ENGINEERING LTD.

WATERWORKS SYSTEM ASSESSMENT FOR THE TOWN OF OUTLOOK

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TOWN OF OUTLOOK
WATERWORKS SYSTEM ASSESSMENT 2020

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1. BACKGROUND

The purpose of this Waterworks System Assessment for the Town of Outlook is to review the community's water supply, treatment, storage and distribution facilities in accordance with the *Waterworks and Sewage Works Regulations*, 2015. These regulations require all waterworks supplying water intended for human consumption to obtain an independent engineering assessment every 5 years. This assessment is intended to identify, analyze and mitigate any potential adverse risks and environmental impacts related to the waterworks.

The Town of Outlook is a community of approximately 1,800 people, located in central Saskatchewan along the South Saskatchewan River. The Town is approximately 90 km south of Saskatoon, with access provided by Highway 15. BCL Engineering Ltd. conducted a site inspection of the Town waterworks facilities on February 13th, 2020.

An overview of the Town waterworks system is as follows:

- raw water is supplied by an intake structure and raw water pumphouse, which draws surface water from the adjacent South Saskatchewan River and pumps it to the treatment plant in the Town;
- within the plant, treatment is provided by a 3 stage flocculation chamber, followed by dual mixed media gravity filters and disinfection by chlorination;
- treated water storage is provided by two underground concrete storage reservoirs and a pump well;
- the pump well is equipped with three vertical turbine distribution pumps and an engine driven standby pump, which provide pressure for the Town water main network.

2. EXISTING INFRASTRUCTURE

2.1 RAW WATER SUPPLY

The raw water source for the Town of Outlook is the South Saskatchewan River. A 600 mm diameter intake pump, complete with 1,000 mm diameter steel intake screen are installed in the river, supplying water to a pumphouse on the riverbank. Water flows by gravity into the wet well under the pumphouse. The Operators reported that the intake screen experiences issues with sediment build-up and is occasionally landlocked by shifting sandbars along the river.

The pumphouse is a timber framed building situated on a concrete wet well structure and contains the following equipment:

- two vertical turbine pumps for supply of raw water to the water treatment plant;
- related piping and valves, including solenoid activated pressure sustaining valves to prevent emptying of the raw water main while the pumps are not operating;
- pump motor starters and related electrical;
- level sensor with alarm communication;
- electric unit heaters;
- telephone communication wire for communication of alarm and pump initiation signal.

The facility is aging, and corrosion and general deterioration of structure and finishes was observed.

The pumps are driven by 60 hp, 3 phase, 460 V motors and are capable of pumping upwards of 56.8 L/s. One motor was replaced in 2019, while the other is reportedly original from the time of construction. A new turbine was also recently replaced on one pump. The pumps are run individually and manually alternated every few days. Due to the facility arrangement, pump removal is difficult.

Raw water is pumped from pumphouse to water treatment plant through approximately 700 m of 400 mm diameter series 100 polyethylene piping, installed in 1989.

The raw water license held by the Town allocates an annual quantity of 697,000 m^3 of raw water at a maximum diversion rate of 185.8 L/s.

2.2 TREATMENT

Raw water entering the plant is metered, sampled for turbidity with an online turbidimeter, and dosed with a coagulant for flocc development. The raw water header deposits raw water into a concrete, three stage flocculation chamber. Each chamber stage is equipped with a motorized paddle wheel; however, only the unit in stage 2 is used during regular operation. Heavier flocc settles to the chamber bottom and clarified water overflows a weir into dual mixed media gravity filters. The anthracite and sand media filter remaining flocc and other suspended particulate. Filter effluent is sampled for turbidity before deposition into the pump well chamber below the plant. The pump well is dosed with chlorine for disinfection as well as fluoride. The operating rate of the treatment filters running in tandem is approximately 56.8 L/s. New media was reportedly added in 2004. An inspection conducted by AWI Filter in 2019 found that the filters were generally operating as intended.

The filters are backwashed daily using a dedicated backwash pump that draws treated water from the pump well. The pump is a vertical turbine pump, driven by a 30 hp, 3 phase, 600 V motor. Each filter is individually air-scoured and then backwashed at a rate of approximately 114 L/s. The backwash process is initiated and controlled by the operators, who must manually close filter effluent valves and open the appropriate backwash influent and waste valves before operating the pump. Backwash effluent is deposited to the storm sewer system. The filters are not equipped with a filtration to waste option; therefore, a spike in turbidity in the filter effluent is typically observed following backwash.

2.2.1 Chemical Feed Systems

Raw water is dosed with a coagulant prior to entering the flocculation chamber. The coagulant currently used by the operators is Clearpac 182 supplied by ClearTech. Coagulant is dosed by a Grundfos Alldos DDE chemical pump at a typical rate of 14 mg/L. This is below the maximum use limit of 200 mg/L, as recommended by NSF60 regulations.

Following filtration, water is deposited into the pump well. The pump well is dosed with chlorine gas for disinfection and fluoride for consumer oral health. The fluoridation chemical used by the operators is Hydrofluorosilicic Acid supplied by Brenntag. Fluoride is dosed by a Grundfos Alldos DDE chemical pump at a typical rate of 0.7 mg/L. This is below the maximum use limit of 6 mg/L, as stipulated by NSF60 regulations.

Disinfection is provided by dosing with pure chlorine gas. A separate room with dedicated ventilation and gas detection devices is provided for storage of gas cylinders. Access to the room is available from the plant exterior only in order to maintain separation of the gas from the rest of the building. Chlorine gas is dosed at a rate of 0.2 mg/L. This is less than the maximum use limit of 30 mg/L, as recommended by NSF60 regulations.

In the current arrangement, chemical is dosed directly to the pump well, which is also where the distribution pumps draw from. This scenario presents risk of inadequate mixing and contact time of the chemical prior to distribution, as well as stagnation of the water in the other reservoirs. This condition would only be in effect while the plant is making water.

With exception of the chlorine gas cylinders, chemical is stored in the maintenance and storage area of the plant. The feed stations and pumps appear clean and in good working order.

2.2.2 Contact Time Disinfection

To ensure effective disinfection in the treated water the chlorine residual in the water must be maintained and given adequate contact time. The effectiveness is determined by a CT value (residual disinfectant concentration multiplied by the contact time), which is determined for a specific temperature and pH.

Typically, surface water treatment facilities are required to provide 3 log removal (99.9%) removal/inactivation of giardia and 4 log (99.99%) removal/inactivation of viruses. Log removal credits are allowed for various filtrations processes. The treatment process for the Town is considered to be conventional surface water treatment and as such, would receive 2.5 log credits for giardia and 2 log credits for viruses. Applying the credits to the total facility requirements, results in disinfection requirements of 0.5 log removal/inactivation for giardia and 2 log removal/inactivation viruses.

There are two scenarios that must be evaluated to determine the contact time requirements for the plant. When the treatment unit is not running, water circulates through the reservoirs to the pump well in series. A sample calculation for the contact time in this scenario is as follows:

The contact time of the system is calculated from the reservoir size and peak hour flow rate:

Example CT calculation:
Estimated Average Day Consumption = 11.3 L/s

Peak Hour = 4.0 x Average Day = 11.3 x 4.0 = 45.1 L/s
Total Reservoir Volume = 2,886,500 L

Assuming reservoir levels dropped to 50% of normal operation, yields a reservoir volume of:

2,886,500 L x 50% = 1,443,250 L

A baffling factor must also be applied to account for the potential for water to 'short circuit', passing through the reservoirs too quickly, without adequate mixing. The baffling factor is selected based on the reservoir configuration and flow path between the points of disposition and withdrawal. Higher factors area awarded to configurations which limit potential for stagnation and maximize flow path distance. Due to the multi-compartment reservoir, transfer pumping requirements and overall flow path distance, a baffling factor of 0.7 is deemed appropriate.

Reservoir Volume x 0.7 Baffle Factor = 1,010,275 L

Time for 70% of water to pass through reservoirs
1,010,275 L ÷ 45.1 L/s = 22,404 seconds = 373.4 min.

Based on available records, the Operators typically maintain a free chlorine residual in the range of 1.0 - 1.5 mg/L. The minimum free chlorine residual measured at the water plant in 2019 was 0.34 mg/L. Applying the free chlorine residual to the reservoir detention time yields a chlorine contact time of:

CT (May 25, 2018) = 0.34 mg/L x 473.0 min. = 160.8 mg/L x min.

