CITY OF YELLOWKNIFE

YELLOWKNIFE WATER TREATMENT PLANT OPERATION AND MAINTENANCE MANUAL

Version 2

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1. GENERAL

1.1. Objectives

The purpose of this Operation and Maintenance Manual is to provide reference material for those persons involved in the operation and maintenance of the City of Yellowknife Water Treatment Plant (WTP). The secondary intent of this document is to support City decision-makers, regulators, such as the Mackenzie Valley Land and Water Board (MVLWB) and other stakeholders, with an understanding of WTP functionality and capacity. Specific objectives served by the Operation and Maintenance Manual include the following:

- To organize and report supplementary information for submission as an appendix to water licence applications and operation and maintenance plans.
- To provide descriptions of major water treatment, storage, and pumping processes integrated within the water system.
- To develop summaries of control features utilized in operation of major plant processes.
- To describe routine maintenance and material handling tasks undertaken by plant operators.
- To provide an overview of potential operational contingencies and mitigative features in place.

Specifications of equipment and product-specific operations and maintenance requirements are described with more detail in the construction submittals forming the volumes of the Operation and Maintenance Manuals. In-depth accounts of the WTP controls and fundamental automation programming are provided in the *City of Yellowknife Water Treatment Plant Control Philosophy* (AECOM, 2015).

1.2. Background

The Yellowknife WTP supplies potable water to the City of Yellowknife and the neighbouring Yellowknives Dene First Nation communities of N'Dilo and Dettah. This facility is the largest and most complex of its kind in the Northwest Territories. This system has become the training ground for water treatment plant operators working at facilities in surrounding territorial municipalities.

The WTP is located on the east end of the City on the shore of the Upper Yellowknife Bay, Great Slave Lake. Until 2003, gold mines had been operating to the north of the WTP site and near the mouth of the Yellowknife River. The Con and Giant mines were established in 1938 and 1948 respectively and, until the 1950's, these sites had generated airborne emissions containing arsenic. In 1968, the City transitioned the water supply from Yellowknife Bay to the current Yellowknife River source. Since then, an 8.5 km long, submerged supply main installed along the bed of the Yellowknife Bay has been utilized to tie in the WTP to Pump House No. 2 located on the Yellowknife River.

A remediation site was established in 1999 at the Giant Mine to mitigate release of arsenic trioxide waste to the environment. Both mines have since ceased production of gold. Although the risk is low, the potential release of arsenic from the containment at the Giant Mine remediation site remains a primary concern for the community's drinking water quality. For background and technical assessments related to local raw water sources refer to the *City of Yellowknife Potable Water Source Selection Study* (AECOM, 2017).

The current water system was commissioned in 2015 and was designed to source raw water from the primary and secondary sources of Yellowknife River and Yellowknife Bay respectively. The WTP continues to accept River raw water from the existing Pump House No. 2 which was upgraded in the mid-90s. Significant funding was secured in 2019 to replace the existing submerged 8.5 km raw water supply main and increase the capacity it can carry from **the River**. Pump House No. 2 is located off Ingraham Trail, a driving distance of about 14 km north from the WTP site.

1.3. Water System Operation and Maintenance Overview

The following sections summarize water treatment plant training requirements and list relevant resources for WTP monitoring of raw water and potable water quality parameters, occupational health and safety, environmental protection, and documents describing interconnected infrastructure.

1.3.1 Required Water Treatment Plant Operator Training

Water Treatment Plant Operators are required to obtain their Class 2 Water Treatment Operator Certification through the Government of Northwest Territories (GNWT) to work at the Water Treatment Plant. The courses are facilitated by the School of Community Government, Department of Municipal and Community Affairs (GNWT).

The City is responsible for the training of staff. Water Staff are trained to perform their job in a safe and environmentally responsible manner, in accordance with applicable regulations.

Water and Sewer Staff attend regular weekly safety meetings at which any safety issues are brought up for discussion. The items from the safety meetings are discussed between the Manager (Public Works Operations), the Superintendent W/S (Water and Sewer), and the City's Safety and Training Officer. Results of the meetings are relayed to Water Staff by the W/S Supervisor during toolbox meetings. All personnel are to be familiar with and abide by the City's Occupational Health and Safety Program and the Northwest Territories Safety Act and Regulations.

A review of this Operations and Maintenance Manual, and related documentation, is a prerequisite for any employee before being declared eligible for work in the water and sewer division. Documentation to be reviewed includes the following:

- City of Yellowknife Safety Manual
- Safe Work Practices, Policies and Procedures
- Service Standards
- Spill Contingency Plan

The Superintendent W/S and all Water Staff are required to comply with all laws and regulations affecting the execution of the work at all water facilities or any aspect of the water system, including all applicable Federal, Territorial and Municipal laws and regulations pertaining to socio-economic and environmental matters.

1.3.2 Emergency Response Contact List

In the event of medical or fire emergencies, call the following emergency response contacts:

- General Emergency: ………………………… 9-1-1
- Fire Department: …………………………… (867) 873-2222
- RCMP Detachment: ………………………… (867) 669-1111
- 24 Hour Spill Response Line: ……………. (867) 920-8130

1.3.3 Relevant Regulations, Guidelines, and Plans for Treatment Plant Operators

In addition to the documentation listed in Section 1.3.1, water treatment plant operators should review relevant sections of the reference documents listed in Table 1.

Table 1: Regulatory and Municipal Reference Documents

Reference Document	Objective and Relevance
Yellowknife Water Treatment Plant Operation and Maintenance Plan, Mackenzie Valley Land and Water Board; MV2009L3-0007; December 2017.	Reports previous operational parameters and maintenance tasks agreed upon with the MVLWB in water licence application.
Guidelines for Canadian Drinking Water Quality Summary Table; Health Canada, September 2020.	Summarizes maximum acceptable concentrations, aesthetic objectives, and monitoring guidelines for drinking water quality parameters.
Water Supply System Regulations (Government of Northwest Territories, September 2009)	Summarizes territorial drinking water sampling and testing requirements
Water Quality Guidelines for the Protection of Aquatic Life; Canadian Council of Ministers of the Environment (CCME).	Provides quality guidelines for treated or wastewater releases for mitigation of environmental impacts on receiving water bodies.
Occupational Health & Safety Regulations, Workers' Safety & Compensation Commission; January 2012	Comprehensively outlines health and safety regulations, hazard identification, and safety precautions/training for various occupational tasks.
Northwest Territories & Nunavut Codes of Practice, Confined Spaces, Workers' Safety & Compensation Commission.	Employer Guideline for safe entry of confined spaces.
Northwest Territories & Nunavut Codes of Practice, Counterbalanced Forklifts, Workers' Safety & Compensation Commission.	Employer Guideline for safe operation of forklifts.
Sewage Disposal Facilities Operations & Maintenance Manual, City of Yellowknife.	Provides an overview of sampling and monitoring program at the wastewater facility receiving residuals streams from the WTP.

2. WATER SYSTEM DESCRIPTION

The integrated processes at Yellowknife WTP are detailed in terms of process flow and function on the Process & Instrumentation Diagrams attached to the Operations and Maintenance Manual as Appendix A. Refer to these P-series drawings for unique equipment and instrument identifiers and relevant legends.

Powered and automated equipment at the WTP is controlled remotely using a supervisory control and data acquisition (SCADA) platform referred to as the Process Control System (PCS). The PCS communicates and interfaces with equipment programmable logic controllers (PLC) for coordination of independently operating subsystems. Refer to Section 3 for subsystem control philosophies.

2.1. Yellowknife River Intake Supply and Pump House No. 2

The Yellowknife River is the primary raw water source for the Yellowknife WTP. Pump House No. 2 contains pumps that convey river water to the head of the WTP. A series of buried concrete chambers are utilized as a wet well and this structure is the foundation for the Pump House No. 2 building. The pumps draw water through the wet well from two independent buried mains extending to intake screens suspended above the riverbed. Pump House No. 2 discharges to an 8 km submerged supply main bedded along the floor of Yellowknife Bay. This supply main terminates at Pump House No. 1 located next to the WTP.

2.1.1 Yellowknife River Intakes

The Pump House No. 2 wet well is supplied by two redundant, 600 mm dia. buried intake mains, which draw water from the Yellowknife River. The Yellowknife River surface freezes over in November and thaws in April. Nonetheless, this source is drawn upon all year round, seven days per week. The intakes are cantilevered abreast of the shore with their inlet ends suspended above the riverbed. Metallic screens are welded to the plain ends of the intake mains. Both intake screens are designed with a 10 mm mesh for exclusion of debris. Each intake main is supplied with a manual butterfly valve just inside the wet well chambers for isolation. One or both of the isolation valves may be closed to facilitate cleaning and maintenance of the screens and intake main piping.

