhole prior to entering. Do not, under any circumstances, perform interior work on any access vault alone, work on the interior of an access must be performed with a two man crew.
SA	2	If the access vault contains a sump pump, inspect the pump and control floats, and operate the pump for a short period of time.
SA	3	Check manhole heating systems operation (where applicable).
SA	4	Check and service main valves (refer to activity #110-1).
SA	5	Check for obvious obstructions in the sewer main in the vicinity of the access vault by removing the clean out cover.
SA	6	Check to see that sewer pipe clean out cap is closed and sealed tight.
SA	7	Check that access vault lock is in place and operational.
SA	8	Check that frost cover is intact.
SA	9	Inspect grading around manhole/access vault, and confirm that grading drains all surface runoff away from the access vault.
SA	10	Check for groundwater or other infiltration into access vault from surcharging, permafrost or water main cross connections. Infiltration into an access vault, or debris that accumulates must be removed.
SA	11	Check access vault structure for shifting, or structural damage as a result of permafrost degradation or ice formation.
SA	12	If insulation of access vault is accessible, check to see that insulation is dry.
SA	13	Check ladder rungs for corrosion and tightness.
SA	14	Check that manhole interior is relatively clean.
SA	15	If any odours associated with Petroleum Products or solvents are observed within the access vault, this information should be recorded for potential action associated with dumping of hazardous substances by system users. Inform senior staff for possible initiation of investigation.

Crew	Freq	Trades	Hours	Total	Work Unit
1	SA	PL	0.25	0.25	Manhole- Exterior Work
2	SA	PL/HL	0.75	1.5	Manhole-Interior Work (Spotter)
SPECIAL TOOLS/MATERIALS:1 Sewage tanker, safety gear as required.					

M.M.S. Standards

Activity Name: PREVENTATIVE MAINTENANCE - MACERATORS/COMMINUTORS	**Activity # :110-8**
Date Issued: 2008-08-01	**System: COMMUNITY SEWAGE SYSTEM**

Frequency		Task
D	1	Check for excessive noise, heat and/or vibration of the motorized components.
D	2	Drain basket and remove debris; 90% of the maximum flow-through capacity must be maintained.
A	3	Flush basin.
A	4	Clean combs.
A	5	Inspect cutting edge and shear bars. Replace if necessary.
A	6	Open, check, overhaul and sharpen cutters.
A	7	Lubricate all components of system as recommended by the manufacturer.
A	8	Service motor as recommended by the manufacturer.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	PL	0.25	0.25	Ea
2	A	PL HL	8.0	16.0	Ea
SPECIAL TOOLS/MATERIALS:					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE -COMMERCIAL HOT WATER BOILER	**Activity # : 440-3A**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		**Task**
		Annual maintenance servicing and inspection
A	1	Drain boiler, remove handhole/manhole covers, flush with high pressure hose.
A	2	Check water side of the tube sheets and tubes for scale formation, pitting or corrosion.
A	3	Remove low water cut-off, clean inspect.
A	4	Remove front and rear doors.
A	5	Inspect all fire tubes after removing soot. Brush then vacuum or flush with hose.
A	6	Check refractory lining. Repair if necessary coat with searset or equivalent.
A	7	Check forced draft fan, motor bearings, change belts, check drives, clean fins.
A	8	Check, calibrate all gauges, thermometers, check/label limit and high limit switches.
A	9	Clean and service all oil flow valves.
A	10	Change nozzle, oil filter. Check/clean swirler disk.
A	11	Check transformer and high voltage cables.
A	12	Check safety valves.
A	13	Reassemble boiler after inspection. Use new gaskets.
A	14	Verify full programmer operation.
A	15	Verify operation of any boiler alarm devices.
A	16	Adjust boiler for peak efficiency. Record.
A	17	Add chemicals until proper level is obtained.
A	18	Test glycol per activity #440-15.
A	19	Clean interior of stack.
A	20	Clean exterior of stack.
A	21	Check for leaks and deterioration of stack flashing and cap.
A	22	Make certain that all stays are secured, adjust as necessary.
A	23	Check draft regulators, gauge I/A. And any Motorized dampers.
A	24	Make any minor repairs necessary.
AR	25	Paint metal stacks/chimneys with hi temp paint.

Note: Charge repairs as activity # 441

Note: **Do not touch, vacuum or use soot remover on ceramic fibre combustion chambers.**

Crew	Freq	Trades	Hours	Total	Work Unit
2	A	SM SE	8.00	16.00	Boiler
2	A/R	PT / HL	2.00	4.00	Stack

SPECIAL TOOLS/MATERIALS: Combustion analyser, glycol test kit, graphite, searset, gaskets, soot vacuum. Safety equipment for chemical use. Hi temp paint.

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - COMMERCIAL HOT WATER BOILER	**Activity # :440-3D**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
		Daily commercial boiler and system checks:
D	1	Visually check boiler water and fuel connection for leaks.
D	2	Check operation of all controls.
D	3	Check for any unusual noise in fuel pump.
D	4	Check for any unusual noise in circ pumps.
D	5	Check stack temperature.
D	6	Check all temperature and pressure gauges.
D	7	Check air damper linkages.
D	8	Check expansion tank check level in gauge glass.
D	9	Check glycol system. Adjust as required.
D	10	Do any minor repairs / adjustments necessary to ensure efficient operation of the heating system.
D	11	Enter in logbook all information required. Report any deficiencies. (See ASME VI exhibit "B" for the minimum acceptable information)
		TREATED WATER SYSTEMS:
D	12	No prescribed chemical tests. Record.
	13	Add any chemicals required. Record.
	14	If required blow down boiler, before adding chemicals. (pot feed)

Note: Charge purchase of boiler chemicals and water treatment consulting to activity #440-15. If water tests are not done as part of daily boiler check do as activity #440-15

Note: Charge repairs to activity # 441

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SM/SE	NIL	NIL	Time included activity #441-05
1	D	SM/SE	.50	.50	Boiler with treated water
SPECIAL TOOLS/MATERIALS: Safety equipment for chemical use.					

