ONTARIO CLEAN WATER AGENCY
AGENCE ONTARIENNE DES EAUX

Report to the Township of Madawaska Valley for the Condition Assessment of the Water System

SUBMITTED BY

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Report approved by:

Nick Larson, P.Eng.

STATEMENT OF CONFIDENTIALITY

OCWA's Report to
Township of Madawaska Valley for the
Condition Assessment of the Drinking Water System

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1 Background

The Ontario Clean Water Agency (OCWA) was retained by the Township of Madawaska Valley to complete condition assessments of the water and wastewater systems that service the community.

The purpose of the condition assessment is to:

1. Understand the present state of the facilities and underground assets that are used to deliver water and wastewater services; and

2. Identify required spending on the infrastructure systems to ensure water and wastewater services can be sustained over the long term.

The outcomes of this report support other asset management planning processes in the Township, including the Asset Management Plan, Water and Wastewater Rate Study and the Water Financial Plan.

It should be noted that although called a condition assessment, the scope of this project includes a comprehensive assessment of the current state of the system that considers functional and operational observations in addition to an assessment of physical condition.

It is noted that two separate reports have been prepared for the water and wastewater systems, respectively. The details of the wastewater system are located in the report entitled “Report to the Township of Madawaska Valley for the Condition Assessment of the Wastewater Treatment System”.

2 Scope

This report captures all assets that comprise the water system. This includes:

- Water Treatment Plant
- Water Tower
- Watermains

3 Methodology

The methodology to complete the condition assessment was as follows:

1. Complete a desktop analysis of all available asset information. This includes drawings, schematics, annual reports, past budgets, plant performance data and plant maintenance data.

2. Complete site visits to obtain visual condition information of assets and to understand other plant performance issues that may be observed through hands-on observations of the facilities. It should be noted that the scope of the project did not include the visual assessment of sewer mains or other buried assets.

3. Discuss with system operators to understand history and issues with the assets that may not be apparent through a review of available information or visual assessment observations.

4. Establish the spending that is required to address any observed asset condition or performance deficiencies. The majority of the spending is related to the rehabilitation or replacement of infrastructure assets, however, in some cases additional studies or investigations have been recommended.

4 Limitations

This report is a planning document to inform future works that will be necessary to maintain the current performance of the wastewater treatment system. The recommended spending includes proposed projects to address asset needs as they deteriorate over the planning period. The recommended projects are expected to generally ensure that the systems continue to perform at recent historical levels (i.e. to maintain current service levels). The spending recommendations do not reflect any projects that would be required to increase system performance or increase service levels.

The following limitations are noted:

- Some of the expenditures identified may require preceding engineering studies to properly refine associated cost estimates or refine the scope of work. The costs of potential front-end engineering work have been estimated and included in the cost estimates.
- The accuracy of spending amounts identified in the report decrease with time. OCWA uses the AACE cost estimating framework to identify our cost estimate classification. Activities recommended in the 5+ year window are considered to be Class 5 cost estimates (+/- 50%), with increasing accuracy in shorter term project cost estimates.
- Expenditures recommended in this report are the costs required to maintain proper functioning of the infrastructure assets and do not include the costs associated with routine operational expenditures such as operational service costs (i.e. OCWA O&M), labour costs, energy costs, chemical costs, communication costs, etc.
- The state of assets can change quickly. The assessment of the assets reflect a point in time based on information that was readily observable.
- No destructive or intrusive testing was completed. In some cases, recommendations for additional testing may be made to confirm the current state of an asset.

5 Water Distribution System Overview

The Madawaska Region Drinking Water System is comprised of a treatment plant, a treated water storage tank, and a distribution system, which are all included in this report. The water treatment plant (WTP) in Barry's Bay was originally constructed in the early 1970s and has undergone major upgrades and rehabilitation works since its construction, with the most significant work being conducted between 2005 and 2007. The water distribution system is largely the original 1970s vintage PVC.

5.1 Barry's Bay WTP Overview

The Barry's Bay drinking water treatment plant is a direct filtration plant that utilizes coagulation/flocculation, filtration, and chlorination process to treat raw water from Kamaniskeg Lake. Alum is added to assist in the coagulation before being processed through the filters. Soda ash is also added for pH adjustment and to increase alkalinity. The filtered effluent is injected with chlorine gas for disinfection before entering the clearwell.