The table below illustrates the CT values required for 2 log inactivation of viruses and 0.5 log inactivation of giardia versus the actual distribution chlorine residual samples and the resulting CT value.

CT Requirements for Giardia and Virus Inactivation

Free Chlorine Residual (mg/L)	CT Requirement for 2 log Virus Inactivation (mg/L x min)			CT Requirement for 0.5 log Giardia Inactivation (mg/L x min)*			Actual Calculated CT (mg/L x min)
	at 10.0 °C	at 5.0 °C	at 0.5 °C	at 10.0 °C	at 5.0 °C	at 0.5 °C	
1.50	3.0	4.0	6.0	23.9	31.9	45.4	560.1
1.00	3.0	4.0	6.0	22.3	29.8	42.2	373.4
0.34	3.0	4.0	6.0	20.8	27.7	39.5	127.0
0.10	3.0	4.0	6.0	20.5	27.7	39.5	**37.3**

*Giardia inactivation requirements for raw water pH level of 7.5.

In this scenario, a minimum free chlorine concentration in excess of 0.1 mg/L is required to provide both giardia and virus inactivation by disinfection.

However, during the operation of the treatment process, filtered water is deposited directly to the pump well and can potentially bypass the storage reservoirs and enter the distribution system. It is very difficult to determine how much of the filtered water is distributed and how much is removed by the transfer pump. In the worst-case scenario, the effective storage for chlorine contact would be limited to the pump well volume (129,000 L). In this scenario, the baffling factor must be reduced to 0.1 due to the chlorine dosing arrangement and effective single cell operation. Applying this scenario, the calculated CT values for the residuals are as follows:

CT Requirements for Giardia and Virus Inactivation

Free Chlorine Residual (mg/L)	CT Requirement for 2 log Virus Inactivation (mg/L x min)			CT Requirement for 0.5 log Giardia Inactivation (mg/L x min)*			Actual Calculated CT (mg/L x min)
	at 10.0 °C	at 5.0 °C	at 0.5 °C	at 10.0 °C	at 5.0 °C	at 0.5 °C	
3.0	3.0	4.0	6.0	27.7	36.8	52.7	**17.7**
1.5	3.0	4.0	6.0	23.9	31.9	45.4	**8.8**
1.0	3.0	4.0	6.0	22.3	29.8	42.2	**5.9**
0.34	3.0	4.0	6.0	20.8	27.7	39.5	**2.0**
0.10	3.0	4.0	6.0	20.5	27.7	39.5	**0.6**

*Giardia inactivation requirements for raw water pH level of 7.5

As shown, a free chlorine residual of well in excess of 3.0 mg/L must be maintained to ensure adequate inactivation of viruses and pathogens entering the distribution system. Therefore, this scenario puts the Town at significant risk and should be addressed as soon as possible.

2.2.3 Treated Water Quality

Raw water from the South Saskatchewan River is typically of good quality, but periodically exhibits elevated levels of coliforms, turbidity and organic carbon. These conditions typically occur at times of the year when surface runoff into the river is high.

The treatment process used is effective in lowering the level of turbidity present in the raw water. However, conventional surface water treatment filters are often ineffective at removing dissolved organics. Dissolved organics react readily with chlorine to produce undesirable by-products in water, such as trihalomethanes (THMs) and haloacetic acids (HAAs). A full list of water quality test results is appended.

A description of the relevant constituents are as follows (provided by SRC Analytical Chemical Health & Toxicity Package, with the exception of *):

Dissolved Organic Carbon*

Dissolved organic carbon (DOC) is defined as carbon content in water which can pass through a filter smaller than 0.7um. Generally, organic carbon is the result of decomposition processes from dead organic matter such as plants and animals. Some dissolved organics are a food source for heterotrophic bacteria and can therefore support biological regrowth within a water distribution system. Organic carbon also reacts with disinfection products such as chlorine, resulting in development of undesirable disinfection by-products such as THMs and HAAs. Currently the raw water at Outlook is only tested for turbidity. Data obtained from the City of Saskatoon indicates the DOC levels of approximately 3.0 mg/L in the South Saskatchewan River system. It is likely that these levels fluctuate significantly during differently periods of the year. There is no limit for DOC defined by the Canadian Drinking Water Quality Guidelines or Saskatchewan Drinking Water Quality Standards and Objectives.

Trihalomethanes*

The use of oxidants, such as chlorine, for disinfection, taste, odour and colour removal produces disinfection by-products (DBP). The most notable DBP at this time are THMs and HAAs. THMs and HAAs are formed when chlorine reacts with organic substances in the water. It is critical that proper optimization of water treatment processes be adhered to in order to reduce / minimize the levels of DBP precursors, such as organics, in filtered water prior to the addition of chlorine. The current federal and provincial guideline for THMs is 0.1 mg/L and the current federal and provincial guideline for HAAs is 0.08 mg/L. It is expected that the maximum allowable concentration for total trihalomethanes will be further lowered, keeping with trends set by the U.S. Environmental Protection Association. Testing conducted in the past five years on the treated water indicated THM levels ranging from 0.04 – 0.09 mg/L and HAA levels ranging from 0.02 – 0.08 mg/L.

Turbidity

Turbidity in waters is caused by suspended material such as algae, silts and organic matter. Turbidity is often considered to be the clarity of the water. Turbidity is considered to be very important for health and aesthetic reasons. A high level of turbidity, or "cloudy" water, is not aesthetically pleasing. In addition to this, turbidity levels are related to the effectiveness of disinfectants. Higher turbid waters occasionally mask the effects of disinfectants against viruses and pathogens. A review of the water plant records indicates that the filters are effective in reducing turbidity to acceptable levels. Turbidity leaving the plant is monitored and within Permit requirements.

2.3 WATER STORAGE

Filtered water is deposited directly to the pump well, which is a subgrade concrete structure that serves as part of the water plant foundation. The pump well has a volume of approximately 159,000 L. Access to the pump well is available by floor hatch located in the dry pit. The backwash pump is used to transfer water from the pump well to the external reservoir.

The external reservoir is a subgrade concrete structure with a storage volume of approximately 2,273,000 L, located approximately 50 m west of the plant. Access to the external reservoir is provided by an insulated hatch, which is kept locked at all times. Water from the external reservoir is transferred by gravity main to the concrete reservoir that serves as the foundation of the original water plant.

The water plant reservoir has a storage volume of approximately 454,500 L. Access to the reservoir is provided by floor hatch located in the original water plant building. Water from the plant reservoir is transferred back to the pump well for distribution by a transfer pipe equipped with an automated valve, controlled by float switch. The total available storage volume is approximately 2,886,500 L.

The operating level of the pump well is several metres below that of the two reservoirs, which necessitates transfer to and from the reservoirs by mechanical means. The distribution and transfer pumps are mounted in a dry pit, which is situated adjacent to the water plant reservoir and above the pump well. There are inherit risks associated with this arrangement, such as failure of the control valve or floats controlling the pump well level resulting in flooding of the dry pit, or draining the pump well to a low level condition. Either scenario results in damage to the pumps and potential significant disruption to the supply of water to the Town.

2.4 DISTRIBUTION

The plant is equipped with three vertical turbine distribution pumps, which draw from the pump well. Each pump is driven by a 20 hp, 3 phase, 600 V, 1,800 rpm motor, equipped with a variable frequency drive. The pumps provide pressure for the distribution network, which operates at approximately 47.2 psi. The exact pumping capacity of the system is unknown, but it is estimated to be in the order of 40 – 50 L/s with two pumps in operation. It was reported that during typical operation only one pump is required to maintain set pressure. Peak periods occasionally require a second pump, with third pump operation only required during hydrant flushing activities. Lead-lag pump duties are alternated daily by the operators. Emergency power provisions at the plant only operate the lead pump.

The plant is equipped with a truck pipe supplied by a dedicated line connected directly to the distribution header. The supply pipe is equipped with a backflow prevention device, air gap, flow meter, pressure gauge, and solenoid operated drain valve.

The plant is also equipped with a vertical turbine standby pump, which is powered by a right-angle drive and a natural gas fueled engine. The engine must be operated manually and is not equipped with a variable frequency drive. The distribution header is equipped with a pressure relief valve which discharges back to the pump well.

Distribution water is sampled with an online turbidimeter and chlorine analyzer prior to entering the water main network. It was reported that the majority of the original water main installations within the Town were constructed of asbestos cement (AC) pipe, with select sections constructed of cast iron pipe. Subsequent repairs and expansions of the network have been constructed of polyvinyl chloride (PVC) pipe. The distribution network is equipped with 150 mm diameter hydrants for fire protection.