Activity Name: PREVENTIVE MAINTENANCE - COMMERCIAL HOT WATER BOILER	**Activity # :440-3M**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
		Monthly commercial boiler check:
M	1	Do full combustion, CO(2) test and record. Adjust as required to ensure maximum operating and combustion efficiency is met at all times.
M	2	Verify operation of low water cut-off. Glycol systems included.
M	3	Check all boiler and combustion controls for correct settings and operation. Record settings in log book.
M	4	Check operation of all standby pumps or rotate duty.
M	5	Check containment section of self bermed oil storage tanks. Pump out as required.
		Note: Disposal of any waste oil or any liquid containing oil must be approved by RWED.
M	6	Enter in log book all required information, record all work done. Report any deficiencies. (See ASME VI exhibit "B" for the minimum acceptable information)
		Note: Charge all repairs to activity #441

Crew	Freq	Trades	Hours	Total	Work Unit
1	M	SM SE	1.00	1.00	Boiler
SPECIAL TOOLS/MATERIALS: Combustion analyser.					

Activity Name: PREVENTIVE MAINTENANCE - HEAT EXCHANGERS	**Activity # : 440-8**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
		All Types:
D	1	Check temperature and pressure readings, record as required.
D	2	Check for leaks.
3M	3	Check operation of control.
3M	4	Check insulation.
3M	5	Check pressure relief valve.
A	6	Recalibrate or replace gauges.
A	7	Flush or solution wash to remove scale.
A	8	Pull tube bundle/element, clean/check, replace gaskets, pressure test.
A	9	Verify pressure rating of all pipe, fittings, shell and tube nest.
A	10	Check element on electric units.

Note: Charge repair as activity # 441

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SE/SM	NIL	NIL	Time included activity #441-05
1	3M	SE/SM	NIL	NIL	Time included activity #440-3m
2	A	SE SM	4.00	8.00	Exchanger length up to 600 mm
			8.00	16.00	Exchanger length over 600 mm
SPECIAL TOOLS/MATERIALS: Descaler, flushing solution, tank, pump gasket material graphite.					

Activity Name: PREVENTIVE MAINTENANCE - FUEL SUPPLY (COMMERCIAL)	**Activity # : 440-10**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task

Note: This activity is for annual maintenance, not for checks.

OIL:

A 1 Thoroughly inspect all pumps, heaters, and pressure reducing valves. Do any minor repairs required.
2 Change all fuel filters. Clean all screens and strainers.
3 Check all lines and repair any leaks...regardless of volume. Check fusible valves.
4 Check, calibrate all gauges.
5 Clean and service oil flow valves.
6 Check control on heaters. Check low oil temperature alarm.
7 Check oil flow, low pressure alarms.
8 Service pump per manufacturers instruction.
9 Adjust pump discharge pressure.

GAS:

1 Check controls.
2 Check thermo-couples.
3 Check pilot. Check gas valve with voltage tester.
4 Check vaporizer, check heat trace.
5 Grease gas cocks.
6 Test leak detection system/alarm.
7 Leak test entire system and piping.

Note: Charge repair to activity # 441.

Crew	Freq	Trades	Hours	Total	Work Unit
1	A	SE/PL	3.00	3.00	Fuel system
		PL/GF	3.00	3.00	Gas system (certification required)
Special TOOLS/MATERIALS: Volt meter, gas detector.					

Activity Name: PREVENTIVE MAINTENANCE - PUMPS (Group One)	**Activity # : 440-16**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
		Note: Group one pumps include all pressure and circulating pumps whose drivers are electric and are greater than 1 h.p. except fuel pumps and submersible pumps.
D	1	Check for any irregularity in pump operation, excess vibration, unusual noise or leaks.
D	2	Check pressure gauge and flow meter, record.
D	3	Any change in pressure or flow should be investigated immediately.
D	4	Check for change in bearing temperature.
D	5	Check for proper packing operation, leakage should be sufficient for cooling and lubrication purposes but not excessive.
D	6	Visually check couplings, belts and mounting bolts.
M	7	Check lubricant, add as required.
M	8	On dual pump systems rotate primary duty.
SA	9	Check/record amp draw at full operating level.
SA	10	Clean and lubricate adjusting nuts, bolts and studs.
SA	11	Check condition of packing, add or replace as necessary.
SA	12	Check/correct alignment of pump and driver.
SA	13	Check lubrication of bearings, replenish as required.
A	14	Remove strainer screen, clean check and replace.
A	15	Remove all old packing, clean/inspect gland, install proper packing, lubricate as required.
A	16	Replace seals/packing as required.
A	17	Replace coupling insert or belts as equipped.
A	18	Flush/inspect all piping, including drains.
A	19	Check pipe hangers to ensure piping is not stressing the pump casing.
A	20	Clean and service all check / non return valves.
AR	21	Remove pump from service and overhaul.

Overhaul should be based on either :

1. Factual evidence such as a decline in performance, excessive noise, high bearing temperatures, driver overload or similar trouble.
2. Circumstantial evidence such as historic data showing that similar type and duty pumps require overhaul after attained operating periods.

CONTINUED...