From the clearwell, high lift pumps direct the treated water into the water distribution system, which consists of PVC piping and a standpipe water tower. The water level of the standpipe is used to control the treatment plant's high lift pumps.

Wastewater generated from the treatment plant is stored in a sludge holding tank and periodically pumped into the sewage collection system. Emergency generators are on-site to provide electrical power in the event of a power failure

5.2 Watermains

The vast majority of the water distribution systems was constructed as part of a single project from 1972 to 1974. A small amount of new watermains have been constructed in the north end of the system over the past 20 years to service new development. A schematic of the system is included in Appendix A.

There is a total of approximately 11.4 km of watermains. There is a mix of 150 mm and 200 mm diameter pipes. The pipe material is PVC. Dimension ratio or pipe classification is not known as it was not detailed on the drawings.

6 Condition and Performance Assessment

Condition and performance assessments identify areas/processes/equipment that have deficiencies which require spending to ensure services can be maintained. This assessment is broken down into different sections:

- Assessment of Capacity (Treatment Plant, Water Storage, Future Demand Projections)
- Assessment of Treatment Proficiency
- Assessment of Equipment Condition (Site visit)
- Assessment of Recent System Events

6.1 Assessment of Plant Capacity

The plant's capacity to supply the existing and future water demand while providing sufficient water storage for emergencies is critical for determining the timeline for future plant or storage expansion.

6.1.1 Flow Capacity

To assess the present demand for treated water, the last 15 years of daily treated water flows were compiled.

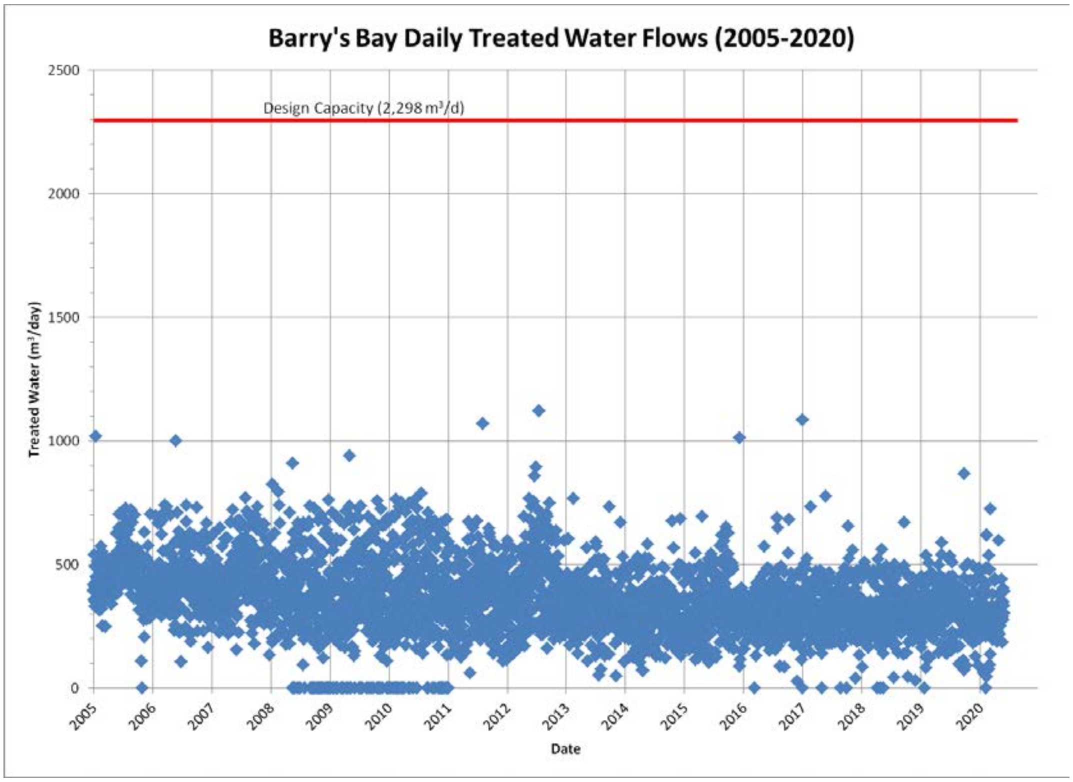

Figure 1: Barry's Bay Treated Water Flow History (2005-2020)

Figure 1 shows the historical water demand in comparison to the plant's design capacity. The average flow for the past 15 years is 364 m^3/day, while the plant has a capacity to produce 2,298 m^3/day. Plant production capacity must always exceed water demand to prevent shortages and low-pressure events in the distribution system. Water treatment capacity expansion is a consideration when the average flow is between 70-80% of design capacity. At present, average flow is at 16% design capacity.