2.5 CONTROLS AND ELECTRICAL

The electrical service to the water plant is a 3 phase, 600 V service. Surge protection is provided by a transient suppression device. Emergency power is provided by a 25 kW, diesel fuelled generator, complete with transfer switch. The generator is capable of operating the water plant facility and a single distribution pump. Water treatment is not possible while operating on emergency power.

The water treatment plant control is provided by several systems and instruments, including the following:

- the water treatment process is initiated by a Milltronics level sensor within the water plant reservoir. When the low-level condition is reached, the PLC sends a signal to the raw water pumphouse to operate the pumps;
- a flow switch on the raw water header within the plant energizes the chemical pumps and flocculator motor;
- float switches within the filter tanks control a modulating effluent valve to maintain consistent filter level during operation;

- a pressure transducer on the distribution header communicates directly to the distribution pump VFDs to maintain distribution pressure.

The plant is equipped with an online system for monitoring, data logging, and alarm generation. Data monitored includes:

- raw water pump status;
- raw water turbidity and flow status;
- filter effluent turbidity;
- pump well and water plant reservoir levels;
- distribution pump speed and status;
- transfer and backwash valve status;
- turbidity for raw water, filter effluent, and distribution;
- distribution turbidity, free chlorine, pressure, and flow rate.

Alarms for numerous conditions are generated and communicated to the operators by an autodialler.

2.6 Water Treatment Facility

The original water treatment facility was constructed in 1962 and consisted of the reservoir, pump well, and overlying building. The original building is constructed of masonry block walls and a wood truss roof on concrete reservoir foundation. The roof was replaced with pre-finished metal cladding in 2012. The building electrical equipment was also upgraded at this time.

An addition was constructed in 1982, consisting of a pre-engineered steel building with metal-clad walls and roof, on concrete slab and foundation. The original treatment process equipment was replaced with the current systems during these upgrades.

Aside from process equipment the building contains the following:

- fluorescent and incandescent light fixtures;
- natural gas unit heaters;
- an emergency shower and eye wash station;
- storage space for chemical, maintenance equipment, and supplies;
- a lab testing area;
- office space and document storage;
- a washroom.

In general, the building appeared well maintained and no concerns with the building envelope or structure were observed. The exception to this is partial settlement of the grade supported slab below the filter unit. The settlement reportedly occurred shortly after construction and has not progressed since. Adjustments to the filter weirs have been made to account for the settlement.

2.7 New Components and Upgrades

A new raw water pump motor and turbine have been installed since the previous report.

2.8 HISTORICAL ISSUES

Previous assessments and inspection reports were reviewed to identify ongoing issues pertaining to the waterworks facilities. Key issues identified in these documents include:

- backwash waste piping and floor drains were noted to discharge directly to the Town storm water system. Waterworks design guidelines recommend water plant wastewater be directed to sanitary disposal systems for treatment. At the time of inspection, water plant wastewater was still directed to the storm sewer;
- it was identified that there is possibility of the reservoirs stagnating due to the transfer piping arrangement. Filtered water is discharged to the pump well, where distribution water is drawn from. This condition was still in place at the time of the inspection;
- recommendations were made for conducting periodic sampling for HAAs. Testing reports reviewed during this assessment indicate that testing for HAAs is completed by the operators;
- elevated chlorine residuals were noted and the recommendation was made to reduce levels. Review of current records indicates that residuals are often well in excess of the permit requirement. However, due to the chlorine dosage arrangement and potential for reduced contact time, maintaining a high residual is advisable.

3. OPERATION AND MAINTENANCE

3.1 TESTING PROCEDURES AND EQUIPMENT

Water quality testing is completed for the following parameters:

Test Parameter	Test Frequency and Location
Distribution Chlorine Residuals	Tested daily at the plant using handheld Hach DR890 device. Samples from random locations on the distribution network are collected weekly and submitted to the provincial laboratory for testing.
Fluoride Concentration	Tested daily at the plant using handheld Hach DR890 device.
Turbidity	Recorded daily at the plant for raw water influent, filter effluent, and distribution using online turbidimeters. Samples from random locations on the distribution network are collected weekly using a Hach 2100P handheld device and submitted to the provincial laboratory for testing.
Bacteria	Samples from random locations on the distribution network are collected weekly and submitted to the provincial laboratory for testing.
General Chemical Analysis	Every second year, treated water samples are taken four times annually and submitted to the provincial laboratory for testing.
Chemical Health and Toxicity Analysis	Treated water samples are taken every second year and submitted to the provincial laboratory for testing.
THMs and HAAs	Treated water samples are taken quarterly from the distribution system and submitted to the provincial laboratory for testing.

A summary of recent water quality testing is appended to this report.

3.2 OPERATION AND MAINTENANCE

The Town of Outlook has three Level 2 certified operators. Routine operations and maintenance procedures are as follows:

Test Parameter	Test Frequency and Location
Daily	Tasks performed by the operators include daily testing and logging activities, performing manual filter backwash, monitoring and adding chemical as necessary, monitoring the raw water pumphouse and solenoid valve status, and routine housekeeping.
Weekly	Tasks include generator exercising (without load), operation of the standby pump and motor, and sampling for bacteria, chlorine residual, and turbidity in the distribution system.
Monthly	Tasks include greasing the pumps and air blower at the water plant, greasing the pumps at the raw water pump house, scrubbing the filters with a cleaning agent, and THM/HAA testing (quarterly).
Annually	Tasks include hydrant flushing (bi-annual), sludge removal from the flocculation chambers, and water quality testing. Reservoir cleaning is performed every five years. The operators are also in the process of implementing a valve exercising program for the Town.

Overall, the facilities and equipment appear well maintained. Daily operations logs appear neat, orderly, and complete. A separate log is kept for documentation of equipment maintenance.

4. SYSTEM CAPACITY ANALYSIS

In order to determine the remaining service life of a component of the waterworks, we must consider its condition as well as its sizing/capacity and ability to meet future requirements. The future requirements are a factor of the population and water consumption of the community.

4.1 POPULATION

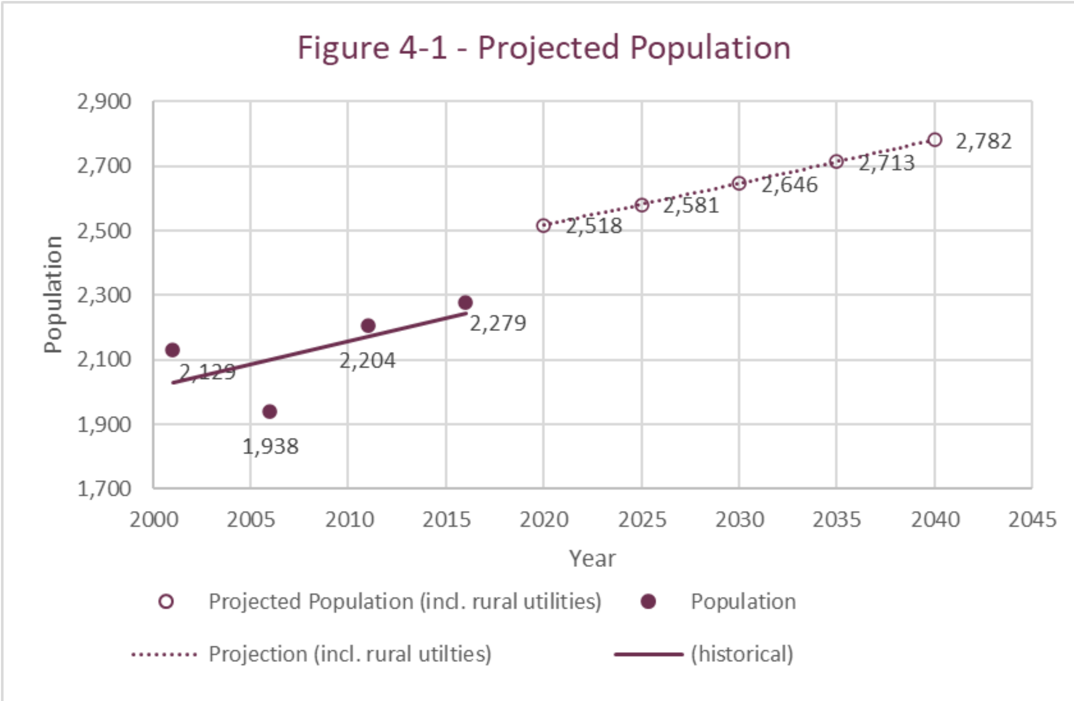
Population data is important for predicting future requirements of the Town's waterworks infrastructure. Historical population data was obtained from Census Canada and is summarized in the following table:

Historical Population (Canada Census)

Year	Population	Average Annual Growth Rate	
2001	2,129	-	0.5%
2006	1,938	-1.9%	
2011	2,204	2.6%	
2016	2,279	0.7%	

As shown, the long term population growth rate experienced by the Town is approximately 0.5%. Therefore, this rate has been used in determining community growth projections for the next 20 years.