Note: When greasing bearings it is recommended that the relief plug opposite the grease

Activity Name: PREVENTIVE MAINTENANCE - PUMPS (Group One)	**Activity # : 440-16**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

fitting be removed so the old grease will be purged from the bearing. The pump should be started briefly with the plug out to spin out any excess grease before the plug is replaced.

Note: Charge repair to appropriate activity determined by type of service the pump is providing, ie. Heat.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	PL / SM	NIL	NIL	Time included activity #441-05
1	M	PL / SM	0.25	0.25	Pump
1	SA	PL / SM	0.50	0.50	Pump
1	A	PL / SM	2.00	2.00	Pump
2	AR	PL / SM	4.00	8.00	Pump
SPECIAL TOOLS/MATERIALS: Amp meter, lubricants, gaskets, seals, packing, shims.					

Activity Name: PREVENTIVE MAINTENANCE - PUMPS (Group Two)	**Activity # : 440-17**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task

Note: Group two pumps include all pressure and circulating pumps whose drivers are electric and 1 h.p. or less, except fuel pumps and submersible pumps (other than sump pumps).

D	1	Check for any irregularity in pump operation excess vibration, unusual noise and leaks.
D	2	Check pressure gauge and flowmeter if equipped, investigate any changes in pressure or flow.
D	3	Check oil and lubricant levels; replenish as required.
A	4	Check alignment of shafts, adjust as required.
A	5	Replace flex coupling or belts as required.
A	6	Install new seals and gaskets as required.
A	7	Replenish oil and lubricants.
A	8	Clean any inlet screens or filters.
A	9	Check and service any check or o return valves.
A	10	Check and record amp draw normal operating condition. Check service any check or no return valves.
A	11	Test run pump, adjust as required.

Note: Daily check is for commercial applications.

Note: Overhaul of these units is normally not viable. Time in service and replacement costs should be considered before major repair is done.

Note: Charge repair to appropriate activity determined by type of service the pump is providing, ie: heat.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	PL/SM	NIL	NIL	Time included activity #441-05
1	A	PL/SM	0.50	0.50	Pump
SPECIAL TOOLS/MATERIALS: Lubricants, seals and gaskets.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - LIGHT TUBES/BULBS	**Activity # : 440-42**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
AR	1	Supply fluorescent tubes to schools and owned buildings on an as required basis for the custodian to install.
AR	2	Supply and install fluorescent tubes in schools where custodian is not able due to height or type of fixture.
AR	3	Supply and install H.I.D light bulbs.
AR	4	Supply and install exit light bulbs in schools and owned buildings.

Crew	Freq	Trades	Hours	Total	Work Unit
SPECIAL TOOLS/MATERIALS:					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - MOTOR CONTROLLERS (OVER 1 HP)	**Activity # : 440-46**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
A	1	De-energize motor controller, lock and tag out power supply.
A	2	Check enclosure for signs of damage.
A	3	Repaint or touch up as required.
A	4	Check conductors and/or wiring harnesses for chaffing and wear; repair/replace as required.
A	5	Look for evidence of overheating.
A	6	Tighten connections, repair or replace. A/R.
A	7	Clean, adjust or burnish connection points.
A	8	Check, clean, dress or replace contacts. A/R.
A	9	Ensure smooth free movement of operating mechanisms; lubricate as required.
A	10	Check size and type of protective devices; replace or otherwise correct to provide proper protection.
A	11	Check arc-chutes and quenchers for damage; replace if necessary and ensure that they are securely in place.
A	12	Manually operate racking mechanisms to ensure free operation.
A	13	Lubricate all hardware. Ensure that electrical /mechanical interlocks are functional.
A	14	Clean and wipe down all bushings and porcelains.
A	15	Remove dust and dirt accumulation from enclosure interior.
A	16	Ensure cooling vents and louvres are free of obstructions
A	17	Remove tags lockouts and return to service.
A	18	Energize and test.
A	19	Check ground connections.
A	20	Verify proper labelling of device.

Note: Charge repair to appropriate activity determined by type of service the motor is providing, ie. Heat

Crew	Freq	Trades	Hours	Total	Work Unit
1	A	EL	0.50		Controller
SPECIAL TOOLS/MATERIALS:					

Activity Name: PREVENTIVE MAINTENANCE - SECONDARY TRANSFORMERS	**Activity # : 440-48**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
A	1	De-energize lock and tag out.
A	2	Visually check the transformer tank exterior for evidence of rusting or moisture.
A	3	Wipe and/or wash down tank exterior. Repair, repaint or touch up as required.
A	4	Remove primary protective devices and ensure it is proper size.
A	5	Clean and wipe dry all insulators, bushings and porcelains.
A	6	Inspect closely all insulators, bushing and porcelains for chips, cracks and fractures repair or replace as required.
A	7	Check, tighten, repair or replace primary and secondary connections.
A	8	Ensure cable or other protection properly in place.
A	9	Tighten all bolts and hardware.
A	10	Remove dust/dirt/debris.
A	11	Check entire unit for signs of overheating.
A	12	Visually check dry transformer winding insulation for evidence of deterioration.
A	13	Ensure adequate ventilation or circulation.
A	14	Assure ground bus connections are tight.
A	15	Initiate corrective action as required.
A	16	Remove tags and return to service.