6.1.2 Water Storage Assessment

Over the last 15 years, the plant's maximum daily flow was 1,123 m^3/day A plant's ability to handle peak flows is a combination of treated water storage capacity and the plant's design capacity. High instantaneous water demand can be mitigated by utilizing stored water for temporary equalization. Water storage capacity is a combination of storage volume in clearwells (provided emergency power is in place), and usable storage volume of a system's water towers. The design guidelines for drinking water systems developed by the MECP has recommended treated water storage requirements (TWSR) based on equalization water storage, fire flow protection water storage, and emergency water storage. The TWSR can be expressed in the equation below.

$$\boldsymbol{TWSR}\ (m^3) = 0.24275 Population + 0.3125 Peak\ Day\ Demand + 263.225$$

By inputting the population and Peak Day Demand information for Barry's Bay, the Drinking Water System's TWSR was determined to be 926 m^3.

$$\boldsymbol{TWSR}\ (m^3) = 1{,}287 people * 0.24275 \frac{m^3}{person} + 0.3125 * 1{,}123 m^3 + 263.225 m^3$$

$$\boldsymbol{TWSR}\ (m^3) = 926m^3$$

The existing storage tank in the system has a volume of 1,364 m3, which is sufficient to meet the treated water storage needs of the town. As Barry's Bay grows in the future, the TWSR will need to be reassessed to account for the increasing population.

6.1.3 Population Growth

The last factor that is significant in determining the necessity of future plant or storage expansion is the population growth within the municipality. As a population grows, both peak day demand and average water use grow proportionally. Estimations on future expansions to treatment capacity or water storage can be determined by estimating the rate of growth within a municipality.

To estimate the growth of water users on the system, the population of Barry's Bay has to be projected into the future. This projection can be accomplished by looking at planning documents and population census history.

Table 1: Barry's Bay Population History

YEAR	BARRY'S BAY CENSUS POPULATION
1996	1086
2001	1115
2006	1178*
2011	1241
2016	1259

**Population for 2006 was interpolated based on 2001 and 2011 data since no data for that date was available.*

As seen in Table 1, the population of Barry's Bay has been increasing steadily over the last 20 years. This increasing population is the equivalent of an annual growth rate of 0.74%, which is approximately half the Canada average of 1.4%. Based on a 0.74% annual population growth rate, the existing storage and treatment facilities of the Barry's Bay Drinking Water System will not require expansion within the next 20 years. Based on present water demand rates in Barry's Bay, capacity expansion will not be needed until the Town's population reaches approximately 2,600, which based on recent trends may take 50 years or longer to be realized.

6.2 Treatment Proficiency Assessment

From the recent Drinking Water System Annual reports, a history of the Water Quality Parameters was compiled for the Treated and Distribution Water in Table 2.

Table 2: Treated Water Quality Parameter History (2015-2018)

PARAMETER	WATER QUALITY STANDARD	2015	2016	2017	2018
Distribution Free Chlorine (mg/L)	>0.05	0.29-1.63	0.26-1.42	0.83-2.35	0.25-1.55
Turbidity (NTU)	<5	0.1-0.49	0.09-0.21	0.12-0.26	0.14-0.59
Alkalinity as CaCO3 (mg/L)		22-29	24-30	21-27	16-32
pH	7-10.5 (6.5-8.5)*	7.02-7.64	7.28-7.66	7.19-7.67	6.95-7.6
Lead (µg/L)	<10	0.13-0.72		0.27-5.51	0.08-2.1
Trihalomethane (µg/L)	<100.00	39.75	38.75	43.75	43.25

*refers to older Ontario Standard for pH as opposed to the new Canada Standard

Table 2 illustrates that between 2015-2018 water quality standards have been maintained. These results also provide information that can be used to understand the properties of the water in Barry's Bay:

- The presence of THMs in the treated water is indicative of a raw water source containing organics compounds. The low level of THMs shows the effective performance of the filtration system to limit these organic compounds from reaching the chlorination treatment stage. Although there is presently no issue with the filters, THMs will always be a potential concern.
- The treated water turbidity is almost always maintained below 0.5 NTU, which shows both the effectiveness of the existing filters, but also a low turbidity raw water source.
- The factors of pH, alkalinity, and lead concentration are linked. Alkalinity and pH are the primary factors that control the corrosiveness of the water in the distribution system. With a pH between 7-8 and alkalinity below 30 mg/L as $CaCO_3$, the water would be at least mildly corrosive to most metal piping. This predicted corrosivity is corroborated by coloured water complaints and reported lead concentrations as high as 5.5 µg/L which is still below the Ontario standard of 10 µg/L but above the new Health Canada MAC of 5 µ/L.
- Coloured water comes from dissolved and particulate metal that has entered the treated water, usually through the corrosion of piping. Considering that the distribution system is entirely PVC, the sources available to cause coloured water or corrosion of lead would have to be metal distribution valves/connections or water pipes in resident's homes.

6.3 Equipment Condition Assessment

The condition of each asset was determined through visual observations and discussions with operational staff during a site visit to the Barry's Bay WTP. The assessment results of each process area is provided below.

6.3.1 Process – Mechanical

Although this category covers all equipment not otherwise specified below, it is mainly referring to the filtration units. The media filters which were upgraded in 2005-2007 appear to be in good condition with little visible wear on the units. These types of in-door metal filters can operate for a long time, especially if there is humidity control in the building to limit the corrosive effects of condensation.

6.3.2 Process – Mechanical & Process - Chemical Addition

The chemical addition of soda ash and alum and the chemical addition of chlorine gas both occur in rooms separated from the rest of the plant. Presently, all three chemical systems were in good working order. Over time, the chemical feed pumps and chlorine injector units will continue to deteriorate and require replacement. Recommendations to replace these assets have been made in the 5+ year time frame and will be reviewed on an annual basis. This type of equipment usually last 15-20 years, so it is recommended that spare part kits and/or replacement spares be available as appropriate.

6.3.3 Process – Mechanical & Process - HL/LL/BW Pumps

The process pumps of the plant were the equipment with the most visible wear and deterioration. This was expected as they are in constant use. In particular, high lift pump #1 and backwash pump #2 were observed to be in the worst state with areas of extensive corrosion. It is recommended that all high lift and backwash pumps be rehabilitated within 5 years. The lowlift pumps were in good condition and are expected to perform as expected over the medium term, but will require rehabilitation or replacement in the long term.

6.3.4 Process – Mechanical & Process – Media

Media used for filtration usually lasts for a minimum of ten years before requiring replacement. Media life is primarily based on use and the amount of material that has to be filtered out. As media performance declines, backwashing frequency increases (i.e. filter run times decrease). At present, the media is performing adequately and is unlikely to need to be replaced in the medium term.

6.3.5 Process – Mechanical & Process – Valves

The plant contains a large number of new isolation valves along with several Singer-type control valves. Actuators are common throughout the plant to allow for remote isolation of process equipment. These valves and actuators were in good condition and did not exhibit much corrosion or wear. Actuators are expected to fail periodically over the next 10 years, but several spares are available on-site for this eventuality. The control valves are a more critical asset, but they are expected to meet performance expectations for the medium to long term.

6.3.6 Process – Electrical

The process electrical systems associated with the Motor Control Centre (MCC) were part of the recent facility upgrade. This system was in good condition and it is unlikely that there will need significant expenditures within the next 20 years.

6.3.7 Process – Instrumentation and Control

The instrumentation and control equipment was observed to be in good condition. Considering the varied lifespan of instrumentation and control equipment, it is likely that replacement will continue to be a regular occurrence. Control systems like SCADA can require regular updates (3-7 years), Process Logic Controllers (PLCs) last between 10-20 years, while meters can start to fail as early as 10 years. Considering that the plant's turbidity meters were recently replaced, it should be expected that other instrumentation and control equipment will need replacement over the next decade. Spare part kits should be considered in order to reduce replacement costs and extend the longevity of instruments.

6.3.8 Process – Piping

As previously noted in Section 3.2, the raw water is somewhere corrosive. This may be causing internal corrosion within the non-stainless piping and equipment which is not visible.