2.1.2 Pump House No. 2 and Wet Well

Pump House No. 2 contains four vertical turbine pumps, which draw raw water from the wet well-constructed below the building. The two, variable speed river raw water pumps, P-1 and P-2, have been designed to operate in a lead-lag configuration and can supply a combined parallel flow capacity of up to 260 L/s. However, the dual pump capacity is not currently required, therefore, the existing on-site transformer has not yet been upgraded for this lead-lag service. At present, a single pump delivers supply to the WTP under normal conditions, while the parallel variable speed pump is available in standby. An emergency diesel-driven pump, P-3, is available for abnormal conditions such as an extended power outage. The three raw water supply pumps discharge to a common piping header directing flow to a 400 mm dia., buried supply main. This buried main subsequently transitions to the submerged main running from the Yellowknife River to Yellowknife Bay. A raw water flow meter (FT-1) is installed downstream of the common discharge header and this instrument is utilized for monitoring river water consumption and pump operation. For monthly and annual Yellowknife River water consumption volumes, refer to the Water Licence MV2009L3-0007, 2019 Annual Report. Daily records are maintained to report monthly water volumes withdrawn from the Yellowknife River in licence quarterly reports. For additional Pump House No. 2 capacity and controls details, refer to Section 3.1.

The wet well is a gravity-fed arrangement and, since the water level in the wet well essentially matches that at the river, no raw water storage capacity is contributed by this structure. The wet well is comprised of chamber cells separated by concrete walls to control intake flow path. A wall is oriented along the width of the wet well between the two river intake penetrations. A pipe stub is cast in this wall with a manual butterfly valve to facilitate isolation of the north cell from the south cell. The north cell houses one of the river inlets and the P-3 impeller, while the south cell houses the other inlet and the impellers of the lead-standby pumps. This interconnection allows operators to take either the duty-standby pumps' wet well or the diesel-driven pump's wet well offline for inspection and maintenance. Immediately downstream of each intake main penetration, concrete channels direct inlet flow to the wet well supply trains. At the entrance to each wet well, coarse screens are mounted at the channel ends to retain debris that has passed through the intake screens in the river.

The fourth pump, which is no longer used and termed the Truckfill Pump, draws raw water from the north cell of the wet well. When it was operation, this pump discharged to a truck onloading connection via an insulated and heat-traced, above-ground riser pipe. A flow meter (FT-101) was installed on this truckfill line for tracking of revenue flows. The truckfill connection is now only used in the event of emergencies such as during a fire on Ingraham Trail.

2.2. Yellowknife Bay Intake Supply and Pump House No. 1

Yellowknife Bay on Great Slave Lake is the secondary and emergency raw water source for supply to the WTP. Pump House No. 1 is located next to the WTP and is designed as the interface for supply of raw water from both the Bay and River sources. Pump House No. 1 includes an integrated wet well and an inlet main from the Yellowknife Bay intake. Pump House No. 1 is also utilized as the tie-in to the submerged raw water supply main from the Yellowknife River and, under normal conditions, accepts flow from this primary raw water source. This area of the plant houses the river raw water booster pumps and the bay wet well raw water pumps. Further, Pump House No. 1 contains two smaller pumps related to the membrane microfiltration and treated water recirculation subsystems.

Pump House No. 1 is the primary location for collection of raw water samples as it houses the interconnecting piping between the two raw water sources. Routine analyses are performed to quantify raw water bacteriological, chemical, and physical parameters. The raw water concentration of particles, or cloudiness, is measured as turbidity (NTU) from these samples. Raw water turbidity is highest during spring and summer runoff to the Yellowknife River and can peak in the range of 10 to 15 NTU. Outside of this period, turbidity may drop to 0.5 NTU or less. Refer to Section 3.2.4 for an expanded list of monitored raw water parameters.

2.2.1 Yellowknife Bay Intakes

Pump House No. 1 wet well is supplied by a 600 mm dia. buried intake main, which draws water from the Yellowknife Bay. Yellowknife Bay freezes over in November and thaws in June. This source is drawn upon only as required under emergency conditions or for maintenance. The intake main extends into the bay and a metallic screen is welded to the submerged end of the main. This intake screen is designed with a 10 mm mesh for exclusion of debris. At the tie-in penetration within the bay wet well, the intake main is supplied with a manual butterfly valve for isolation and to facilitate cleaning and maintenance of the screen and piping.

2.2.2 Pump House No. 1 and Wet Well

Under normal conditions, raw water from the Yellowknife River intake at Pump House No. 2 is supplied to Pump House No. 1 via the submerged supply main running to the Yellowknife Bay tie-in. At Pump House No. 1, the supply pressure of river raw water is boosted by three, horizontal end-suction centrifugal style raw water booster pump units (P-101, P-102, and P-103). Downstream of the WTP tie-in, the river raw water supply passes through a pressure reducing valve (PRV-180), which is used to sustain a minimum flow and prevent solids deposition in the submerged main during low demand. Upstream of the booster pump suction header, a pressure control valve (PCV-110) is provided to allow for more controlled delivery of pressure and flow to the WTP irrespective of the discharge pressure received from Pump House No. 2. The three booster pumps are configured in a lead-lag-standby arrangement and each of them is installed complete with a variable frequency drive (VFD) such that discharge flow and pressure may be tailored to meet WTP demand. Downstream of the booster pump discharge header, a raw water flow meter (FIT-101) is installed on the supply main to monitor and totalize flow received from the Yellowknife River. The lead-lag river booster pumps are designed to provide a combined discharge flow capacity of 28,500 m^3/day (330 L/s; 165L/s per pump). However, since the transformer at Pump House No. 2 is rated only for operation of a single river raw water pump, the river booster pumps are limited to a supply capacity of approximately of 19,900 m^3/day (230 L/s). Refer to Section 3.1.2 for the expected current range of river supply flows handled by the raw water pumps (PH2) and booster pumps (PH1).

Recycle streams from the WTP, including excess recirculation water from the membrane microfiltration system and supernatant from the gravity thickeners, are delivered to the River booster pumps' suction header. Under normal conditions, with the booster pumps online, these recycle streams are blended with raw water and distributed to the membrane system. This connection to the booster pump suction is constructed from a repurposed supply main that acts as a header for drainage collection. When the booster pumps or membrane system is offline, a small recycle pump (P-106) operates as required to pump this drainage from the collector to the bay wet well. To avoid overflows at the thickeners, feedback from the Process Control System (PCS) will shut down the pumps in the waste equalization tanks when the booster pumps and membrane systems are not running.

The Pump House No. 1 recirculation pump (P-602) is also housed in this area. This small pump operates continuously, at a fixed speed, directing treated water from the distribution main to Pump House No. 1 and conveys this flow back to distribution system. The intent of this recirculation line is to keep water fresh and flowing in the repurposed treated water main, which runs back to Pump House No. 1 for supply to domestic building connections, the backup power generator, and fire protection services. For instrumentation and controls related to P-602, refer to Section 3.7.

2.2.3 Yellowknife Bay Raw Water Pumps and Conditions for Operation

The emergency Yellowknife Bay raw water source is handled by two, vertical turbine style Bay Raw Water Pumps (P-104 and P-105) and a below-ground wet well. These pumps convey raw water delivered from the bay intake to a WTP supply main connection downstream of the river booster pumps. The bay raw water pumps are only operated in abnormal conditions such as during a loss of communication with Pump House No. 2 or during maintenance. These two pumps are arranged in a lead-lag configuration and have each been supplied with a VFD. Bay raw water flow meter (FIT-100) independently monitors and totalizes flow from this source and is located upstream of the connection where river and bay raw water supply mains intersect. The bay raw water pumps are each designed with capacity to supply a variable flow in the range of 5,600 to 28,500 m3/day (65 to 165 L/s). As required, the lag bay raw water pump may be called upon and together the two pumps could potentially supply 28,500 m^3/day (330 L/s) to the membrane microfiltration system. Note that the capacity of the bay raw water supply system currently exceeds the functional capacity available from the river via Pump House No. 2. For additional Pump House No. 1 capacity and controls details, refer to Section 3.2.

The current municipal water licence does not permit extended withdrawal of water from Yellowknife Bay for non-emergency supply. However, the bay raw water pumps must be tested routinely in the interest of emergency preparedness. The conditions under which the bay raw water pumps can be operated are currently dictated by a provisional approval (Monthly Yellowknife Bay Water Withdrawal Approval; MVLWB, January, 2019). Under routine operating circumstances, these pumps must not be operated for a duration in excess of one (1) hour per month. Furthermore, the volume withdrawn from the bay for testing must not exceed 300 m^3 in any month.