In addition to Town residents, the Outlook waterworks also supplies water to the adjacent Rudy Landing development and the Outlook East Pipeline Utility. These utilities supply water to approximately 30 and 33 households, respectively. Census data indicated that there were 845 occupied dwellings in Outlook in 2016, which equates to an average housing density of approximately 2.35 people per dwelling. The housing density in the adjacent developments is anticipated to be exclusively single-family dwelling. Therefore, an estimated housing density of 3.0 people per dwelling was applied, resulting in additional populations of 90 and 99 people, for a total of 189 additional people served by the waterworks. A summary of the future population is shown in the following graph.



4.2 Water Consumption

Historical water consumption data was obtained from the water plant and Water Security Agency records. A summary of raw water consumption data from 2009 – 2018 is as follows:

Raw Water Consumption

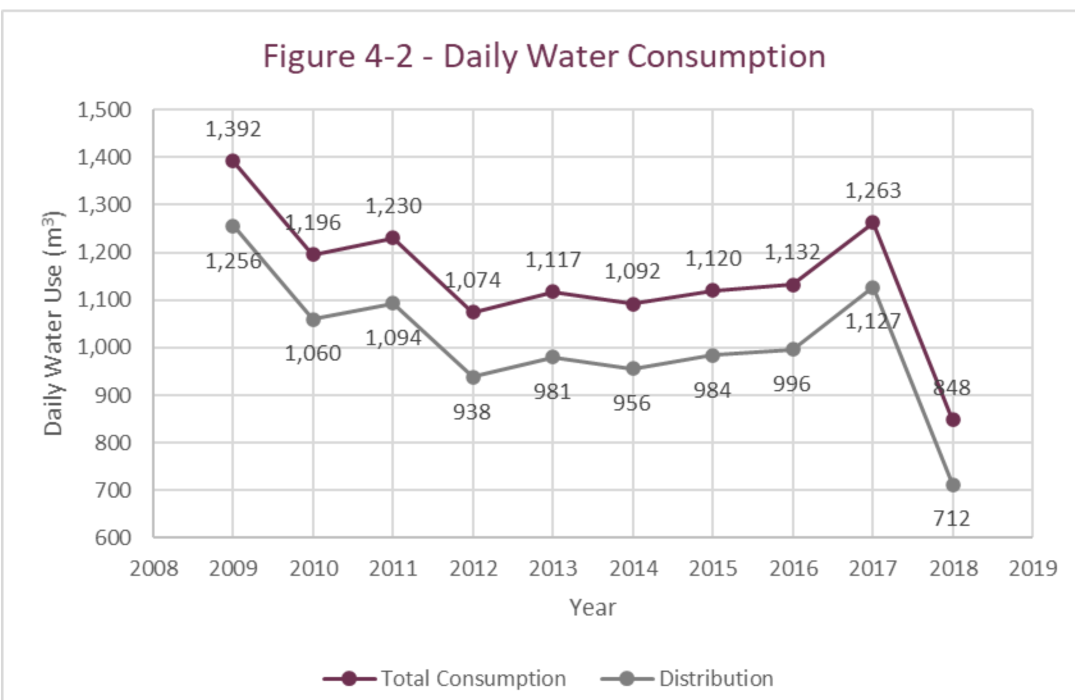
Year	Population	Water Consumption (m^3)			Peak Factor	Lcd
		Annual	Average Day	Peak Day		
2018	2,493	309,593	848	1,957	2.31	340
2017	2,480	461,252	1,263	3766	2.98	509
2016	2,468	414,402	1,132	2637	2.33	459
2015	2,453	409,139	1,120	2848	2.54	457
2014	2,438	398,865	1,092	2513	2.30	448
2013	2,423	407,925	1,117	2417	2.16	461
2012	2,408	393,177	1,074	2418	2.25	446
2011	2,393	449,160	1,230	2900	2.36	514
2010	2,337	436,887	1,196	2427	2.03	512
2009	2,283	508,225	1,392	2904	2.09	610

The Operators reported that the filters are each backwashed daily. Backwashing typically lasts 8 minutes per filter and is completed at a rate of approximately 114 L/s. This equates to a typical daily raw water wastage of 136 m^3 per day. Applying this, the following table summarizes the estimated volume of treated water distributed to the community.

Treated Water Distribution

Year	Population	Water Distribution (m^3)			Peak Factor	Lcd
		Annual	Average Day	Peak Day		
2018	2,493	259,741	712	1,821	2.56	285
2017	2,480	411,216	1,127	3,630	3.22	454
2016	2,468	363,401	996	2,501	2.51	403
2015	2,453	359,021	984	2,712	2.76	401
2014	2,438	348,801	956	2,377	2.49	392
2013	2,423	357,926	981	2,281	2.33	405
2012	2,408	342,231	938	2,282	2.43	389
2011	2,393	399,171	1,094	2,764	2.53	457
2010	2,337	386,761	1,060	2,291	2.16	453
2009	2,283	458,301	1,256	2,768	2.20	550

Historical trends for total consumption and distribution are shown on the following graph:



Future water consumption rates are dependent on both population and demand period. In the past five years, the Town has experience per capita demand rates of 443 L/day and 387 L/day for raw water supply and treated water distribution, respectively. These figures are used in this report to forecast future demands.

Consumption rates can vary widely during different periods of the year and hours of the day. Two characteristic demand periods are normally recognized as being critical factors in the design and operation of a water system. These are the peak day and peak hour demand. The peak day consumption is the highest day of consumption in any one year. From 2009-2018, the average peak day factor (peak day consumption divided by the average day consumption) was approximately 2.34. However, in more recent years the average peak factor has increased to approximately 2.5. For the purposes of this report, a peak day factor of 2.5 will be used to estimate peak day rates. A peak hour consumption rate of 4.0 times the average rate will be used to determine pumping requirements, since peak hour pumping rates are not recorded.

4.3 SYSTEM COMPONENTS

Based on the projected populations and water consumption rates, each major component of the water system has been evaluated to determine its ability to satisfy future water demand. Typical design standards indicate that a system's raw water supply and treatment capacity should be capable of providing peak day demand, the treated water storage should be a minimum of twice the average day demand to meet minimum firefighting requirements, and the distribution pumping should be able to meet the peak hour demand.

Based on these conditions, the components sizing requirements are summarized below:

COMPONENT SIZING REQUIREMENTS 2020 – 2040						
	Existing	**2020**	**2025**	**2030**	**2035**	**2040**
Population (0.5% growth)		2,518	2,581	2,646	2,713	2,782
Water Demand*:						
Lcd (raw)		443	443	443	443	443
L/s (raw)		12.9	13.2	13.6	13.9	14.2
Lcd (treated)		387	387	387	387	387
L/s (treated)		11.3	11.6	11.9	12.2	12.5
Water Supply (L/s; P.F. = 2.5)						
Raw Water Pumps (L/s)	56.8	32.2	33.0	33.9	34.7	35.6
Water Treatment (L/s; P.F. = 2.5)						
Treatment Filters (L/s)	28.4	**32.2**	**33.1**	**33.9**	**34.7**	**35.6**
Distribution (L/s; P.F. = 4.0)						
Pumps (L/s)	40 - 50	45.1	46.2	47.4	48.6	49.8
Reservoirs (L; 2 x avg day)	2,886,500	2,228,334	2,284,602	2,342,291	2,401,437	2,462,076

*water demand is based on raw water consumption for previous years.