Note: Charge repair as activity #444

Crew	Freq	Trades	Hours	Total	Work Unit
2	A	EL HL	2.0		Per transformer
SPECIAL TOOLS/MATERIALS:					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - BATTERY CHARGERS	**Activity # : 440-49**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
A	1	De-energize, lock and tag out.
A	2	Check, repair or replace, and tighten connections as necessary.
A	3	Ensure cable harnesses are clear and free from chaffing.
A	4	Check that clips, supports and cable protection are secure and tight.
A	5	Record specific gravity of battery cells.
A	6	Adjust charge rate as required. This can be determined from checking monthly levels.
A	7	Read, measure and record ac input, amperes and volts.
A	8	Read, measure and record equalize voltage and amperage.
A	9	Read, measure and record float voltage and amperage.
A	10	Check first upstream protective device for proper size; if a circuit breaker exercise it to assure free operation.
A	11	Blow out or vacuum the interior.
A	12	Wipe down exterior.
A	13	Remove tags and return to service.

Note: Normally associated with engine driven pumps and generators.

Note: Charge repair as Activity #444.

Crew	Freq	Trades	Hours	Total	Work Unit
1	A	EL	NIL	NIL	Time included activity #440- 51a
SPECIAL TOOLS/MATERIALS: Multi meter, hydrometer.					

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE - BATTERIES (LEAD ACID)* *NORMALLY ASSOCIATED WITH STATIONARY, ENGINE DRIVEN GENERATORS AND PUMPS.	**Activity # : 440-50**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
M	1	Read, measure and record voltage.
M	2	Check specific gravity of each cell, record.
M	3	Remove Salt deposits from connection points.
M	4	Protect terminals with suitable lubricant.
M	5	Tighten, repair or replace wiring or connections.
M	6	Closely inspect cases or containers for evidence of cracks, leaks and swelling. Repair or replace if damaged.
M	7	Check liquid levels and top up per Manufacturer's specifications.

Note: Charge repair as activity # 444

Crew	Freq	Trades	Hours	Total	Work Unit
1	M	SM/SE	NIL	NIL	Time included activity #440-51 do with test run
SPECIAL TOOLS/MATERIALS: Hand tools, distilled water, volt meter.					

Activity Name: PREVENTIVE MAINTENANCE - GENERATORS (STATIONARY)	**Activity # : 440-51**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
		CONTINUOUS USAGE:
D	1	Check all safeties and controls.
D	2	Check oil/lube levels, top up as required.
D	3	Check rads and coolant level.
D	4	Check hose connections.
D	5	Check all drive belts.
D	6	Check all gauges.
D	7	Check for any operational irregularities.
D	8	Record all required data in unit log book. Include output levels, volt/amp/hertz
D	9	Check fuel level in tanks and record.
		STANDBY:
W	1	Obtain clearance for test run of generator.
W	2	Check battery - electrolyte level.
W	3	Check coolant level.
W	4	Check fuel level in tanks and record.
W	5	Check for loose bolts and nuts, starter connections, isolators, air cleaner.
W	6	Check all belts for proper tension.
W	7	Check engine block and/or lubricant oil heater.
W	8	Check lubricant oil level and condition (if lubricant oil is contaminated or diluted, or condition is doubtful, oil must be changed and sample sent for analysis.)
W	9	Select "test"/disconnect power. Check transfer time (time specified in operating manual).
W	10	Record all required readings in unit log. Include output levels, volt/amp/hertz.
W	11	Check for proper function of louvres, fuel transfer pump, fan on remote radiator.
W	12	Check for oil, fuel and cooling fluid leaks.
W	13	Check exhaust piping and muffler for leaks.
W	14	Check intake air restriction indicator.
W	15	Listen for abnormal noises during operation.
W	16	Run unit with full load 30 minutes minimum.
W	17	When run complete, restore power, select "auto" check for correct transfer and cooldown times.
W	18	Check condition of entire unit.

CONTINUED...

		ANNUAL ELECTRICAL CHECK ON GENERATOR:
A	1	Test transfer equipment, panel and switch.
A	2	Apply safety tags, locks and grounds.

Activity Name: PREVENTIVE MAINTENANCE - GENERATORS (STATIONARY)	Activity # : 440-51
Date Issued: 2008-08-01	System: BUILDING SERVICES

Frequency		Task
A	3	Disconnect battery.
A	4	Clean all components and panels and load bank.
A	5	Inspect and tighten wiring and connections (including load bank).
A	6	Inspect load bank air intakes to ensure they are free and clear of debris and obstructions
A	7	Inspect all contacts, burnish if required.
A	8	Inspect and tighten busbar connections.
A	9	Maintain high voltage transfer switches as per manufacturer's manual.
A	10	Check and test protective relays- over/under voltage, over current.
A	11	Inspect safety and interlock devices as per manufacturer's instructions.
A	12	Measure and record insulation resistance of each contactor; phase to phase and to ground.
A	13	Remove inspection covers of generator assembly.
A	14	Clean sliprings and commutator if applicable.
A	15	Inspect brushes for proper tension and seating.
A	16	Clean internally with blower or vacuum cleaner.
A	17	Inspect and tighten connections.
A	18	Lubricate bearings per manual.
A	19	Take vibration reading while plant is running.
A	20	Clean intake and exhaust louvres.
A	21	Check damper linkages adjust as required.
A	22	Test operation of ventilating system.
A	23	Inspect wiring in and grounding of trenches.
A	24	Test main ground and record
A	25	Reconnect batteries, coat terminals.
A	26	Remove safety lockouts and grounds.
A	27	Test all engine safety devices; overcrank, overspeed, low oil pressure, over/under voltage and overheat.
A	28	Close all access panels and covers,
A	29	Switch transfer panel selector to "auto".
A	30	Switch by-pass switch to normal.
A	31	Confirm load bank is available for load transfer.
A	32	Conduct a full-load, 2 hour test of the generator and prime mover using the load bank. Record all pertinent data (full-load shall equal nameplate kW rating of emergency generator set less applicable derating factors).
A	33	Clean engine room.

With all equipment of this nature the operating manual should be adhered to for all maintenance and service guidelines and frequencies.