Testing of the bay raw water pumps requires that water from the bay wet well be pumped through the WTP processes to the user. In advance of testing, the source water contained in the bay wet well must be sampled. The instantaneous quality of the available bay water is assessed using a rapid arsenic test kit. Pump testing may proceed under the condition that the sample arsenic concentration is less than the maximum acceptable concentration (MAC) of 10 μg/L (*Guidelines for Canadian Drinking Water Quality Summary Table*; Health Canada, September 2020). If the sample exceeds the MAC, the pump testing operation must be abandoned and Public Works Management is to be notified. Any samples exceeding this MAC are subsequently reported to the following Government of Northwest Territories officials:

1. Public Health Officer
2. Environmental Health Officer
3. Water Licence Inspector

Arsenic is naturally occurring in the local watershed, however, records of water quality from the bay wet well are valuable given the proximity of the WTP to the former Giant Mine site. The results of bay raw water arsenic tests are documented in plant operation and maintenance records. Based on monthly Yellowknife Bay testing results from 2005 to 2019, dissolved arsenic concentrations in the bay raw water are known to range from 0.3 to 3.0 μg/L. For each monthly bay raw water pump testing operation, the following records must be maintained for water licence quarterly reports:

1. Date and duration of pump tests
2. Volume withdrawn from Yellowknife Bay

2.3. Micro-Strainer, Membrane Microfiltration, Clean-in-Place, and Neutralization Systems

The membrane microfiltration, micro-strainer, membrane clean-in-place, and neutralization systems are part of a prefabricated, vendor-supplied (Pall Water) treatment process package. This package is supplied with an integrated membrane system PLC, which coordinates operation of the microfiltration equipment, the micro-strainers, clean-in-place and neutralization systems, while also communicating with the overall plant PCS. The micro-strainer and membrane systems are utilized as the pre-treatment and filtration barriers respectively for removal of raw water particles, contaminants, and biological pathogens. The treated water passing through the membranes is suitable for subsequent stages of treatment including fluoridation, disinfection, storage, and distribution to the user. The membrane systems require intermittent cleaning to remove retained materials and to prevent clogging (fouling) of the openings in strainer and membrane filter barrier surfaces. Membrane cleaning is undertaken through an array of maintenance operations and each is carried out at different time-scales and requires specialized equipment and chemicals. The main cleaning operations for these systems include flushing for the micro-strainers and backwashing (reverse flush), chemical clean-in-place (CIP), and chemically enhanced flux maintenance (EFM) for the membranes. Each of these tasks produce a waste stream that must be disposed of or partially recycled to the head of the WTP. Two such subsystems that handle waste streams are the clean-in-place neutralization system and the gravity thickener systems. For instrumentation and controls related to the micro-strainers, membrane microfiltration system, chemical cleaning system and neutralization system refer to Section 3.3.

2.3.1 Micro-Strainer Systems

From Pump House No. 1 or No. 2, raw water is conveyed through two, parallel micro-strainers (STR-220 and STR-221) before it is processed by the membrane microfiltration system. The functional intent of these strainers is to provide a barrier that removes particulate matter larger than 300 micron in size from the raw water before it reaches the membranes. This pre-treatment is physically protective of the membranes, reduces the required frequency of membrane cleaning operations, and increases the overall throughput across the membranes. The strainers are automatically flushed clean using a raw water side stream, one unit at a time, but do not need to be taken offline during a flushing operation; The micro-strainers continue to supply strained water to the membranes while the mesh surfaces are flushed. Flushing waste flows by gravity from the strainers to the waste equalization tanks for holding prior to thickening and disposal.

2.3.2 Membrane Microfiltration Systems

The membrane microfiltration system is comprised of three independently operating racks of pressure vessels, each densely packed with hollow fibre membrane strands. Strained raw water is pumped into the vessels and forced through the porous membrane surfaces. Filtered water (filtrate) is collected within the hollow core of the strands while particles, contaminants, and some pathogens (foulants) are retained on the membrane surfaces. The treated water from the membranes remains pressurized and is conveyed to the downstream fluoridation and chlorination systems. To manage fouling of the membranes by retained materials, raw water is recirculated to establish a crossflow along the length of the strands. Further, air bubbles are introduced to the vessels to scour and disturb materials retained against the membranes. Air is supplied by two duty-standby compressors, CMP-250 and CMP-251. The excess portion of the recirculation flow is returned to the head of the plant by a pressurized line running back to the bay raw water wet well drainage header.

As particles and contaminants build up on the membrane surfaces, the drop in pressure across the membrane increases (pressure on feed side minus pressure of filtrate). This transmembrane pressure (TMP) parameter is monitored and managed by performing routine backwashing after a pre-defined volume of filtrate has been generated. Backwashing is performed automatically by isolating each membrane rack and supplying a reverse flow through the membranes. Membrane vessel racks are backwashed using treated water from the reservoirs and two, duty-standby membrane backwash pumps (P-506 and P-507) located in the reservoir pump wells. Backwash water is pumped into the microfiltration racks to force flow through the hollow cores of the membranes and outward to dislodge the retained material at the membrane surfaces. This backwash waste containing particulates is conveyed by gravity to the waste equalization tanks for processing by the gravity thickeners.

The microfiltration system has the ability to perform automatic membrane integrity testing at pre-defined time intervals. The integrity test is based on pressure decay across the membranes within an isolated rack. Air is introduced to the hollow cores of the membranes (filtrate side) from the compressors. Due to the small pore size of the membranes, these fibres will retain air unless they are damaged. If the pressure inside the membrane strands decreases, this can indicate the presence of torn or broken membrane strands or leak at piping fittings which require repair or replacement.

The performance of membranes and associated mechanical components is sensitive to drops in raw water pressure. To reduce maintenance requirements for this system, the raw water is tempered to 3°C or higher by exposing a portion of the flow to a heat exchanger before it is delivered to the micro-strainers.

2.3.3 Membrane Clean-in-Place and Neutralization Systems

A critical parameter in maintenance of microfiltration systems is membrane flux which is defined as the volume of filtrate per unit area of membrane per unit time. As foulants accumulate on membrane surfaces, the specific flux of a rack may decrease to a level that warrants specialized cleaning operations. To manage this gradual loss of capacity, automatic EFM and CIP sequences are initiated to improve or restore the specific flux of a rack. The chemical cleaning system includes 13 pumps, which facilitate a variety of chemical dosing, dilution, and waste transfer tasks. The neutralization system includes two collection tanks (T-216 and T-217), which accept waste cleaning solutions for chemical treatment prior to disposal.

The enhanced flux maintenance (EFM) cleaning sequence is performed more regularly than the membrane CIP sequence. The EFM is performed automatically after a pre-defined volume of filtrate has been generated by a membrane rack and this sequence is typically run multiple times per month. The intent of EFM is to remove particulate matter and routine foulants to improve membrane flux periodically until a CIP sequence can be initiated. Concentrated sodium hypochlorite is stored for this purpose in a dedicated storage tank located in the same area as the chemical cleaning system. The EFM typically consists of a cleaning with a diluted sodium hypochlorite solution that has been tempered by an integrated heater. This solution is recirculated through the rack for a set time period before it is flushed out with treated water and conveyed to the neutralization system. The EFM sequence frequency varies seasonally but has been estimated to occur once every 5 days with a runtime of approximately 40 minutes per membrane rack.

The membrane Clean-in-Place sequence is performed for each membrane rack approximately once per month. The CIP is an operator-initiated sequence that typically runs for 4 to 5 hours per membrane rack. The chemicals required for CIP, including sodium hydroxide and citric acid, are stored in dedicated tanks near the chemical cleaning system. The CIP sequence commonly consists of the following stages of tempered solution circulation: Blended sodium hydroxide (caustic soda) and sodium hypochlorite wash; rinse cycle; citric acid wash; and rinse cycle. The CIP sequence removes all chemically reversible foulants from the membranes and flushes them to the neutralization system with the residual chemical waste stream.

The neutralization system utilizes the chemical cleaning system’s pumps and chemical stock to manage the chlorine concentration and pH of the chemical waste stored in these tanks. Within the neutralization tank, the membrane cleaning residuals undergo an automated treatment process which includes dosing and circulation with neutralization agents. Citric acid is added to the system, as required, to lower the pH, while caustic soda (base) is dosed to raise pH. The dechlorinating agent, a sodium bisulfite solution, is pumped into the neutralization tank to reduce free chlorine concentrations. Online conductivity and pH instruments are installed in the tanks to monitor the product of neutralization operations. Conductivity is measured through the treatment process to monitor the effectiveness and status of dechlorination reactions. The pH is also measured over this waste circulation period to verify the status of acid/base neutralization reactions. Neutralized waste is typically discharged within a pH range between 7 and 8.5. This waste will contain constituents present in the raw water such as particulates as well as salt byproducts from the neutralization agents. Once the waste has been treated to membrane manufacturer-defined pH and conductivity setpoints, drain pump, P-209, is employed to drawdown the tanks and deliver the blended residuals to the sanitary sewer. This discharge operation occurs automatically at a time selected by the operators and usually occurs during sanitary sewer off-peak hours between 12 a.m. to 6 a.m.

Each CIP and EFM cleaning sequence is associated with a specific cleaning agent recipe and dosing regimen. These cleaning solutions are collected in the neutralization tank where they are mixed with neutralization agents. The volumes of chemical solutions administered for cleaning and neutralization are recorded daily. Therefore, the volume of neutralized waste discharged to sanitary sewer may be calculated based on the chemical solution volume consumed between tank discharge operations.

Since these CIP and EFM waste products are ultimately accepted by the sewage lagoon, discharges from the neutralization system are subject to the City of Yellowknife Water and Sewer By-Law No. 4663. Refer to Schedule D (Restricted Wastes) of this By-Law for discharge concentration limits defined for waste constituents such as total suspended solids, chlorine, and sulfate.

Both the chemical cleaning system and the neutralization system are located within containment structures, each complete with level switches to alert operators of flooding or a potential chemical spill.