As shown, the capacity of the existing reservoirs and raw water supply pumps are adequate to serve the community for the next 20 years. The exact distribution pumping capacity is unknown, but is reported to be sufficient for current demand, based on Operator observations. However, the treatment filters are showing a current shortfall in capacity. Treatment shortfall has not been observed or reported by the Operators. It is expected that the shortfall is offset by the excess reservoir capacity, which would sustain the Town during periods of peak operation, should treatment rates be unable to keep up with demand. The Town should begin planning for treatment capacity upgrades as growth continues. The annual consumption volume is well within the allocation of the existing water rights license. Based on component sizing and historical consumption rate, the threshold population for each system component is as follows:

Component	Capacity	Threshold Population
Raw Water Pumps (L/s; P.F. = 2.5)	56.8	4,436
Mixed Media Filters (L/s; P.F. = 2.5)	28.4	**2,218**
Distribution Pumping (L/s; P.F. = 4.0)	40-50	3,570 – 4,462
Reservoir Storage (L)	2,886,500	3,261

5. WATERWORKS COST AND SUSTAINABILITY

5.1 INTRODUCTION

All waterworks and wastewater systems should be operated as a self-sustaining utility. Water and sewer rates should be sufficient to off-set all operating costs, debt retirement, and to provide a surplus for future capital investment. The American Waterworks Association has a policy statement regarding the economic principles of operating a water utility that is widely accepted in North America. The statement can be found at www.awwa.org and is summarized as follows:

1. Water utilities' revenues from water service charges, user rates, and capital charges (e.g., impact fees and system development charges) should be sufficient to enable utilities to provide for:

    - annual operation and maintenance expenses;
    - capital costs (e.g., debt service and other capital outlays); and
    - adequate working capital and requires reserves.

2. Water utilities should account for and maintain their funds in separate accounts from other governmental or owning entity operations.

3. Water utilities should adopt a uniform system of accounts based on generally accepted accounting principles.

4. Water rate schedules should be designed to distribute the cost of water service equitably among each type and class of service.

5. Water utilities should maintain asset records that detail sufficient information to provide for the monitoring and management of the physical condition of infrastructure.

The community should consult with the Saskatchewan Municipal Board if it requires assistance in determining an equitable rate. The Municipal board has adopted the above noted principles in its assessment of water and sewer utility rates.

We have prepared the following cursory review of the Town's operating costs and revenue.

5.2 HISTORICAL EXPENDITURES

The Town of Outlook's administrative staff provided the utility services revenues and expenditures from 2014 - 2018 for review. The following table summarizes the information provided.

Item	2014	2015	2016	2017	2018
Utility Revenues					
Operating Revenue	$615,864	$613,166	$646,597	$814,186	$949,345
Grants and Funding	-	-	-	-	-
Total Revenue	**$615,864**	**$613,166**	**$646,597**	**$814,186**	**$949,345**
Utility Expenditures					
Operating Expenses	429,622	466,478	471,919	592,936	719,761
Total Expenditure	**$429,622**	**$466,478**	**$471,919**	**$592,936**	**$719,761**
Surplus / (Deficit)	**$186,242**	**$146,688**	**$174,678**	**$221,250**	**$229,584**

As indicated, the Town has been meeting their water and wastewater operating expenses in addition to retaining an adequate surplus.

6. RECOMMENDATIONS AND COST ESTIMATES

6.1 Immediate Issues and Risks

The following items were noted as posing immediate risk to user health or water plant integrity:

6.1.1 Disinfection Contact Time

The primary concern observed during the inspection is the chlorine dosing arrangement. Currently chlorine is deposited directly to the pump well, which at times results in poor mixing and inadequate contact time between the chemical and filtered water prior to distribution. Without adequate contact time there is potential for viruses and pathogens to remain active and reach users. It is recommended that the chemical dosing and filter effluent treated water discharge to reservoir piping be reconfigured to eliminate this risk. Changes to the transfer piping and level control between the external reservoir and pump well would also be required.

6.2 Recommendations

The following items observed during inspections should be reviewed and considered by the Town:

6.2.1 Backwash Waste

Backwash waste piping and floor drains were noted to discharge directly to the Town storm water system. Waterworks design guidelines recommend water plant wastewater be directed to sanitary disposal systems for treatment. It should be noted that the volumes generated during backwash are likely to surcharge a sanitary sewer system. A containment and controlled release system may be required to mitigate this. An evaluation of the existing lagoon should also be conducted to ensure it has adequate capacity to handle anticipated backwash volumes.

6.2.2 Raw Water Intake and Pumphouse

During the inspection it was noted that the raw water pumphouse building and components were aging and in deteriorating condition. Corrosion was prevalent, particularly on the metal grating suspended overtop of the wet well, which provides access to most of the building. The pump installation was also noted to be unconventional and difficult for maintenance and removal of the pumps. The Operators noted that the intake screen location is often landlocked due to shifting sandbars in the river. Due to the extent of upgrades necessary and the operational issues, it is recommended that the Town plan to replace the intake and pumphouse system within the next 10 years. Depending on further evaluation of condition, the existing wet well structure may be suitable for re-use.

6.2.3 Water Treatment Units

Water testing records from 2015 - 2019 indicate that THM and HAA levels remained within the distribution system were within regulatory limits, but were frequently elevated. In anticipation of the regulatory limits being lowered, it is recommended that the Town explore options for an additional treatment process capable of removing dissolved organic content from the raw water.

It was also noted that capacity shortfall of the filters may become an issue within the foreseeable future. Any upgrades planned for the treatment process should take this into consideration.

6.2.4 Lighting and Heating

During inspection of the water treatment equipment in the plant addition, it was noted that the lighting was dim and off-colour, providing poor visibility and making it difficult to observe water clarity and flocc conditions in the treatment units. A large temperature differential from floor to ceiling was also noted. Installation of additional ceiling fans and new LED lighting would not only improve operability, but may also present cost savings due to improved energy efficiency.

6.2.5 Treatment Filter Monitoring

As discussed in the 2019 AWI Filter inspection report, additional monitoring of the filtration and backwash processes would be beneficial to operation. This would include monitoring and documenting parameters such as differential pressure across the filter beds, media freeboard levels, filter run and backwash durations, and periodic raw water quality testing. These parameters would provide additional information to operators, which would be useful in identifying gradual changes in filter performance, seasonal fluctuations in process requirements, and service requirements.

6.3 ESTIMATED CAPITAL REPLACEMENT COSTS AND REMAINING SERVICE LIFE

It is very difficult to estimate the remaining service life of most major components, as many factors are involved, including age, environment, maintenance procedures, quality of workmanship, etc. It is particularly difficult for those components that are buried underground. However, in compliance with the Water System Assessment requirements, our assessment of capital replacement costs and remaining service life is as follows:

Component	Year of Construction / Installation	Typical Service Life	Estimated Remaining Service Life	Estimated Replacement Cost
Raw Water Supply:				
River Intake	1989	20-50 years	20-50 years	$400,000
Raw Water Pumps and Motors	1962/2019	20 years	20 years	$150,000
Raw Water Main Pumphouse	1962	40-50 years	40-50 years	$725,000
Raw Water Main (~700 m)	1989	40-60 years	40-60 years	$350,000
Water Treatment Plant:				$5,000,000
Building	1962	40-50 years	10-20 years	
Mechanical	1962/1982	20-30 years	0-20 years	
Pumps and Motors	2000/2018	20 years	15-20 years	
Electrical	1982/2012	20-30 years	5-20 years	
Reservoirs:				
Pump Well				
- under WTP (159,000 L)	1962	50-70 years	5-15 years	$300,000
Treated Water Storage Reservoir				
- external (2,273,000 L)	1990s	50-70 years	35-45 years	$2,200,000
Treated Water Storage Reservoir				
- under WTP (454,500 L)	1962	50-70 years	5-15 years	$1,100,000
Distribution System:				
150 mm diameter Pipe (22,500 m)	1962	40-60 years	0-20 years	$6,200,000
Total Estimated Replacement Cost:				**$16,425,000**

* Estimated replacement costs include 25% for engineering and contingency.

7. CONCLUSION

We trust that this report fulfills the requirements for this *Waterworks System Assessment*. Should you require additional information, please do not hesitate to contact our office.

"I, the undersigned, declare that the information contained within this submission is, to the best of my knowledge, completed and accurate, and has been prepared in accordance with the standard for this submission as published by the Saskatchewan Water Security Agency."

Respectfully Submitted,

BCL ENGINEERING LTD.

T. T. Braun, P.Eng.

Appendix A
Water Quality Summary

BCL ENGINEERING LTD.