CONTINUED...

Activity Name: PREVENTIVE MAINTENANCE - GENERATORS (STATIONARY)	Activity # : 440-51
Date Issued: 2008-08-01	System: BUILDING SERVICES

Frequency		Task
		SERVICING GENERATOR ENGINE:
A/R	1	Servicing of the generator engine should follow the schedule outlined in the operating manual. Service levels outlined in the manuals vary with the usage of the equipment. Stand by units which run seldom other Than the weekly test require servicing on average, twice each year. This service is basically equivalent to the mobile equipment "I" check. Units which run significantly more or continuously even if on a seasonal basis should be serviced as outlined in the operating manual. The mobile equipment "I" and "II" checks can be used if the unit manual is not available or is not clear on service levels. **Note:** It is important to avoid over servicing.
Q		**Note:** Charge repair to the engine and its components to the appropriate mobile equipment activity.

Crew	Freq	Trades	Hours	Total	Work Unit
1	D	SM/EL	1.0	1.0	Continuous use
1	W	SM/EL	1.0	1.0	Standby
2	A	EL MC	4.0	8.0	Standby
2	A	EL MC	8.0	16.00	Continuous use

SPECIAL TOOLS/MATERIALS: Operating manual, time allotted for annual should cover engine servicing.

M.M.S. Standards

Activity Name: PREVENTIVE MAINTENANCE – Automatic Transfer Switch	**Activity # : 440-54**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
M	1	Operate transfer switch under load. Use the test switch to check electrical operation. (Test switch only simulates failure of the normal source so service is interrupted during actual transfer of the load.)
M	2	Check for timing sequence: a) Time of transfer; and b) Time of re-transfer.
A	1	Isolate transfer switch, open all inspection covers, and inspect all electrical connections.
A	2	Operate all moving parts to ensure free movement.
A	3	Clean and dress contacts as necessary.
A	4	Remove all dust
A	5	Clean and lubricate linkages.
A	6	With the generator set operating at full load, conduct an infrared survey of all electrical connections to identify any high resistance connections.
3YR	1	Check for signs of overheating faulty insulation and loose wires. Brush & vacuum any excessive dust accumulation. Leave the cover on the control panel.
3YR	2	Maintain transfer switch lubrication: generally not required if factory lubricated. If subjected to severe dust or abnormal operating conditions, renew factory lubrication. Re-lubricate if the TS coil is replaced.
3YR	3	Inspect main current carrying contacts. De-energize all sources, then remove barriers to check condition of contact material. Replace contacts when pitted or worn excessively.
3YR	4	Check all mechanical parts for tightness and wear, check terminals are tight.
3YR	5	Calibrate time and voltage sensors.
3YR	6	Test operation of transfer switch after inspection a minimum of 3 times, check all parts move freely.

Note: Ensure that all equipment lockout and safety practices are followed.

Crew	Freq	Trades	Hours	Total	Work Unit

Activity Name: PREVENTIVE MAINTENANCE - ELECTRICAL PANELS	**Activity # : 440-56**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
		Commercial buildings
A	1	De-energize lock and tag out.
A	2	Replace or repair and tighten connections. A/R.
A	3	Ensure breaker size is proper for equipment it protects.
A	4	Exercise breaker to ensure freedom from binding.
A	5	Wipe down breaker faces; ensure they are clean and dry.
A	6	Ensure fuse size and type is proper for equipment it protects.
A	7	Ensure fuse holders in good condition.
A	8	Check out and ensure labelling on the index card is correct.
A	9	Ensure labelling is legible.
A	10	Note spare circuit capacity remaining.
A	11	Remove accumulation of dirt dust and debris.
A	12	Install knockout seals if required.
A	13	Remove locks, tags and return to service
3YR	1	Clean interior of enclosure – blow our dust and dirt using a vacuum cleaner.
	2	Check the voltage and amperage on the primary wires.
	3	Check the grounding

Note: Charge repair as activity # 444

Crew	Freq	Trades	Hours	Total	Work Unit
1	A	EL	1.00	1.00	Panel
SPECIAL TOOLS/MATERIALS:					

Activity Name: PREVENTIVE MAINTENANCE – Motor Control Centre	**Activity # : 440-65**
Date Issued: 2008-08-01	**System: BUILDING SERVICES**

Frequency		Task
3YR	1	Pull disconnect switch before working on control.
3YR	2	Clean interior of enclosure; remove dirt, rust or corrosion. Note if excessive.
3YR	3	Torque electrical connectors; look for discolouration of any current carrying parts.
3YR	4	Check mechanical connectors; torque bus bar connectors to manufacturer's specifications and record data.
3YR	5	Check for spring clip pressure of fuse clips.
3YR	6	Look for frayed strands on flexible leads, flexing over entire length.
3YR	7	Check for any signs of overheating or mechanical injury to coils.
3YR	8	Push Buttons, Selector Switches or Pilot Devices: Clean, check device contacts. Test continuity of pilot circuit.
3YR	9	Check contactors for flashing; if so, check for adjustment to eliminate contact bounce.
3YR	10	Check for noise, shading coils, magnetic surface, sealing, mechanical binding, loose rivets.
3YR	11	If fuse ferrules are copper, polish; check for loose ferrules and proper size fuses.
3YR	12	Replace contact tips if burned excessively. Do not file silver tips. Check, wipe and replace when less than 50% contact surface remains.
3YR	13	Check contact pressure for uniform pressure on all tips.
3YR	14	Clean magnet faces, check shading and striking coil, misalignment and binding.
3YR	15	Trip overload relays by hand to ensure mechanically free. Clean, check heater coil and tighten oil connections.
3YR	16	Check arc shields for breaks and burning of arc blowout segments. Replace if 1/3 vaporized.
3YR	17	Check continuity and voltage of rectifiers.
3YR	18	Clean relays, check for mechanical binding and striking. Check contacts.
3YR	19	Check starting sequence to ensure control functions properly.
3YR	20	Pilot Devices, Pressure Switches, Temperature Switches: Check bottom and top limits of operation. Check for fluttering of contacts (revealed by pumping of main contacts).
3YR	21	Check for proper sizing of over current and overload devices.
3YR	22	Inspect mounting insulators for defects.
3YR	23	Check grounding.
3YR	24	List any parts which must be replaced.
3YR	25	Perform infrared scan of unit.
3YR	26	Ensure that all equipment lockout and safety practices are followed.