2.4. Backwash Residuals Handling Systems

Non-chemical backwash waste from the membrane microfiltration system containing particulate matter and other raw water contaminants is delivered to the residuals handling systems for treatment. This system agglomerates and thickens the backwash solids into residual sludge for disposal. The residuals handling system consists of waste equalization tanks, gravity thickeners, a coagulant dosing system, thickened sludge transfer pumps, and sludge storage tanks.

2.4.1 Backwash Waste Equalization Tanks

Backwash from the membrane microfiltration system and micro-strainers is delivered by gravity to two buried waste equalization tanks (T-710 and T-711). These two tanks are constructed in a common wall arrangement with a valved interconnection for redundancy of equipment. This interconnection facilitates isolation of a single tank for drainage and cleaning. In each tank cell, a mechanical mixer (MXR-720 and MXR-721) is installed to re-suspend waste solids and minimize deposition of material in the bottom of the tanks. Two submersible style waste pumps (P-700 and P-701), one in each tank, transfer stored residuals from the equalization tanks to the gravity thickeners. These pumps are configured to operate in a lead-lag arrangement. Each tank is equipped with dedicated level instruments to accommodate a single tank operating mode when one tank is offline for service. Since both tanks are normally online, these instruments are also utilized in calling the lead and lag pumps to run as tank levels increase. Downstream of the waste pump discharge header, a flow meter (FIT-700) is installed to monitor the residuals flow delivered to the gravity thickeners.

2.4.2 Waste Equalization Tanks Overflows and Valve Chamber Collector

In each of the equalization tanks, an overflow pipe is installed that runs to a buried overflow collector main. The overflow main drains to a buried valve chamber located near the treated water reservoirs. This dry well valve chamber also accepts overflows from the reservoir cells and pump clear wells. The chamber is a plant wide collection point for tank overflows and is dimensioned at approximately 3.7 m long x 3.7 m width and 8 m deep. In the chamber sump, a drain is installed which runs to Yellowknife Bay. Currently this drain is blocked using a pneumatically inflated plug to prevent release of sludge or chlorinated water to the bay. A level switch is installed in the chamber sump to alert an operator of a potential equalization tank overflow.

2.4.3 Coagulant Dosing and Gravity Thickener Systems

The vendor-supplied residuals handling system consists of two, parallel gravity thickeners (GT-730 and GT-731). The packaged system is installed with a dedicated PLC, which automates operation of the interconnected equipment while communicating with the overall plant PCS. The system is capable of operating in a dual thickener mode and each thickener is equipped with dedicated coagulant dosing connections. Nonetheless, the thickener valving permits shutdown of a single thickener train for maintenance or cleaning.

The gravity thickener trains consist of three stages: coagulant mixing, flocculation, and settlement. The first baffled compartment of each train contains a fixed speed, rapid mechanical mixer (MXR-722 and MXR-724). The intent of this stage is to rapidly mix the dosed coagulant and residuals into a uniformly blended volume, allowing the solids to react with the coagulant, before advancing to the flocculation stage. The coagulant effectively neutralizes the electrical charges on the surfaces of the particles, reducing the repulsive forces between particles, and alleviating their tendency to remain suspended. The variable speed flocculation mixers (MXR-723 and MXR-725), gently mix the residuals to encourage the particulate solids to interact with each other. Flocculation mixing facilitates collisions of particles allowing them to agglomerate as larger, more settleable solids. The variable speed drives for these mixers accommodate optimization of mixing speed for variations in conditions such as coagulant type, dose, water temperature, pH, etc. The final train is the thickener tanks consisting of parallel plate separators (lamella) and conical shaped tank bottoms equipped with mechanical scrapers (SK-740 and SK-741). The flocculated wastewater flows upward through the plate separators. The agglomerated particles drop under gravity and roll down the plates into the tank bottom. The scrapers serve to thicken and move the settled sludge to the bottom of the tank where it is collected at the outlet and drawn out by the fixed speed, rotary lobe style thickened sludge pumps (P-706 and P-707). The clear liquid portion of the residuals (supernatant) continues upward to the top of the tank and overflows to the supernatant recycle piping. A turbidity analyzer is located on the supernatant recycle header which monitors the quality of this stream. If turbidity remains above a pre-defined limit, a motorized three-way valve (TWV-710) returns the supernatant to waste equalization tanks for further treatment. Once turbidity is within the preferred range of operation, TWV-710 is automatically actuated to direct supernatant to the recycle header located at Pump House No. 1 where it is picked up by the river raw water booster pumps. If the booster pumps or membrane system is not operational, the drainage is pumped by P-106 into the bay wet well. A recycle flow meter (FIT-710) is installed on this line to quantify the volume of supernatant returned to the head of the WTP.

The variable speed, peristaltic type coagulant dosing pumps (P-704 and P-705) are utilized to deliver coagulant (or polymer if required) to the head of the gravity thickeners. Dosing pump P-704 is dedicated to GT-731, while P-705 is dedicated to GT-730. These pumps are configured on a vendor-supplied skid with manual valving accommodating crossover flow to either thickener should a dosing pump be taken offline. This system is designed to handle a variety of coagulants and flocculant aids as it is installed alongside two polymer mixing/aging tanks (T-714 and T-715) complete with mechanical dilution mixers (MXR-726 and MXR-727). At present, the coagulant used at the plant for residuals thickening is ClearPAC® 180, which requires no dilution or aging. Therefore, the dilution mixers are not currently in operation. The coagulant dosing skid and mixing tanks are surrounded by a chemical containment structure to prevent spills in the thickening area.

When the raw water contains a low concentration of particles, such as in the fall and winter, the thickeners operate effectively without coagulant. Therefore, thickened backwash solids only contain coagulant over periods when the raw water contains high concentrations of particles, such as the spring or summer.

2.4.4 Thickened Sludge Storage and Disposal

The thickened sludge storage system consists of two storage tanks (T-712 and T-713). Thickened sludge is pumped from the bottom of the gravity thickeners by the sludge pumps through one or both of the sludge tank inlet flow control valves (FCV-712 and FCV-713). The control valves facilitate automatic selection of the receiving sludge storage tank based on the level of sludge contained in the tanks. Each tank is equipped with dedicated level instruments to monitor waste storage and to trigger closure of an inlet FCV at tank full condition.

The gravity thickening and sludge storage system was originally designed to accommodate sludge extraction by vacuum truck for subsequent disposal at the local sewage lagoon. However, at present, the sludge volumes produced during the fall and winter periods are low and this waste is discharged intermittently to the local sanitary sewer by gravity. During the spring and summer, when particulate loading is higher, coagulant is used to thicken the sludge and it is generated in greater volumes. When conditions permit the generation of sludge with higher solids content, the sludge tanks are emptied by vacuum truck. In some raw water conditions, the quality of the flocculation product has been known to suffer. It is not uncommon, in the spring and summer, for the thickened sludge to be produced with a suboptimal solids content. Under such seasonal conditions, thickened sludge containing coagulant is discharged to sewer. At the time of development of this manual, the City had engaged a consultant to assess options for flocculation process optimization with the aim of enhancing sludge solids content while minimizing coagulant consumption. In turn, optimization of dosing minimizes the concentration of coagulant residues, such as aluminum, contained in recycled thickener supernatant and thickened sludge.

The backwash thickened sludge will contain concentrated raw water constituents such as organics and naturally occurring minerals as well as residual aluminum originating from coagulant. Given the dual tank arrangement, sludge tanks are emptied once full by vacuum truck or by discharge to sewer. The capacities of the sludge tanks are known and, therefore, sludge disposal volumes can be logged for each emptied tank. Further, this waste flow is typically captured by the downstream flow meters located in the sewage lift stations. Since this waste product is ultimately accepted by the sewage lagoon, thickened sludge is subject to the City of Yellowknife Water and Sewer By-Law No. 4663. Refer to Schedule D (Restricted Wastes) of this By-Law for discharge concentration limits defined for waste constituents such as total suspended solids, biochemical oxygen demand, and aluminum.

2.5. On-site Sodium Hypochlorite Generation and Storage Systems

An on-site sodium hypochlorite solution generation (OSG) system is utilized at the WTP to produce chlorine for disinfection of the treated water. OSG is an electro-chemical process using granulated salt (sodium chloride), softened, tempered water, and electricity. An OSG system offers several benefits compared to dosing from commercially manufactured and delivered 12% sodium hypochlorite solution in totes or drums. Operator and environmental safety is inherently improved with the production of a significantly weaker hypochlorite solution (0.8%), which requires transportation, delivery, and handling only of dry salt. On-site generated 0.8% sodium hypochlorite solution undergoes far less degradation compared with 12% SHS. This is particularly important for locations where chemical transportation distances are significant as is the case for Yellowknife. In remote communities, OSG systems are an ideal selection to address supply chain uncertainty.

The OSG system is an integrated equipment package supplied by Microclor (PSI International) consisting a brine saturation tank (T-410), water softeners (WS-420 and WS-421), a softener regeneration brine tank (T-416), softeners' brine pump (P-407), brine solution pumps (P-400 and P-401), an electrolytic cell (EL-430), hypochlorite storage tanks (T-411, T-412, T-413, and T-414), and hydrogen dilution blowers (B-450, B-451, B-452, and B-453). The vendor-supplied OSG package is installed with a dedicated PLC, which automates operation of the interconnected equipment while communicating with the overall plant PCS.