TOWN OF OUTLOOK
Water Quality Summary
(2014-2019)

#177.62

Mar. 27, 2020

Constituents	Unit	Samples Recorded	Range of Results	2010 Raw Water Testing	Saskatchewan Drinking Water Quality Guidelines		Canadian Drinking Water Quality Guidelines	
METALS					MAC	AO	MAC	AO
Arsenic, As	mg/L	5	0.0008-0.0012		0.01		0.01	
Aluminum, Al	mg/L	5	0.16-0.32					
Barium, Ba	mg/L	5	0.078-0.086		1		1.0	
Boron, B	mg/L	3	0.02-0.04				5	
Cadmium, Cd	mg/L	5	<0.00015		0.005		0.005	
Copper, Cu	mg/L		0.0008-0.0083			1		≤1.0
Iron, Fe	mg/L	3	0.0006-0.0017			0.3		≤0.3
Lead, Pb	mg/L	5	<0.0001		0.01		0.01	
Manganese, Mn	mg/L	3	0.0011-0.0018			0.05		≤0.05
Selenium, Se	mg/L	5	0.0004-0.00113		0.01		0.05	
Uranium, U	mg/L	5	0.0012-0.0015	0.0012	0.02		0.02	
Zinc, Zn	mg/L			0.0121		5		≤5.0
Routine Analysis								
Bicarbonate, HCO3	mg/L	13	179-196					
Calcium, Ca	mg/L	7	45-49					
Carbonate, CO3	mg/L	13	0-8					
Chloride, Cl	mg/L	7	11.7-15.2			250		≤250
Fluoride, F	mg/L	weekly	0.14-1.10		1.5		1.5	
Hardness	mg/L	13	173-205	178		800		
Magnesium, Mg	mg/L	7	17-21			200		
Nitrate	mg/L	7	0.6-1.4		45		45	
Orthophosphate, o-PO4-P	mg/L							
pH in Water	pH	13	7.9-8.9	8.19		6.5-9.0		7.0-10.5
Sodium, Na	mg/L	7	23-32	23		300		≤200
Sulphate, S04	mg/L	13	67.4-98.4	63		500		≤500
Total Alkalinity	mg/L	13	147-162	153		500		
Turbidity	NTU	weekly	0.08-0.95	**3.4**			≤0.3/≤1.0/≤0.1	
Dis. Organic Carbon	mg/L			**3.9**				
Coliforms	positives	weekly	3	**266 (CFU/100mL)**				
Chlorination By-Products								
Total THMs: Water	mg/L	22	0.0391-0.0915		0.1		0.1	
Total HAAs Water	mg/L	22	0.022-0.078				0.08	
Validation								
Sum of Ions	mg/L	52						
Specific Conductivity	uS/cm	13	465-527	445				
Total Suspended Solids	mg/L					15		15
TDS (Calculated)	mg/L	7	350-404	345	1500			≤500

Appendix B
Water Consumption Summary

Client: Town of Outlook
Project: Waterworks System Assessment
Job#: 177.62
Date: Apr. 20, 2020

Historical Water Consumption

Year	Type	Pop.	Raw Water Consumption (cu.m.)															P.F.	Lcd
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Avg Day	Peak Day		
2018	R	2,493	17,033	15,028	19,026	18,795	31,232	44,320	40,676	43,855	21,196	19,735	18,668	20,030	309,593	848	1,957	2.31	340
2017	R	2,480	28,858	25,425	29,213	30,648	40,541	53,931	59,937	52,735	44,062	34,409	31,603	29,891	461,252	1,263	3,766	2.98	509
2016	R	2,468	28,735	27,408	30,741	33,842	45,917	49,971	37,274	36,244	34,852	30,264	28,693	30,461	414,402	1,132	2,637	2.33	459
2015	R	2,453	27,856	25,070	30,322	29,158	45,839	54,407	43,392	37,294	33,652	28,782	26,188	27,179	409,139	1,120	2,848	2.54	457
2014	R	2,438	27,286	24,549	30,191	29,613	37,299	36,754	45,232	45,026	34,451	31,706	27,296	29,462	398,865	1,092	2,513	2.3	448
2013	R	2,423	28,004	25,081	28,201	28,248	39,788	41,153	46,549	51,106	36,762	29,519	26,803	26,711	407,925	1,117	2,417	2.16	461
2012	R	2,408	29,474	29,268	26,782	28,557	34,916	36,460	42,801	42,136	39,611	28,981	26,105	28,086	393,177	1,074	2,418	2.25	446
2011	R	2,393	30,216	26,833	32,776	31,945	39,024	51,505	53,135	54,963	40,241	30,856	28,192	29,474	449,160	1,230	2,900	2.36	514
2010	R	2,337	31,270	29,137	34,190	34,723	40,125	37,875	50,438	45,642	35,034	33,983	31,647	32,823	436,887	1,196	2,427	2.03	512
2009	R	2,283	32,578	28,565	34,257	34,541	51,032	62,051	51,975	52,310	55,912	38,780	32,596	33,628	508,225	1,392	2,904	2.09	610
2008	R	2,230	33,933	30,561	34,922	33,411	54,577	54,912	63,992	59,609	39,439	34,611	30,081	33,399	503,447	1,375	3,129	2.28	617
2007	R	2,178	31,902	27,631	32,519	32,695	44,937	48,071	70,984	43,888	40,058	37,700	33,226	35,059	478,670	1,311	3,234	2.47	602
2006	R	2,127	32,698	29,053	33,286	35,136	45,885	45,483	83,258	62,971	39,840	33,007	30,484	31,783	502,884	1,377	3,611	2.62	647
2005	R	2,164	29,849	28,031	33,260	33,570	47,978	40,779	63,821	54,798	37,635	34,119	30,855	32,052	466,747	1,278	3,124	2.44	591
2004	R	2,201	32,364	31,091	34,249	36,368	58,922	60,708	63,848	49,264	36,519	35,722	29,203	29,748	498,006	1,360	3,890	2.86	618
5 Year Average																1,091	2,744	2.52	443
10 Year Average																1,146	2,679	2.34	476

Appendix C
Photographs

Raw water pumphouse building

Intake screen location

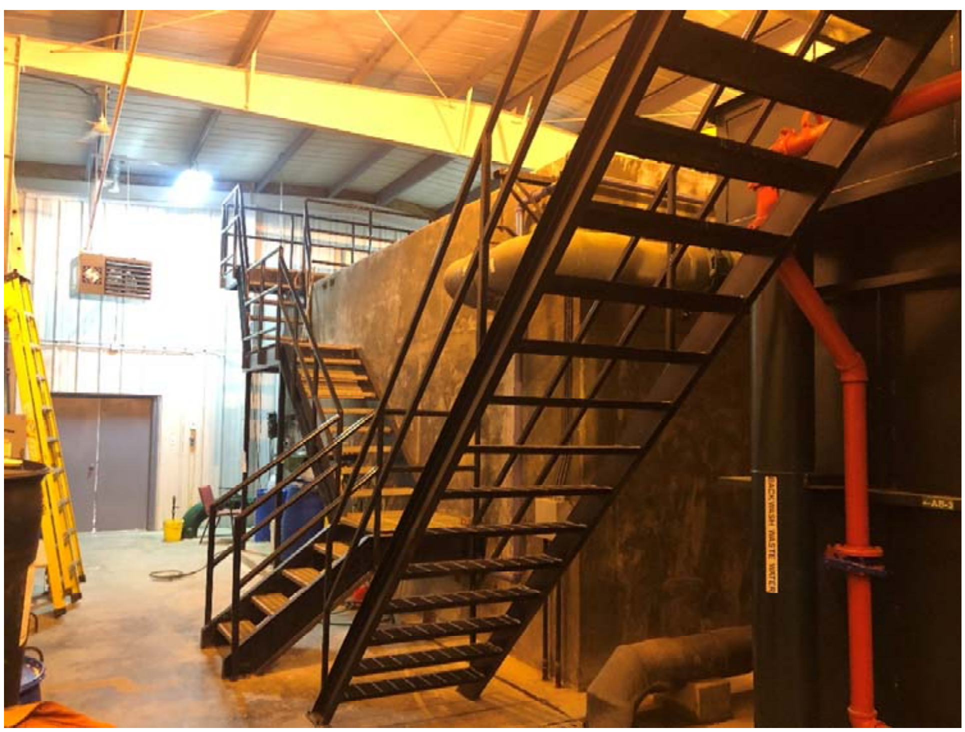
Vertical turbine raw water pumps

Raw water header piping and control valves

Water treatment plant building (original building on left, 1982 addition on right)