6.3.9 Process – Structural

The process structural system refers to concrete clearwells, lowlift well, and raw water intake structure. Much like the facility's concrete structure, there was no significant sign of visible deterioration. Given that the interior of the clearwell is exposed to off-gassing of chlorine, it is recommended that the interior of the clearwell be inspected at a frequency of at least every 5 years. The lowlift well and raw water intake should also be inspected periodically.

6.3.10 Facility – Mechanical

The facility's mechanical equipment refers to the heating, ventilation and air conditioning (HVAC) system through the WTP. This is primarily a number of unit heaters and vents/louvres. The equipment is in good condition. This equipment has an expected service life of approximately 20 years, so these assets will likely require rehabilitation or replacement in the long term (i.e. 10+ years). In the case of the unit heaters, the brand was identified as one with a reputation for long life, so replacement after a longer service life would not be unexpected.

6.3.11 Facility – Electrical

Similar to process electrical, the facility's electrical systems associated with the transformer, cabling, and electrical panels were part of the recent facility upgrade. No immediate spending activities were identified and it is unlikely that a replacement will be needed within the next 10 years.

6.3.12 Facility – Architectural

The facility's architectural assets refer to the red brick cladding, windows, doors, and protective paint. The present condition of the cladding is fair with it a possible touch-up recommended in the long-term (10-20 years) period. The exterior paint has faded and has worn completely in many areas. A touch-up of the exterior could be carried out to improve building aesthetics. Doors and windows were seen to be in good condition.

6.3.13 Facility – Structural

The facility's structure refers to the concrete and steel that makes up the building itself. In this case, the roof is also included as part of the facility structure. This structure dates back to the building's original construction in the 1970s. Given that the structure is approaching 50 years of age, it is in remarkable condition with the exception of the roof. The concrete interior shows little structural deterioration.

The roof has been identified as in need of replacement by operations staff. It is recommended that an inspection of the roof's condition be carried out in the near future to identify the scope of this work and determine an accurate cost of the associated works.

6.3.14 Emergency Power

The onsite emergency generator was installed as part of the recent plant upgrades. With regular maintenance, this type of generator should be able to provide back-up power to the plant for the next two decades before consideration for its replacement. Rehabilitation is recommended to occur between 2028-2032.

6.3.15 Water Storage

The water storage facility in the distribution system is composed of the standpipe and associated control systems. There has been recent work to repair a malfunction in the control system that resulted in an overflow, but this incident was not indicative of a systemic issue. The standpipe was constructed with the original system in the 1970s and is starting to show its age. Specialized inspection and testing services are required to assess the steel and concrete portions of the standpipe. This includes:

- A robotic video inspection of the internal portions of the steel tank
- Specialized concrete testing by non-destructive techniques (i.e. concrete core, Schmidt Hammer, etc.) to fully assess its condition.

Therefore it is recommended that a comprehensive inspection is carried out of the standpipe by experts in this specific type of facility during the next few years.

6.3.16 Distribution System

The distribution system is generally meeting expectations. The recent failures, as summarized in Section 6.4, have been localized to one area of the system.

Watermains failures are caused by stresses on the pipe wall. These stresses are typically due to shifting bedding (from frost action) or integral stresses caused by pressure fluctuations (known as water hammer or transient surge pressures).

The cause of the localized failures is not known. It is noted that the failures were prior to the installation of the variable frequency drives (VFDs) on the high lift pumps at the plant. VFDs have soft starters which reduce the high pressure surge seen during start up of a pump equipped with a standard motor.

The installation of pressure monitoring on hydrants in the vicinity of recent water main failures would help to understand if there are any high pressures that are experienced in the system.

6.4 System Event History Assessment

From the recent Drinking Water System Annual reports a history of the recent major maintenance works was compiled in Table 3.

Table 3: System Work History (2015-2019)

YEAR	2015	2016	2017	2018	2019
WTP Work History	Alum Pump Replacement High Lift Pump VFD Install Chlorine Gas Sensor Replacement Filter#3 Underdrain Replacement	HMI and SCADA Repairs	Turbidity Analyzer Repair PLC Repairs Sediment filters for CO Hall Installation	Filter#2 Underdrain Replacement Chlorinator Upgrades Waste Pump Repairs SCADA Repairs	Heat trace for wasteline Filter #1 PLC repair Sludge pump part replacement Roof inspection and minor repair
Water main Repairs		Wilno St. & Queen St. Replacement	Queen St. & Bay St. Repairs	Stafford St. Repair	Opeongo Line valve repair Casey St. service line repair Brady St. valve replacement

When analyzing the work history in Table 3, it must be done in the context of the system's age and condition. The WTP structure can be dated to the early 1970s along with the Town's distribution system, while a majority of the process equipment was installed in the most recent major upgrade in (2005-2007). This puts the WTP structure and distribution at approximately 50 years of age with the process equipment at around 15 years.