The OSG process begins with the brine saturation tank, which is filled from a truck equipped with a pneumatic offloading system. The salt is continuously dissolved in the tank through application of warm, plant service water that has been pretreated by the water softeners. The produced strong brine is fed to the electrolyzer and replaced by incoming "soft" water. The duty-standby, gear-type brine solution pumps convey the saturated brine through the electrolyzer (electrolytic cells). Utilizing a low voltage DC current, the electrolyzer converts salt and water to a low strength sodium hypochlorite solution, which is delivered to one of the four hypochlorite storage tanks. A byproduct of the electrolysis process is hydrogen gas. The majority of the hydrogen gas generated is liberated at the electrolytic cell and vented to atmosphere outside the building. However, some hydrogen gas is carried in the solution in dissolved form to the hypochlorite storage tanks. As fresh hypochlorite is delivered to the hypochlorite storage tanks, hydrogen continuously degasses from the solution. For each pair of hypochlorite tanks, a venting header system is installed between them with a connection leading to a common vent outlet at the exterior of the building. Duty-standby, centrifugal-type hydrogen dilution air blowers are dedicated to each paired tank system. These systems force air into the tanks and push hydrogen gas to the vent outlet. The intent of the hydrogen gas handling systems is to effectively reduce the hydrogen gas concentration to well below the explosive limit (< 25% of the LEL) and to eliminate the hydrogen to the outside atmosphere.

The OSG system is a batch system and is operated as required to fill the storage tanks according to expected demand. Chlorination of current peak day demand flow rates consumes a full hypochlorite tank in approximately one day. Operation of the OSG system is sequenced to ensure that the WTP maintains at least a four-day supply of 0.8% SHS. In the event that the OSG system is offline for an extended duration, two (2) 1000 L totes of 12% concentrated sodium hypochlorite are stored onsite as backup for the disinfection system. Under these abnormal conditions, the concentrated stock solution is delivered to an empty hypochlorite tank using a manual dilution eductor panel. This eductor utilizes softened plant service water from the OSG system as the motive fluid which draws in hypochlorite for mixing. Dilution and SHS concentration are proportional to the plant service water flow and is controlled manually using an adjustable control valve.

The water softeners play an important role in hypochlorite generation. Utilizing ion exchange resin media, the softeners remove hardness ions (magnesium and calcium) from the plant service water to prevent deposition of these salts as scale on the surfaces of the electrolytic cells. Over time, the water softener resins are exhausted by hardness ions adsorbed to their surfaces. The “hard” plant service water is tempered through exposure to a heat exchanger. Feed water heating serves two functions: 1. Increased temperature improves the rate at which the hardness ions react/exchange with sodium ions (from salt) adsorbed to the resins; 2. Adjustment to service water temperature allows for optimization of dissolved salt concentration in the brine.

The softener resins are regenerable using the same brine solution that is normally supplied to the electrolyzer. The softeners’ brine pump and tank handle the regenerating brine supply. This smaller brine pump is integrated with a set of level switches to start or stop filling the regeneration brine tank. An exhausted water softener may be taken offline and flushed by gravity with brine from the regeneration tank.

The brine saturation tank and the hypochlorite tanks are installed with dedicated instruments to monitor level of contents. The brine tanks and the hypochlorite tanks are located within separate chemical containment structures. The hypochlorite tanks are supplied with overflows that discharge to their respective containment in the event that a tank is overfilled. Both containment structures in the OSG area are equipped with level switches that trigger alarms should overflows or flooding occur during operation of these systems. Refer to Section 3.5 for instrumentation, controls, and alarms related to the OSG system.

2.6. Chlorination and Fluoridation Systems

The chlorination and fluoridation systems consist of metering pumps, instruments, and stock tanks for dosing of on-site generated sodium hypochlorite and fluorosilicic acid. These metering pumps draw stored chemicals and inject them into the filtrate main between the membrane microfiltration system and the treated water reservoirs. A sampling metering pump (P-405) downstream of these systems delivers a side stream of treated water to an instrument panel for verification that fluoride, free chlorine, temperature, and pH are within the preferred range of operation.

2.6.1 Sodium Hypochlorite Dosing Systems

Sodium hypochlorite solution as a chlorine source is utilized for both primary and secondary disinfection. This disinfectant effectively inactivates pathogens such as bacteria, protozoa, and viruses. Hypochlorite also establishes a lasting free chlorine residual to maintain potable quality in the distribution system.

The 0.8% sodium hypochlorite solution dosing system is comprised of two, duty-standby peristaltic metering pumps (P-402 and P-403). These pumps draw hypochlorite from the four SHS tanks. The pumps are variable speed and deliver the sodium hypochlorite solution to the membrane system filtrate main at a rate proportional to the filtrate flow measured by flow meter, FIT-280. Each pump is rated for a range of dosing rates between 23 and 410 L/hour (0.22 to 3.93 mg/L dosed as $Cl2$). For details related to dosing rates, instrumentation, and controls, refer to Section 3.6.

The sodium hypochlorite dosing skid is located within the same containment structure that protects the onsite sodium hypochlorite generation area from chemical spills. Further, the hypochlorite dosing discharge tubing is installed within a PVC containment pipe. The PVC pipe is sloped back to the skid such that leaked product will drain to the containment structure in the event that a discharge tube breaks.

2.6.2 Fluorosilicic Acid Dosing Systems

Fluorosilicic acid is commonly introduced to potable water supplies to improve dental health within serviced communities. The fluoridation system is comprised of two duty-standby peristaltic metering pumps (P-404 and P-405), which draw fluorosilicic acid from a stock storage tank, T-415. The dosing pumps discharge to the membrane filtrate main at injection quills downstream of the filtrate flowmeter and hypochlorite injection point. Since the fluoride dosing pumps are variable speed, the dosing rate of the duty pump is paced proportionally with respect to the supply flow measured by the filtrate flowmeter (FIT-280). The dosing pumps are each capable of metering fluoride at a rate of 0.27 to 3.48 L/hour. Immediately downstream of the fluoride injection point, a static mixer is installed to blend the filtrate with treatment chemicals prior to sampling at the instrumentation panel. Refer to Section 3.6, for details related to fluoridation instrumentation and controls as well as continuous sample monitoring.

The optimal fluoride concentration in treated water for dental health benefits is reported as 0.7 mg/L by the Canadian Drinking Water Quality Guidelines. Since commissioning of the current fluoridation system, treated water sampling has been undertaken to confirm fluoride concentrations are at levels approaching the optimum. Further, the online fluoride analyzer, AIT-401, is utilized to maintain treated water fluoride concentrations below the maximum concentration defined by Health Canada. The *Guidelines for Canadian Drinking Water Quality Summary Table* (Health Canada, September 2020) defines the maximum acceptable treated water fluoride concentration to be 1.5 mg/L. Note that fluoride is a naturally occurring element in the local raw water source and this natural fraction passes through the treatment process.

The fluoride tank is designed to sit atop of a digital weigh scale for remote monitoring of stock reserve. The tank is installed complete with an inlet quick disconnect coupling to facilitate refilling from stock totes positioned by a forklift. Further, the fluoride tank contains overflow piping that drains to a chemical containment structure surrounding the stock offloading area. Within this containment structure a level switch is provided to alert the operator of a potential overflow or tubing leak. The fluoride dosing discharge tubing is contained within a PVC pipe that drains back to the containment structure.

2.7. Treated Water Storage, Distribution, and Backwash Supply System

Following chlorination and fluoridation of the membrane filtrate, treated water is stored in reservoirs and pump clear wells for subsequent delivery to the City of Yellowknife distribution system and equipment using plant service water at the WTP. The treated water system is comprised of distribution pumps, fire pumps, membrane backwash pumps, recirculation pumps, and various analytical instruments for monitoring treated water quality.

2.7.1 Reservoirs and Pump Clear Wells

The intent of the reservoirs is to allow the WTP to more gradually increase and decrease water production for diurnal (variations throughout the day) and seasonal variations in demand rather than responding to short-term peak demands. The reservoirs provide reserve storage to accommodate the delivery of treated water using a pumping system designed for a wide range of flows. The reservoir cells play an important role in disinfection by providing the treated water contact time (CT) required for chlorine to inactivate viruses. This parameter is proportional to working volume of online cells and the outfeed flow to the users. The operating CT is calculated and reported by the PCS based on online tank volume and instrument outputs measured from the reservoir feed main and distribution main. This CT calculation is described in further detail in the *City of Yellowknife Water Treatment Plant Control Philosophy* (AECOM, 2015).

Upstream of the reservoirs, membrane filtrate is delivered to a buried valve chamber containing a reservoir inlet header. This chamber is the junction point containing manual isolation valves at the inlets to three independent reservoir cells (Reservoir 1, 2, and 3). The inlet header facilitates equalization of reservoir levels for the online cells. From the outlets of the cells, water flows through manual sluice gates to two interconnected pump clear wells. The valve and sluice gate interconnections between reservoir cells and clear wells allow for these tanks to be taken offline for maintenance or cleaning. Furthermore, one or more cells may be isolated and drained during seasonal low demand periods to prevent stagnation of treated water (decay of chlorine residual) due to excessive detention time. The overall treated water storage capacity of reservoir and clear well system is approximately 9,000 m3.