Water treatment plant building (1982 addition)

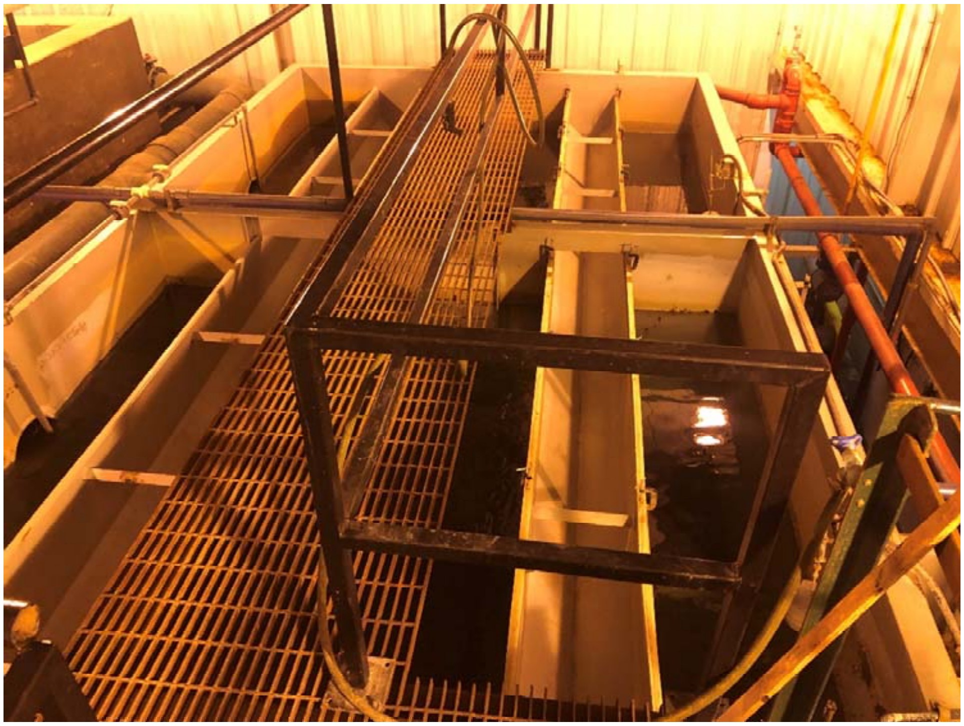
Raw water header piping and instrumentation



Flocculation chambers (center) and filters (right)

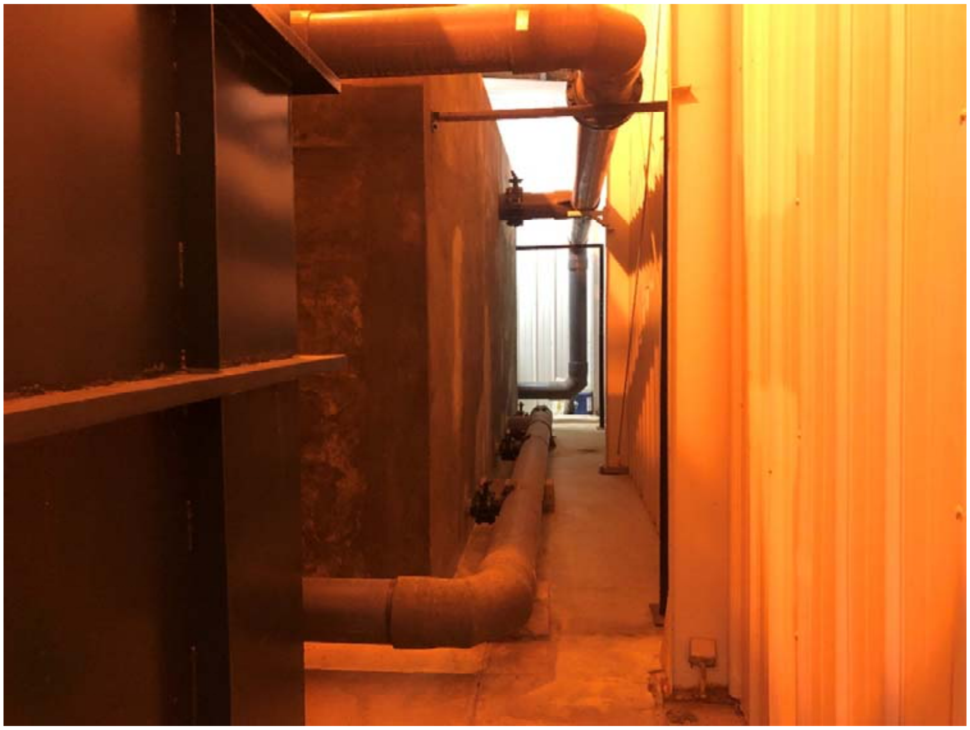
Flocculation chambers and paddle wheel motor (left)

Mixed media gravity filters



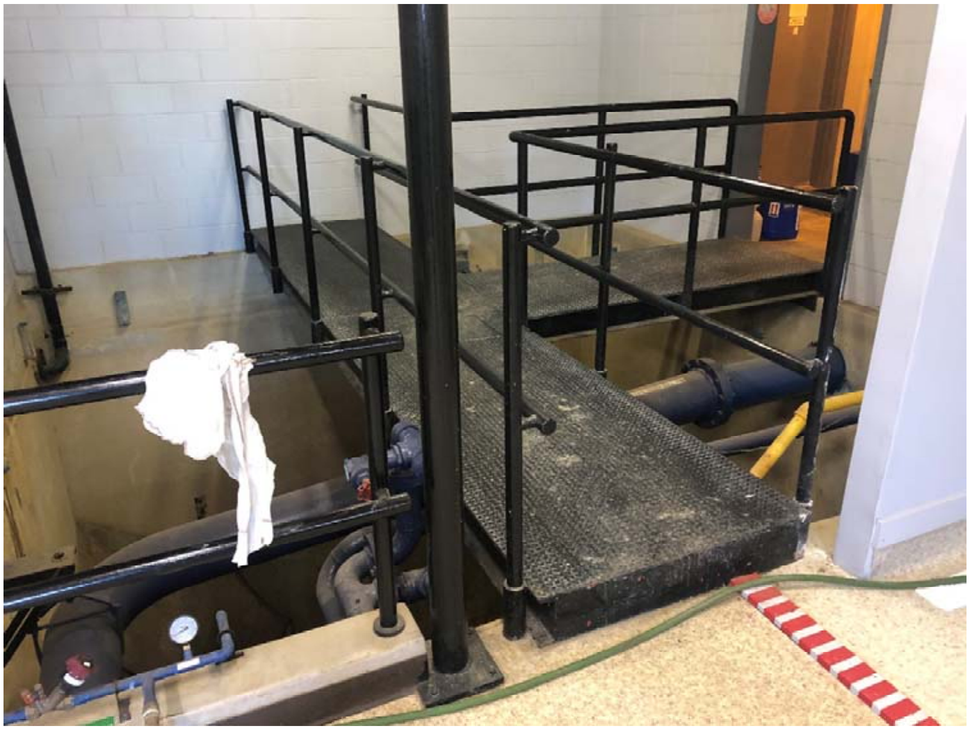
Filter compartments and access platform

Filter effluent and backwash feed piping



Filter overflow and waste piping

Chlorine gas room



Access platform, filter effluent and backwash piping

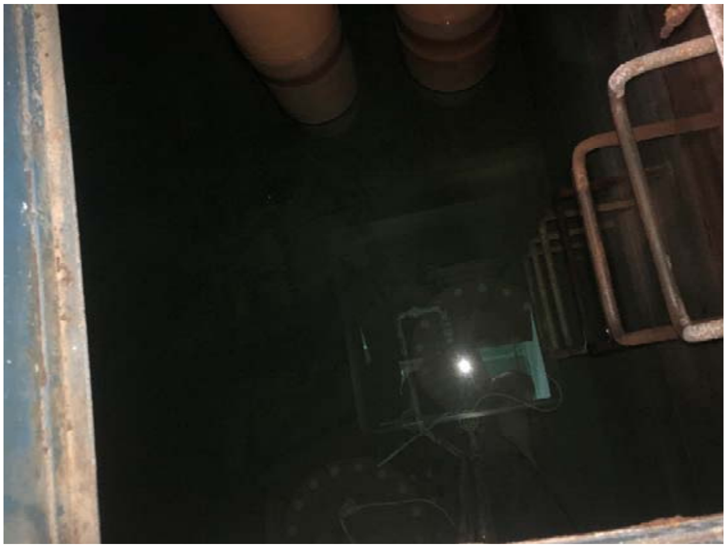
Fluoride dosing station

External reservoir

Water treatment plant reservoir access hatch

Water treatment plant reservoir level sensor

Pump well access hatch



Pump well and flow control valve (sub-surface)