Recommended Spare Parts:

- Contact renewal set
- Contact spring kit
- Magnet coil

Crew	Freq	Trades	Hours	Total	Work Unit

Activity Name: PREVENTIVE MAINTENANCE - HEAT TRACE AND CABLE	Activity # : 440-74
Date Issued: 2008-08-01	System: BUILDING SERVICES

Frequency		Task
A	1	Check heat trace and controls for proper settings/operation. (Water lines)
SA	2	Connect power supply to eve heat cables as required to prevent or remove ice build up. Verify proper operation. Disconnect when not required.

Note: Charge repair as activity #445.

Crew	Freq	Trades	Hours	Total	Work Unit
1	A	EL	0.25		Heat trace system
1	SA	EL	0.25	.50	Eve heat cable
SPECIAL TOOLS/MATERIALS:					

Appendix B: CSA C282 Emergency Power Supply for Building

Trow

Table 2
Weekly inspection, test, and maintenance requirements
(See Clauses 6.11.2, 10.7, 11.1.2, 11.5.1, and 11.5.2 and Tables 3 to 5.)

1. Consumables: (a) Inspect day tank fuel level (gas pressure) and main tank level (gas pressure) (if applicable). Minimum 2 h supply required (see Clause 7.3.1). (b) Inspect lubricating oil level. (c) Inspect engine coolant level. (d) Inspect engine, generator, fuel tank(s), and cooling systems for leakage. (e) Inspect for proper operation of fuel transfer pump (if applicable). (f) Inspect fuel filter for contamination if filter is equipped with a transparent bowl.
2. Starter system: (a) Inspect electric starter for cleanliness, mounting, and terminal security. (b) Air starter: (i) Inspect air tanks for pressure. (ii) Inspect valves for leakage. (iii) Test auxiliary engine and compressor for proper operation. (iv) Bleed off any condensation.
3. Batteries and charging equipment: (a) Inspect all battery cells for correct electrolyte fill level. (b) Test all battery cells for correct electrolyte specific gravity. (c) Inspect electrical connections for tightness and evidence of corrosion. (d) Inspect battery for cleanliness and dryness between terminals. (e) Inspect charger electrical connections for cleanliness and tightness. (f) Test charger for proper operation of float and equalize modes.
4. Engine: (a) Test lubricant and/or coolant heaters for proper operation. (b) Inspect governor control linkages and oil level (if applicable). (c) Inspect fuel pump oil sump (if applicable). (d) Inspect fan belts for correct tension and wear.
5. Control panel: (a) Inspect control panel covers for security. (b) Test annunciator lamps to confirm that they are operational. (c) Inspect control panel settings (ensure that the unit is ready for automatic start-up). (d) Test remote visual and audible trouble signals at the building fire alarm panel.
6. Inspect air control louvre settings to ensure proper operation.
7. Test emergency lighting unit(s).
8. Verify whether room temperature is above 10 °C.
9. Inspect generator and transfer switch room(s) for cleanliness and accessibility to all components of the emergency system.
10. Correct all defects found during inspections and tests.
11. Record all inspections, tests, and corrective actions in the log (see Clause 11.5.3).

Note: *The person performing the work described in this Table shall have received appropriate training and be qualified to perform the specified tasks.*

Table 3
Monthly inspection, test, and maintenance requirements
(See Clauses 10.7, 11.1.2, 11.4, 11.5.1, and 11.5.2 and Tables 4 and 5.)

1. All items specified in Table 2.
2. Test and verify the entire system as follows: (a) Simulate a failure of the normal electrical supply to the building. (b) Operate the system under at least 30% of the rated load for 60 min. (c) Operate all automatic transfer switches under load. (d) Inspect brush operation for sparking. (e) Inspect for bearing seal leakage. (f) Inspect for correct operation of all auxiliary equipment, e.g., radiator shutter control, coolant pumps, fuel transfer pumps, oil coolers, and engine room ventilation system(s). (g) Record the readings for all instruments in the log (see Clause 11.5.3) and verify that they are normal. (h) Drain the exhaust system condensate trap.
3. Inspect block heater hoses and wires.
4. Correct all defects found during inspections and tests.
5. Record all inspections, tests, and corrective actions in the log (see Clause 11.5.3).

Note: *The person performing the work described in this Table shall have received appropriate training and be qualified to perform the specified tasks.*

Table 4
Semi-annual inspection, test, and maintenance requirements
(See Clauses 10.7, 11.1.2, 11.5.1, and 11.5.2 and Table 5.)

1. All items specified in Tables 2 and 3.
2. Inspect and clean engine crankcase breathers.
3. Inspect and clean all engine linkages.
4. Lubricate the engine governor and ventilation system.
5. Test protective devices for proper operation.
6. Before start-up, perform two full cranking cycles (as specified in Clauses 10.4.1 and 10.4.2). Near the end of each cycle (and while still cranking), measure and record the lowest indicated battery voltage. If the measured voltage is less than 80% of the battery's rated voltage, replace the battery. Alternatively, perform a battery load test using a suitable load tester.
7. Inspect ventilation system belt(s).
8. Correct all defects found during inspections and tests.
9. Record all inspections, tests, and corrective actions in the log (see Clause 11.5.3).