The pump clear wells are designed with dedicated level instruments for monitoring storage levels. Since the pump wells are hydraulically connected to the online cells, these instruments measure the reserve level available for outfeed. In each reservoir cell, overflow pipework is installed to direct chlorinated water from overfilled cells and clear wells to the buried valve chamber. As described in Section 2.4.1, this chamber is a plant-wide collection point for overflows. A level switch is installed in the chamber sump to alert an operator of a potential reservoir or equalization tank overflow.

2.7.2 Treated Water Pumping Systems

Each pump clear well contains a pumping system consisting of four vertical turbine style pumps serving various functions. Pump Well 1 houses Distribution Pump 1 (P-500), the smaller of four distribution pumps, Distribution Pump 2 (P-501), Fire Pump 1 (P-504), and Membrane Backwash Pump 1 (P-506). Pump Well 2 contains Distribution Pump 3 and 4 (P-502 and P-503), Fire Pump 2 (P-505), and Membrane Backwash Pump 1 (P-507). The distribution pumps are configured in a lead-lag-lag-lag arrangement for sequenced operation based on demand. All four of the distribution pumps are equipped with VFDs accommodating pump speed adjustment to satisfy an operator-defined normal discharge pressure setpoint. If discharge pressure in the distribution main should continue to drop below the intermediate setpoint limit with all distribution pumps online, this implies that fire hydrants are open, and a fire pump is started. The smaller distribution pump and one lag pump may then be shut down as the fire pump ramps up. In the event that discharge pressure drops below the defined minimum setpoint, the second fire pump will then be brought online. The functional capacity of the distribution and fire pumping system spans a range of 1,700 to 48,600 m^3/day (20 to 565 L/s).

Downstream of the distribution and fire pump discharge header, a treated water flow meter (FIT-520) is provided alongside an analytical instrument panel, which monitors outfeed parameters including turbidity, free chlorine, temperature, pH, and fluoride.

The variable speed membrane backwash pumps are called upon as required by the membrane microfiltration package PLC. These two pumps are configured in a duty-standby arrangement with a supply capacity of approximately 56 L/s.

To deal with the low seasonal temperatures experienced in Yellowknife and to prevent freezing of water mains, the distribution system is designed to supply water along a loop, which returns to the WTP. The return main on this distribution loop runs past the treated water system and splits into a PRV-controlled reservoir feed and a recirculation pump suction header. The duty-standby, fixed speed recirculation pumps (P-600 and P-601) draw water from the return main and blend it with new treated water downstream of the distribution and fire pumps. These pumps are rated for a capacity of 2,000 m^3/day (22.7 L/s). Upstream of the recirculation pump suction, a return flow meter (FIT-600) and free chlorine analyzer are installed to monitor the quality and dilution rate of return water re-entering the distribution system.

3. OPERATION, MAINTENANCE, AND AUTOMATION

In addition to providing a general overview of the Yellowknife Water Treatment Plant and the processes therein, this Manual aims to develop summaries of control features utilized in operation of major plant processes; describe routine maintenance and material handling tasks undertaken by plant operators; and to provide an overview of potential operational contingencies and mitigative features in place.

3.1. Yellowknife River Intake Supply and Wet Well System – Pump House No. 2

The following sections provide an overview of operation, maintenance, and automation features at Pump House No. 2 located near the Yellowknife River intakes.

3.1.1 Instrumentation and Controls – Pump House No. 2 and Wet Well

The two, duty-standby river raw water supply pumps, P-1 and P-2, are each installed complete with variable frequency drives (VFD). The diesel engine driven pump, P-3, and the Truckfill Pump discharge at fixed speed as they are not operated continuously. Table 2 identifies and describes the function of instrumentation and control systems for the Pump House No. 2 subsystem.

Table 2: Pump House No, 2 Systems Instrumentation and Controls

Identifier	Location	Device Type	Device Function
VFD #1	PH2 electrical room; Dedicated to Pump P-1	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
VFD #2	PH2 electrical room; Dedicated to Pump P-2	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
P2-PT1	On common pump discharge header pipe	Pressure Transmitter	Monitors discharge header pressure for control of pumps
P2-PS1 with P-1 Online	On Pump P-1 discharge	Pressure Switch	Triggers pump failure alarm if pressure drops below pre-defined value
P2-PS2 with P-2 Online	On Pump P-2 discharge	Pressure Switch	Triggers pump failure alarm if pressure drops below pre-defined value

Identifier	Location	Device Type	Device Function
P2-PS3 with P-3 Online	On Pump P-3 discharge	Pressure Switch	Triggers pump failure alarm if pressure drops below pre-defined value
FT-1	Supply main to WTP	Flow Transmitter	Monitors instantaneous flow and logs total daily supply flow
FT-101	On Truckfill Pump discharge	Flow Transmitter	Monitors truck onloading flow
FS-101	On Truckfill Pump discharge	Flow Switch	Indicates the presence of flow
P2-LT1	South wet well cell	Level Transmitter	Monitors wet well liquid level
P2-LT2	North wet well cell	Level Transmitter	Monitors wet well liquid level
Diesel ON/OFF Command	PH1 PLC	PLC Control Output	Command to start/stop standby diesel pump from PLC
Truckfill Dispenser Key Box Controller	Control panel external to PH2	Key initiated ON/OFF switch	Facilitates pump start/stop from panel outside building using key

3.1.2 Control Philosophy – Pump House No. 2 and Wet Well

The raw water pumps for the Yellowknife River intake are controlled from the PLC in Pump House No. 1. The lead pump is operated at variable speed such that an array of pressure setpoints may be used to control flow supplied to the WTP. At start-up of the duty unit, the pump will increase speed until discharge pressure reaches 250 kPa and flow is maintained above 30 L/s as measured by flow meter, FT-1. From the Pump House No. 1 PLC, various pumping programs may be selected based on discharge pressure setpoints to prompt an increase or decrease of pump speed to meet the required flow range. Table 3 summarizes these selector programs and provides an overview of the current Pump House No. 2 capacity. As demand flow increases to the upper bound of a program range, the pump will automatically increase the discharge pressure to the next setpoint in ascending order. When flow decreases to the lower bound of the program, the pump will switch to a lower discharge pressure setpoint in a similar manner. Note that Pump House No. 2 operates independently of Pump House No. 1 and the lead pump is not locked out when the WTP is offline. However, should flows drop below 30 L/s for a duration longer than 180 seconds, the duty pump unit will react by shutting down and triggering an alarm.

Table 3: Pump House No. 2 Capacity and Operational Setpoints

Flow (L/s) as Measured by FT-1	Pressure Setpoint (kPa) as Measured by P2-PT1
0 - 60	250
60 - 100	340
100 -140	470
140 - 170	650
170 - 200	850
200 - 220	1020

The emergency diesel-engine driven pump, P-3, is typically controlled from the PH1 PLC. The diesel pump is normally only required when the duty-standby pumps are unavailable. Nonetheless, the diesel pump may be run from the PH1 PLC during routine testing. In the event of an emergency such as an extended power outage at Pump House No. 2 or loss of communication from Pump House No. 1, the standby pump may be started and stopped manually from the diesel engine integrated control panel.

The Truckfill Pump is started from a key-operated dispenser controller panel located external to the Pump House No. 2 building. The truckfill dispenser controller panel is supplied with an emergency stop push button to avoid overfilling trucks in the event that a key becomes jammed.

3.1.3 Routine Maintenance and Inspection – Pump House No. 2 and Wet Well

The maintenance program for the emergency diesel-engine driven pump, P-3, includes routine pump functional testing. Currently, the diesel pump is tested weekly with a runtime of approximately 15 minutes. Testing requires coordination with other WTP operations and, therefore, the duty pump may need to be taken offline prior to commencing standby pump operation. This operative should include an inspection of the diesel fuel tank to log the reading from the fuel level indicator. This task will ensure reserve fuel volume is available for emergencies and will confirm the age of fuel in storage is within its recommended shelf life.

The raw water intake screens require periodic inspection and cleaning. Since the screens are submerged offshore in the river, specialized diving personnel are required for this task. Both intakes are taken offline by closing their respective isolation valves and a diver manually removes debris and biological films from the intakes. While this procedure is undertaken, the diver can transmit a video feed of their observations to staff onshore such that screen condition may be evaluated. These video feeds are recorded to document screen condition assessments.

The isolation butterfly valves installed on the intake mains and the cell interconnection stub are supplied with valve shaft extensions through the PH2 floor slab such that valve handwheels are accessible from grade. Occasionally, these isolation valves should be stroked for confirmation of functionality. The wet well maintenance operative should also include inspection through the wet well access hatches for debris trapped in the chambers. To undertake cleaning of the wet well cells, all three submerged butterfly valves must be closed and locked out and the duty-standby pumps must be taken offline prior to reaching the minimum allowable operating level. The remaining liquid containing sediment may be pumped to site drainage features using a temporary submersible dewatering pump. Should entry be required to clean or retrieve the wet well inlet channel screens, a confined space entry is likely required in accordance with the Northwest Territories & Nunavut Workers Safety & Compensation Commission (WSCC) Codes of Practice.