Vertical turbine distribution pumps

Vertical turbine distribution pumps and header piping

Standby motor and right angle-drive turbine pump

Distribution monitoring equipment lineup

Truck fill piping

Truck fill piping

Plant monitoring equipment

Electrical service equipment, motor control centres, and power transfer switch

Emergency power generator

Water treatment equipment control panel

Office space and lab testing area

Emergency eyewash and shower station

Washroom, pump well access, old electrical equipment, office (left to right)

Maintenance supplies and equipment storage area

Washroom

Appendix D
Figures and Drawings

LEGEND

GTV	GATE VALVE
BFV	BUTTERFLY VALVE
ARV	AIR RELEASE VALVE
FCV	FLOW CONTROL VALVE
CHKV	CHECK VALVE
PG	PRESSURE GAUGE
FS	FLOW SWITCH
TB	TURBIDIMETER
FS	FLOW SWITCH
CA	CHLORINE ANALYZER
(N.O.)	NORMALLY OPEN
(N.C.)	NORMALLY CLOSED

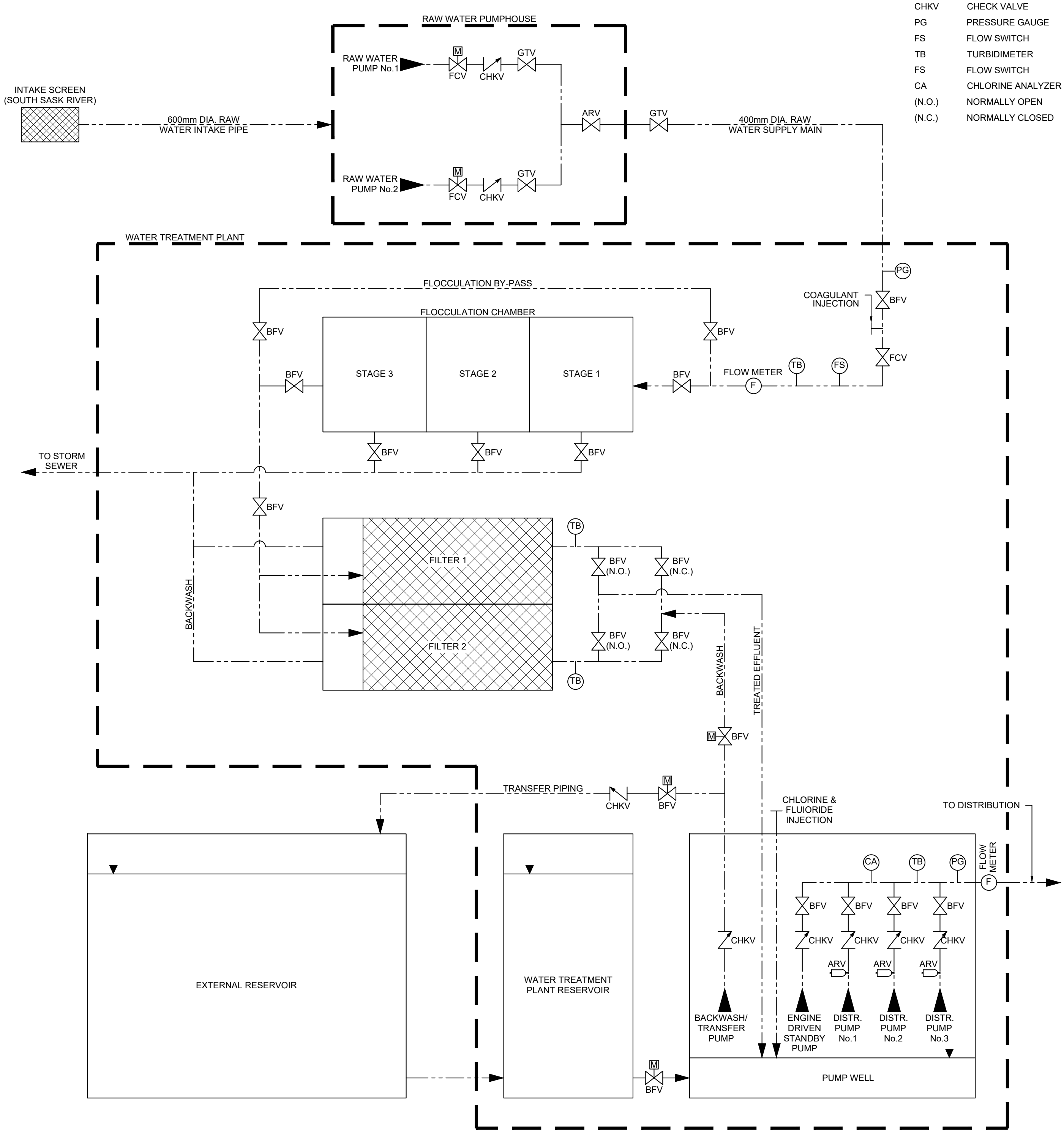


FIGURE 1.0 - EXG. FLOW SCHEMATIC

CLIENT:
TOWN OF OUTLOOK

DATE:
2020/04/01

PROJECT:
WATERWORKS SYSTEM ASSESSMENT

DRAWN:
K.M.N.

JOB NUMBER:
177.62

BCL
ENGINEERING LTD.

| 200 - 302 WELLMAN LANE | SASKATOON, SK | S7T 0J1 |
| 1-306-477-2822 | www.bulleeconsulting.com |

Round 3 Waterworks System Assessment Summary

Waterworks: Outlook Waterworks

Owner(s): Town of Outlook

Env. Project Officer: Lauren Daly

Summary Completion Date: 20-Apr-20

Population: Full Time: 2,059 Seasonal: N/A

Source: Groundwater: [ ] Surface Water: [x] GUDI (groundwater under direct influence): [ ]

Treated Groundwater: [ ] Treated Surface Water: [ ] Treated GUDI: [ ]

Sourcewater Protection Concerns: Intake screen reportedly landlocked by shifting sandbars in river.

Source/Raw Water Quality Issues that May Affect Treatment/Treated Water Quality:

Parameter:	Level:	Parameter:	Level:
Turbidity	+3.0 NTU		
Dissolved organic carbon	+3.0 mg/L		
Coliforms	+200 NO/100mL		

Raw water capacity/allocation: 697,000 cu.m. (annually) at max rate of 185.8 L/s

Treated/Distributed Water Quality Issues (any that exceed Standards and Objectives after treatment):

Parameter:	Level:	Parameter:	Level:
None			

List of Chemicals Used:

ClearPac 182 by Clear-Tech (coagulant)
Cl_2 gas (disinfectant)
Hydrofluorosilicic Acid by Brenntag (fluride agent)

Description of Treatment Processes in Place:

Raw water is dosed with coagulant and deposited into a three-stage flocculation chamber for flocc development and settlement, followed by dual mixed media (sand and anthracite) gravity filters. Filtered water is dosed with chlorine and fluoride.

Treatment Processes with existing issues (including capacity issues):

Treatment unit provides sufficient turbidity reduction but is not proficient in removal of dissolved organics. The disinfection arrangement is likely to provide inadequate contact time.

Other issues identified within the waterworks:

Intake screen is reportedly landlocked seasonally due to conditions in the river. The raw water pumphouse condition is deteriorating. Backwash waste is not directed to the sanitary sewer system. Lightning and heating provisions within the addition could be improved. THM and HAA production is approaching limits.

Major Recommendations:

Recommend re-arrangement of chlorine dosing and filtered water piping. Recommend replacement of raw water intake and pumphouse within 5-10 years. Explore options for dissolved organics removal.

Any Recommendations that may pose an Immediate Health Concern:

Chlorine dosing and filtered water arrangement likely provide inadequate disinfection contact time under select circumstances.

Total Cost of Recommended Upgrades: $3,300,000

Other Comments: Upgrades recommended include immediate and intermediate (5-10 years) items.

*Please submit electronic copy to WSA. If more space is required, a longer summary sheet may be requested.