The majority of the works in the system's recent history were expected to occur based on their expected equipment life span. Control equipment is only expected to last 10-12 years, so repairs to the PLC and HMI were expected. SCADA software is usually designed to be operable for 6-7 years before requiring an update/upgrade, so it would be a reasonable assumption that the 2016 SCADA work was the second upgrade to the SCADA since its original installation. Chemical pumps are usually expected to last around 15 years, but alum pumps are known to clog, so an early replacement is not unexpected. Analyzer equipment tends to last around 15 years so the recent replacement in 2018 is also an expected occurrence.

The unexpected works were the replacement of the filter underdrains and the repairs of the watermains. These types of filters should require minimal maintenance work with only media replacement at this stage in their operation. Therefore, the need to replace the underdrains is currently being considered as a one-time occurrence and not a recurring activity.

Watermain failures are a common event in all drinking water systems, but the unexpected issue is the concentrated location in which these replacements occur. The streets of Wilno, Queen, Bay, and Stafford are all clustered east of the water tower. As noted in Section 6.3, the installation of VFDs on the high lift pumps may have reduced the high pressure surges experienced in the system.

It should also be noted that the break frequency of these pipes has not reached a point where it would be cheaper to replace the pipes rather than continuing to repair sections. Failures will continue to be monitored and tracked to assets on an annual basis. Continued failures in this area would eventually warrant consideration to replace some segments with new PVC pipe. However at this point in time it is not feasible to predict when this is likely to occur. Pressure monitoring or leak detection could be completed in this area to understand if there is any evidence to explain the localized failures.

7 Condition Assessment Recommendations

The follows points are provided to summarize the results of the analysis.

- No Upgrade of treatment or storage capacity is required to account for existing and future demand (
- Upgrade of the treatment process to account for deficiencies in existing treated water quality (Section 6.2),
    - The water quality parameter shown to be most significant is the combination of pH and alkalinity that creates treated water that is at least mildly corrosive. This water chemistry can lead to coloured water event and elevate concentrations of lead. It is possible to address the corrosiveness of the water by increasing the alkalinity and pH of the water or by adding a corrosion inhibitor, like orthophosphate.
    - This action would increase the operating cost of the system and would only correct a relatively minor issue as coloured water events are rare and the concentration of lead is still below the maximum allowable concentration (MAC) limit. However, it should be noted that the MAC limits become increasingly stringent over time, and therefore it is reasonable to expect that at some point in the long term there may need to be a process change to improve treated water quality output at the plant.
- Replacement of equipment to account for an existing poor condition and likelihood of failure in the near future (Section 6.3),
    - The majority of the process equipment is between 13-15 years old, as such the plant is entering the start of the life cycle period were equipment repairs, rehabilitations, and replacements will occur on a more frequent basis. In particular, it should be expected that major maintenance costs for process pumps, chemical feed systems, and instrumentation and control equipment will increase.
    - It is also recommended that inspections of the plant’s structural concrete increase in frequency. This includes raw water intake, low lift wells, clearwells, valve chambers, and standpipes.
- Replacement of equipment based on a history of failure and repairs (Section 6.4).
    - The only trend shown in the repair history is the localized breakages of the watermains. The present cause is unknown and so it is recommended that pressure monitoring be completed in that section of the distribution system. If the watermain breaks frequency in this area accelerates then the long-term solution would be the complete replacement of the watermain in that section of the distribution system.

7.1 Recommended Major Maintenance and Capital Works

Please refer to Section 4 for the limitations associated with these recommended projects and cost estimates.