3.1.4 Fuel Handling – Pump House No. 2

The primary chemical handled at Pump House No. 2 is diesel fuel. The diesel engine driven pump fuel storage tank is located exterior to the building on the south side of Pump House No. 2. The fuel tank is installed directly adjacent to an access driveway which accommodates a small tanker truck. The driveway is configured between entrance and exit gates to minimize vehicle turning hazards. The fuel tank is constructed on top of a concrete dyke and containment structure (2500 L) for collection of fuel spills.

3.2. Yellowknife Bay Supply and Wet Well System – Pump House No. 1

The following sections provide an overview of operation, maintenance, and automation features at Pump House No. 1, located next to the WTP, including systems related to Pump House No. 2 and the Yellowknife Bay intake.

3.2.1 Instrumentation and Controls – Pump House No. 1 and Wet Well

Each of the River raw water booster pumps and the bay raw water pumps are installed complete with VFDs. Table 4 identifies and describes the function of instrumentation and control systems for the Pump House No. 1 subsystem.

Table 4: Pump House No. 1 Systems Instrumentation and Controls

Identifier	Location	Device Type	Device Function
PIT-100	On River raw water main upstream of booster pump suction header	Pressure Transmitter	Monitors suction pressure for river raw water supplied to booster pumps
P-101 VFD P-102 VFD P-103 VFD	Power feeds to Raw Water Booster Pumps P-101, P-102, and P-103	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
FSL-101 FSL-102 FSL-103	On discharge of Raw Water Booster Pumps P-101, P-102, and P-103	Flow Switch	Indicates absence of raw water flow
FIT-101	On raw water main downstream of booster pump discharge header	Flow Transmitter	Monitors instantaneous raw water flow supplied to WTP and logs total flow for pre-determined period
PIT-101	On raw water main downstream of booster pump discharge header	Pressure Transmitter	Monitors combined discharge pressure for river raw water booster pumps and bay raw water pumps
P-104 VFD P-105 VFD	Power feeds to Bay Raw Water Pumps P-104 and P-105	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
FSL-104 FSL-105	On discharge of Bay Raw Water Pumps P-104 and P-105	Flow Switch	Indicates absence of raw water flow
FIT-100	On raw water main downstream of bay raw water pump discharge header	Flow Transmitter	Monitors instantaneous raw water flow supplied to WTP and logs total flow for pre-determined period
TIT-100	On raw water main downstream of river raw water connection	Temperature Transmitter	Measures the temperature in blended river and bay raw water supplied to WTP
LIT-120	In bay wet well	Level Transmitter	Measures the raw water level in bay wet well
LSLL-120	In bay wet well	Level Switch	Triggers Low Low level alarm for bay wet well

3.2.2 Control Philosophy – Pump House No. 1 and Wet Well

As raw water enters Pump House No. 1 from the Pump House No. 2 River supply main, it passes through PRV-180 and PCV-110. A powered solenoid valve pilot is utilized to throttle PRV-180, to apply backpressure for control of upstream pumps, and to sustain a minimum flow through the river water supply main when the WTP is not operating. When the WTP is operated normally, PCV-110 is throttled to reduce incoming pressure at the river raw water booster pump suction to within a pre-defined range.

The lead-lag-standby river booster pumps are started by the PCS based on feedback from the membrane system PLC. The lead booster pump's speed is adjusted to satisfy a flow or pressure setpoint dictated by the PLC and the treated water reservoir level. If the lead pump cannot meet this demand, the lag booster pump is brought online.

During abnormal conditions or emergencies, the lead-lag bay raw water pumps are utilized to feed the WTP. This is an operator-initiated pumping mode which requires selection of the bay raw water pumps and shutdown of the river booster pumps. On start-up, the lead bay pump speed is increased until the setpoint defined by the membrane system PLC is satisfied. Should the lead bay pump operate at a flow of 150 L/s or more for 10 seconds, the lag bay pump is automatically started.

Table 5 summarizes several alarms critical to Pump House No. 1 operations. A more detailed list of alarms, actions, and triggering parameters are described in the City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015).

Table 5: Treated Water Systems Alarms and Operator Dial-Out

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
PIT-100 LOW LOW	Stop Raw Water Booster Pumps P-101, P-102, and P-103	Minimum river raw water pressure limit reached in submerged main	Yes
PIT-100 LOW PIT-100 HIGH PIT-100 HIGH HIGH	None	River raw water pressure in submerged main measured outside of preferred operating range	No

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
P-101 FAIL P-102 FAIL P-103 FAIL Singular Occurrence	Stop failed raw water booster pump and start next pump in programming hierarchy	River raw water booster pump failure registered by pump controller	No
Lead Raw Water Booster Pump FAIL	Adjust pump operation sequence hierarchy	Lead river raw water booster pump failure registered by pump controller	No
Lag Raw Water Booster Pump FAIL	Adjust pump operation sequence hierarchy	Lag river raw water booster pump failure registered by pump controller	No
Lead and Lag Raw Water Booster Pumps FAIL	Start Standby Raw Water Booster Pump	Both Lead and Lag river raw water booster pump failures registered by pump controllers	Yes
Lead, Lag, and Standby Raw Water Booster Pumps FAIL	Shutdown treatment process	Pump failures for all river raw water booster pumps registered by pump controllers	Yes
PIT-101 HIGH HIGH	Stop Raw Water Booster Pumps P-101, P-102, and P-103	Maximum discharge pressure limit reached in river and bay raw water supply main to WTP	Yes
PIT-101 LOW PIT-101 HIGH PIT-101 HIGH HIGH	None	Discharge pressure in river and bay raw water supply main to WTP outside of preferred operating range	No
FIT-101 LOW LOW FIT-101 LOW FIT-101 HIGH FIT-101 HIGH HIGH	None	River raw water supply flow upstream of bay raw water connection measured outside of preferred range of operation	No
P-104 FAIL P-105 FAIL Singular Occurrence	Stop failed bay raw water pump and start standby pump	Bay raw water pump failure registered by pump controller	No

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
P-104 FAIL P-105 FAIL Concurrent	Stop treatment process	Both bay raw water pump failures registered by pump controllers	No
FSL-101 ACTIVE FSL-102 ACTIVE FSL-103 ACTIVE FSL-104 ACTIVE FSL-105 ACTIVE with respective pump online	Stop respective raw water pump and start next pump in programming hierarchy	Absence of flow registered by low flow switch, yet respective pump is running	No
FIT-100 LOW LOW FIT-100 LOW FIT-100 HIGH FIT-100 HIGH HIGH	None	Bay raw water supply discharge pressure measured outside of preferred range of operation	No
LIT-120 LOW LOW	Stop bay raw water pumps	Minimum water level limit reached in bay wet well	Yes
LIT-120 HIGH HIGH	None	Maximum water level limit reached in bay wet well	Yes
LIT-120 LOW LIT-120 HIGH	None	Bay wet well water level measured outside of preferred range of operation	No
LSLL-120	Stop bay raw water pumps	Pump-specific minimum treated water level limit reached in bay wet well; wet well empty	Yes

3.2.3 Routine Maintenance and Inspection – Pump House No. 1 and Wet Well

The Pump House No. 1 wet well and intake requires maintenance schemes similar to that of Pump House No. 2. Refer to Section 3.1.3 for descriptions of these intake and wet well related tasks.

3.2.4 Raw Water Quality Sampling and Monitoring – Pump House No. 1

Raw water quality is currently monitored through routine analysis of samples collected from both the Yellowknife River and Yellowknife Bay supplies. Samples are analyzed for various regulated raw water constituents in accordance with the *Guidelines for Canadian Drinking Water Quality Summary Table* (Health Canada, September 2020) and the Water Supply System Regulations

(Government of Northwest Territories, September 2009). Sample points are available on the discharges of the river booster pumps and the bay raw water pumps. The current monitoring program consists of the analyses provided in Table 6 for these two sampled water sources.

Table 6: Pump House No. 1 Raw Water Quality Monitoring

Yellowknife River and Bay Raw Water Quality Monitoring Parameters – Sample Analyses			
Inorganics - Physical			
Alkalinity (mg/L)	Colour	pH	Total Dissolved Solids (TDS) (mg/L)
Total Hardness (mg/L)	Total Suspended Solids (TSS) (mg/L)	Turbidity (NTU)	
Inorganics - Nutrients			
Organic Carbon Dissolved (mg/L)	Organic Carbon Total (mg/L)		
Major Ions			
Chloride (mg/L)	Fluoride (mg/L)	Hardness (mg/L)	Nitrate (as Nitrogen) (mg/L)
Sodium (mg/L)	Sulphate (mg/L)		
Trace Metals			
Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)
Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)
Manganese (µg/L)	Mercury (µg/L)	Selenium (µg/L)	Uranium (µg/L)
Zinc (µg/L)			
Subcontracted Organics			
Cyanide (Weak Acid Dissociable) (mg/L)			

Since the Yellowknife Bay raw water source is typically only required during emergencies, additional water quality analysis is undertaken prior to testing the bay raw water pumps. A sample of raw water from the bay wet well is analyzed for arsenic concentration in advance of pump tests. Refer to Section 2.2.3 for the provisional requirements for bay raw water pump operation.