Note: *Items 2 to 9 require special skill and shall be carried out by a qualified contractor, the system manufacturer, or individuals trained and certified by the system manufacturer.*

Table 5
Annual inspection, test, and maintenance requirements

(See Clauses 11.1.2, 11.3, 11.5.1, 11.5.2, 11.5.5.1, and B.20.)

1. All items specified in Tables 2 to 4.
2. Control panel: (a) Open all inspection covers and inspect all electrical connections. (b) Test breakers for proper operation. (c) Clean insulators and bushings. (d) Test voltage regulator for proper operation. (e) Operate all moving parts to ensure that they move freely. (f) Clean and dress contacts as necessary. (g) Remove all dust. (h) Check gauge calibration. (i) With the generator set operating at full load (see Clause 11.3), conduct an infrared survey of all electrical connections to identify any high-resistance connections.
3. Engine: (a) Change engine lubrication oil and filters. (b) Test strength of coolant and chemical protection level of coolant inhibitors. (c) Change fuel filters, clean strainer(s), and verify that the fuel supply valve is open. (d) Inspect the exhaust system. Check and record the back pressure of the exhaust system to ensure that it complies with the engine manufacturer's requirements, and compare with previous readings. (e) Clean and lubricate linkages. (f) Inspect air filters. (g) Inspect all mechanical connections. (h) Inspect all electrical connections. (i) For spark ignition engines, inspect all components of ignition system(s) and service or replace as appropriate. (j) Inspect all external surfaces of heat exchanger(s) and clean as necessary. (k) Inspect all belts and hoses and replace if necessary. (l) Test and inspect ignition system(s). Replace any defective components. (m) Inspect coolant pump(s) for leaks and external wear (if belt driven, remove the belt(s) first).
4. Diesel fuel storage tank(s): The fuel oil in any storage tank (and day tank, if used) shall be tested in accordance with Clause 11.5.5, and if the fuel oil fails the test, it shall be (a) drained and refilled with fresh fuel in accordance with Article 6.7.1.5 of the *National Fire Code of Canada*; or (b) full filtered to remove water, scale, bacteria, and oxidized gums/resins in order to minimize filter clogging and ensure diesel start-up (see Clause B.20 for commentary). When the fuel is filtered, it shall be treated with a suitable conditioner and stabilizer to minimize degradation while in storage. **Note:** *The bottom(s) of the tank(s) shall be also tested chemically for water.*
5. Generator: (a) Test surge suppressor and rotating rectifier on brushless machines. (b) Grease bearings (replace old grease with new) (if applicable). (c) Clean commutator and slip rings (if applicable). (d) Clean rotor and stator windings using clean compressed air. (e) Inspect coupling bolts and alignment. (f) Inspect conduits for tightness. (g) Inspect windings at rotor and stator slots. (h) Inspect all electrical connections. (i) With the generator set operating at full load (see Clause 11.3), conduct an infrared survey of all electrical connections to identify any high-resistance connections.

(Continued)

Table 5 (Concluded)

6. Transfer switches: (a) Isolate transfer switch, open all inspection covers, and inspect all electrical connections. (b) Operate all moving parts to ensure that they move freely. (c) Clean and dress contacts as required. (d) Remove all dust. (e) Clean and lubricate linkages. (f) Conduct an infrared survey of all electrical connections, contacts, and energized components while under load on both the normal and the emergency side.
7. Lubricate door locks and hinges (if necessary), especially those of outdoor enclosures.
8. Conduct a 2 h full-load test (see Clause 11.3).
9. As needed, review and provide instruction on the technical requirements specified in Tables 2 to 4 with the person(s) responsible for carrying out the work.
10. Correct all defects found during inspections and tests.
11. Record all inspections, tests, and corrective actions in the log (see Clause 11.5.3).

Note: *Items 2 to 11 require special skill and shall be carried out by a qualified contractor, the system manufacturer, or individuals trained and certified by the system manufacturer.*

Table 6
Quinquennial (every five years) inspection, test, and maintenance requirements
(See Clauses 11.1.2, 11.5.1, and 11.5.2.)

1. Generator: Inspect insulation of generator windings. Use an insulation tester (megger). The resistance in megohms should be not less than $\frac{\text{Rated voltage} + 1000}{1000}$ If the resistance is less, dry out the insulation using the auxiliary heat process.
2. Engine: (a) Drain and flush the cooling system. Refill the system with new coolant. (b) Clean radiator tubes and cooling fins. (c) Replace thermostats. (d) Inspect valve clearances and adjust as appropriate.
3. Correct all defects found during inspections and tests.
4. Record all inspections, tests, and corrective actions in the log (see Clause 11.5.3).