SHORT TERM RECOMMENDED WORKS (1-5 YEARS)	ESTIMATED COST
Pressure distribution investigation	$10,000
Standpipe inspection to more accurately determine condition and needs	$7,500
Roof replacement (2023)	$80,000
Hydrant and watermain replacement program	$250,000 over 10 years
High lift and backwash pump rehabilitation	$35,000
MEDIUM TERM RECOMMENDED WORKS (6-10 YEARS)	ESTIMATED COST
Chemical pump replacement	$55,000
Replacement of PLC and SCADA control system	$35,000
Instrumentation replacement	$60,000
Potential distribution pipeline replacement	$500,000-$1,000,000 - cost dependent on amount of watermain replacement
Standpipe rehabilitation	$50,000-$150,000 - cost dependent on inspection results
Backwash/high lift/low lift pump replacement	$250,000, over several years and dependent on condition

APPENDIX A
Watermain Schematic

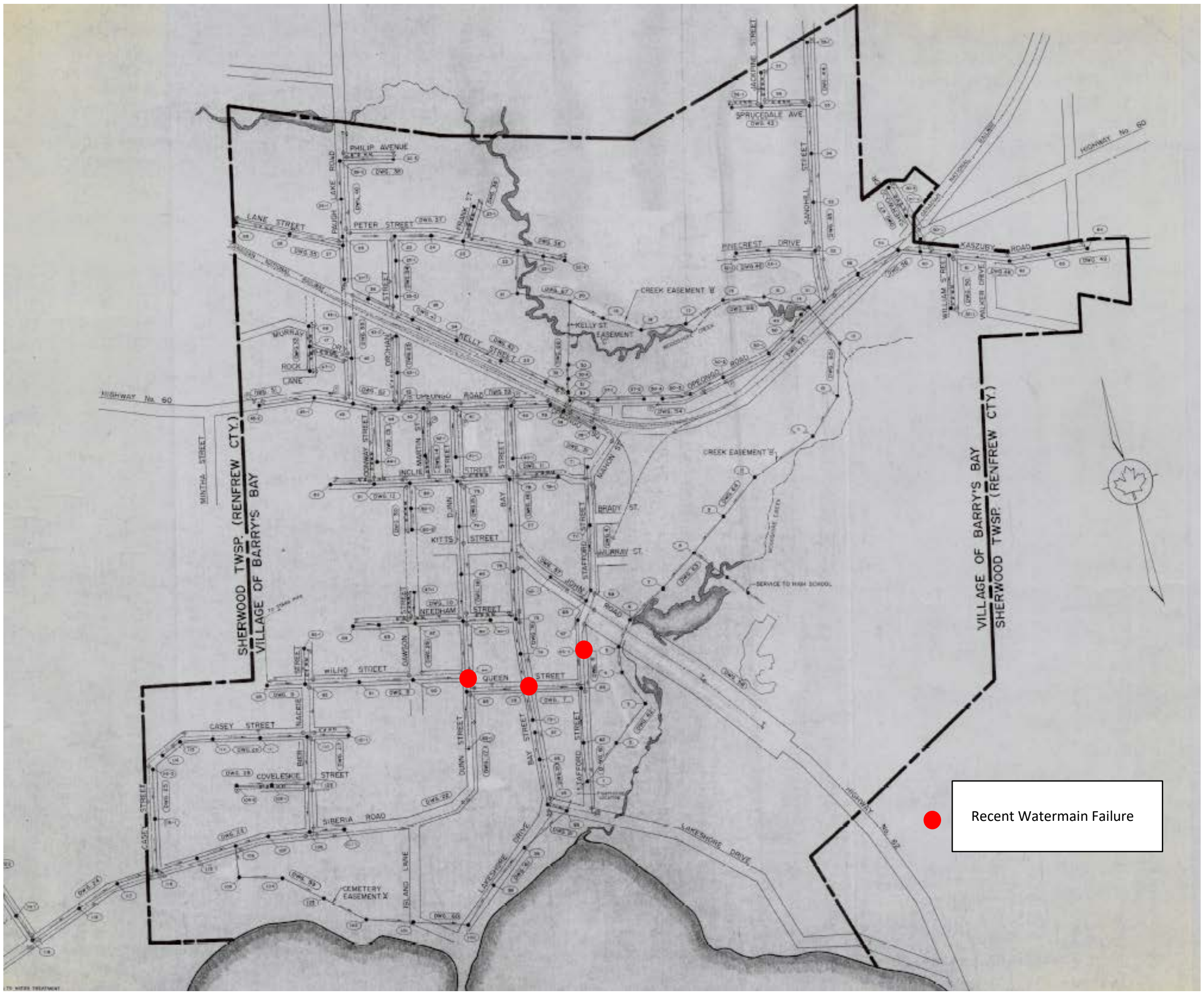

Figure 2: Water System Schematic