Note: *Items 1 to 4 require special skill and shall be carried out by a qualified contractor, the system manufacturer, or individuals trained and certified by the system manufacturer.*

Appendix C:
Response Plan

Event **Watermain Contamination**

Indications

- Low measured chlorine residual
- Chlorinator failure
- Failed bacteriological sampling result
- Water related health concern expressed by Health Department

Actions

- Institute **Boil Water Order**
- Confirm chlorinator operating properly
- Sample and measure water distribution system residual chlorine; adjust chlorinator as required
- Sample for bacteriological testing and submit for analysis
- If bacteriological fails
    - Flush water distribution system
    - Confirm satisfactory operation of chlorinator
    - Sample for bacteriological testing and submit for analysis
- If continued failure of bacteriological testing
    - Inspect AV's and identify potential points of cross contamination; rectify findings
    - Flush water distribution system; disinfect water distribution piping
    - Sample for bacteriological testing and submit for analysis
- Following receipt of satisfactory bacteriological test results
    - Rescind **Boil Water Order**

Event **Watermain Leak**

Indications

- Localized area of ground thaw
- Water ponding or flowing for no apparent reason
- Unusual increase in water consumption
- Water entry into AV's

Actions

- Localize leak
- Institute **Boil Water Order**
- Prepare to isolate and bypass location of leak
    - Identify operating isolation valves and extent of area placed out of service
    - Identify bypass valves
    - Install bypass between hydrants if possible
- Initiate excavation and more precisely localize leak
- Isolate and depressurize watermain; put bypass into service; complete excavation
- Install repair clamp
- Re-pressurize watermain; confirm repair clamp watertight; confirm watermain circulation re-established; confirm water system operating temperatures
- Take bypass out of service
- Provide temporary protection against weather; provide public protection around excavation
- 24 hours later reconfirm repair clamp; reconfirm repair clamp bolt torque.
- If clamp bolt torque is stable:
    - Reinstate insulation with half shells or foamed in place polyurethane

- Place and heat shrink wrap around insulation repair
- Mark break location with wooden post
- Measure tie distances to fixed objects for future location of leak site.
- Bed piping with graded granular; backfill excavation with graded granular

- Take water samples for bacteriological testing and submit for analysis
- Remove **Boil Water Order** upon receipt of satisfactory bacteriological test results
- During following summer season
  - Provide permanent repair using fusion
  - Take tie measurements for future location of repair works
  - Reinstate bedding with granular materials
  - Backfill excavation with granular materials
  - Update system plan with leak repair location and date of repair

Event **Frozen Watermain**

Indications

- Disruption of circulation
- Loss of service to connected customers

Actions

- Confirm that piping freeze is cause of operating issues
    - Confirm that loss of circulation not due to conditions at water treatment plant
    - Confirm that loss of service the result of main freeze and not service connection issues
- Institute **Boil Water Order**
- Prepare to isolate and bypass location of frozen piping
    - Identify operating isolation valves and extent of area placed out of service.
    - Identify bypass valves
    - Install bypass between hydrants if possible
- Isolate frozen section; place bypass into operation; depressurize watermain
- Clean and disinfect connections onto watermain
- Open watermain drain valves and pump out AV's at both ends of frozen section
- Thaw internal ice using heated water introduced with a thaw lance from downhill AV
- Following thawing of internal ice flush, disinfect and re-flush watermain.
- Refill watermain and confirm ability to contain system operating pressure. If unable to maintain pressure, repair in same fashion as a watermain leak.
- Close and cap drains and connections to watermain

- Re-establish circulation; take bypass out of service; remove any temporary piping.
- Take water samples for bacteriological testing and submit for analysis
- Remove **Boil Water Order** upon receipt of satisfactory bacteriological test results

Event	**Frozen Sewer Main**
Indications	• Sewage backup into AV • Sewage backup into connected buildings • Low or no flow downstream of suspected backup site

Actions	• Pump out upstream AV and haul sewage to suitable disposal location
	• Remove downstream and upstream clean-out cover
	• Thaw internal ice using heated water and sewer cleaning machine
	• Note distance from AV to internal freeze; note distance length of frozen section of sewer piping
	• Following thawing of internal ice:
	  o Clean full length of sewer between AV's using sewer blaster
	  o Replace sewer clean-out covers
	  o Pump, pressure wash and disinfect AV's
	• Record location, length and date of piping freeze on system plan.

Event	**Crushed or collapsed sewer mains**
Indications	• Persisting sewer backups at same location • Impossible to clean sewer using sewer blaster • CCTV reports
Actions	• Localize crushing or collapse using sewer blaster. Attempt to advance blaster from upstream and downstream AV • Examine extent of surface disruption within area of suspected collapse; review with affected building occupants • Provide road detours; notify RCMP and fire department of road closing • Provide public protection; confirm that protective fencing in place at the end of each work day • Pump sewage from upstream AV and haul for appropriate disposal • Excavate and remove damaged piping • Place graded granular materials as pipe bedding; replace damaged piping with new pre-insulated polyethylene piping; connect to existing piping with fusion joints; mark ends of disturbed sections with wooden posts; take tie measurements of repair location and note location on system plan • Backfill excavation with graded granular materials • Remove detours, public protection • Clean, wash and disinfect AV's affected by repair • Amend system plan to show location of repair • Return to repair site and reinstate bedding and backfill if appropriate methods could not be applied during repair due to winter weather conditions.

Event **Frozen Service Connection**

Indications

- Loss of water supply and backup of sewage
- Water recirculation pump not operating
- Confirmation that problems is with service connection and not mains

Actions

- Water Service:
  - Close supply valves and disconnect from building plumbing
  - Thaw supply lines using hot water thaw lance (dedicated to water system thawing)
  - After thawing, close supply valves and reconnect to plumbing
  - Re-open supply valves; start recirculation pump; confirm recirculation pump operation; monitor incoming water temperature
  - Inspect accessible portion of service connection; repair damaged insulation and enclosures
  - Confirm satisfactory operation 24 hours after thawing.
- Sewer Service
  - Thaw using thaw lance (dedicated to sewer thawing)
  - Confirm and adjust bleed rate into service
  - Inspect accessible portion of service connection; repair damage insulation and enclosures
  - Confirm satisfactory operation 24 hours after thawing.