3.3. Micro-Strainer, Membrane Microfiltration, Clean-in-Place, and Neutralization Systems

The following sections provide an overview of operation, maintenance, and operational resilience features built into the microfiltration systems, integrated PLC, and overall plant Process Control System.

3.3.1. Instrumentation and Controls – Microfiltration Systems

Table 7 identifies and describes the function of instrumentation and control systems for the membrane microfiltration subsystem and integrated PLC. Several instruments and controls are not included in this summary as some of these elements do not communicate directly with the PCS. Refer to vendor-supplied package functional description submittals for instrumentation and controls monitored internally by the membrane system PLC.

Table 7: Microfiltration Systems Instrumentation and Controls (PCS-Integrated)

Identifier	Location	Device Type	Device Function
Micro-Strainer Systems			
STR-220 STR-221 Controller	Membrane Microfiltration Package PLC	Microfiltration Package PLC Output	Automatic command to start/stop micro-strainers
TIT-210	On raw water main downstream of strainers	Temperature Transmitter	Monitors instantaneous strained water temperature delivered to membrane microfiltration system
Membrane Microfiltration Package Systems			
CMP-250 CMP-251 Controller	Membrane Microfiltration Package PLC	Microfiltration Package PLC Output	Automatic command to start/stop membrane air compressors
Membrane Clean-in-Place Systems			
P-200A/B P-201A/B P-202A/B P-203A/B P-204 P-205 P-206 P-207 P-209 Controller	Membrane Microfiltration Package PLC	Microfiltration Package PLC Output	Automatic command to start/stop clean-in-place system pumps

Identifier	Location	Device Type	Device Function
MM-230	CIP Containment Sump Pump (P-23) control panel	Start/Stop Switch	Manual push button to start/stop CIP Containment Sump Pump
LSH-203	In CIP Containment	Level Switch	Triggers High level alarm for CIP Containment
Clean-in-Place Chemical Neutralization Systems			
LSH-203	In Neutralization Containment	Level Switch	Triggers High level alarm for Neutralization Containment

(See Section 3.7.1 for Membrane Backwash Pump related systems)

3.3.2. Control Philosophy – Microfiltration Systems

Operation of the micro-strainers, installed upstream of the membrane system, is initiated passively by opening the manual isolation valves at the inlet and outlets of the strainers. The flush sequence for the micro-strainer is automatically triggered based on time elapsed or when the pressure drop measured across a strainer unit exceeds the maximum limit defined by the membrane system PLC. Strainer flushing is undertaken one unit at a time by an internal mechanism. The strainers are designed such that raw water flow through a strainer in clean mode does not need to be interrupted for flushing.

The membrane system PLC controls all operational tasks related to the micro-strainers, membrane microfiltration system, chemical cleaning system, neutralization system, and associated analytical instruments. Prior to start-up of the membrane system, the PCS will communicate permissive signals to the package PLC. Based on treated water reservoir levels, the PLC will call upon the river raw water booster pumps (or bay raw water pumps during abnormal conditions) to deliver supply at an adjustable rate and pressure. Decision-making within the PLC considers inputs from several instruments integrated within the package. The following parameters from the PLC are communicated to the PCS: raw water flow to each individual membrane rack, raw water turbidity, filtrate flow from each individual membrane rack, turbidity from each individual membrane rack, blended filtrate turbidity, particle counts from blended filtrate, and backwash flow supplied from the treated water reservoirs.

Table 8 summarizes several PCS alarms critical to operation of the membrane microfiltration system. A more detailed list of alarms, actions, and triggering parameters are described in the City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015).

Table 8: Microfiltration Systems Alarms and Operator Dial-Out

Alarm Condition Identifiers	PCS Action	Alarm Description	Dial-Out to Operator
TIT-210 LOW LOW	Shut down water treatment process	Raw water minimum temperature limit reached; Risk of membrane freezing	Yes
TIT-210 HIGH HIGH	Shut down water treatment process	Raw water maximum temperature limit reached	Yes
TIT-210 LOW TIT-210 HIGH	None	Raw water temperature is measured outside of preferred range of operation	No
MF-230 FAIL MF-231 FAIL MF-232 FAIL	None – Action undertaken by Microfiltration Package PLC	Membrane microfiltration train failure	No
Two microfiltration trains failed	None – Action undertaken by Microfiltration Package PLC	Two of three microfiltration trains failed	Yes
Three microfiltration trains failed	Stop all raw water pumps	All three microfiltration trains failed	Yes
P-506 FAIL P-507 FAIL Singular occurrence	Stop failed backwash pump and start standby pump	Membrane backwash pump failure registered pump controller	No
P-506 FAIL P-507 FAIL Concurrent	Stop both backwash pumps	Failure of both membrane backwash pumps registered by respective pump controllers	Yes
FSL-506 FSL-507 with respective pump online	Stop respective backwash pump and start standby pump	Absence of flow registered by low flow switch, yet respective pump is running	No

Alarm Condition Identifiers	PCS Action	Alarm Description	Dial-Out to Operator
CMP-250 FAIL CMP-251 FAIL Singular occurrence	None – Action undertaken by Microfiltration Package PLC	Membrane air compressor failure	No
CMP-250 FAIL CMP-251 FAIL Concurrent	Stop all raw water pumps	Failure of both membrane air compressors	No
P-23 running	None	CIP containment sump pump running	No
LSH-203	None	CIP containment filling; tank overflowing or leaking	Yes
LSH-204	None	Neutralization containment filling; tank overflowing or leaking	Yes

3.3.3. Routine Maintenance and Inspection – Microfiltration System

The mechanical components responsible for membrane vessel water/airtightness are sensitive to low temperatures. Periodically, couplings and seals should be inspected to observe the effects of variations in raw water operating parameters. Further, leaks from fittings and other pressurized components may cause issues during membrane integrity testing. Air leaks from mechanical components will produce a false integrity testing result suggesting a broken membrane while the actual problem will elude the operator if they are not aware of the leak. Leaking membrane racks should be isolated and addressed proactively to prevent damage from subsequent changes in conditions.

Should the results of integrity testing indicate the presence of broken membrane fibres, the compromised membrane rack is taken offline for service. The operator may remove the module end caps, apply compressed air to the membranes (similar to integrity test), and locate the broken fibre through observation of the release of bubbles. Once identified, the broken membrane can be plugged and glued to seal the rupture.

3.3.4. Chemical and Waste Handling – Microfiltration System

Handling of acids, bases, and oxidizing agents should be undertaken with due care and only by trained personnel. Refer to Section 3.5.4 for general chemical handling precautions.

Monitoring of the four chemical storage tanks that feed the chemical cleaning system is a visual check. Site glasses are installed on each stock tank facilitating visual monitoring of tank levels. Cleaning chemical tanks need to be routinely refilled from bulk storage totes positioned by a forklift over the chemical containment structure. The totes are offloaded by gravity through a hose to the respective chemical tank.

Chemical cleaning waste from the neutralization tanks is discharged automatically to the sanitary sewer during a time window selected by the operator from the PCS. The neutralization system must meet neutralized water quality parameters to receive permissive signals from PCS which will initiate a drainage operation by starting of P-209. To avoid overwhelming the local sanitary sewer, the PCS will not permit draining of the neutralization tanks if the plant sanitary sump pump is delivering drainage to the sewer. However, should the monitored level of a neutralization tank exceed the maximum setpoint, the PCS will over-ride this control function, and immediately discharge the tank to sewer, to avoid a tank overflow.

Should a worker be accidentally exposed to the cleaning or neutralization chemicals, two emergency shower and eyewash stations are available in the CIP and chemical storage areas. High flow switches, FSH-201 and FSH-202, are installed on the emergency eyewash and shower feed. These switches are triggered when the stations are in use and they call the PCS to raise an alarm. The PCS automatically dials out to lead operators/supervisors to alert them of a potential personnel safety issue.

3.4. Backwash Residuals Handling Systems

The following sections provide an overview of operation, maintenance, and operational resilience features associated with the waste equalization tanks, gravity thickeners, thickeners' PLC, and overall plant Process Control System.

3.4.1. Instrumentation and Controls – Backwash Residuals Handling Systems

Table 9 identifies and describes the function of instrumentation and control systems for the residuals handling subsystem and the thickener package PLC. Several instruments and controls are not included in this summary as some of these elements do not communicate directly with the PCS. Refer to vendor-supplied package functional description submittals for controls monitored internally by the thickeners' PLC.

Table 9: Backwash Residuals Handling Systems Instrumentation and Controls

Identifier	Location	Device Type	Device Function
Backwash Waste Equalization Tank Systems			
MN-700	Waste Pump 1 (P-700 Waste Equalization Tank 1) controller	PCS Control Output	Command to start/stop P-700
MN-701	Waste Pump 2 (P-701 Waste Equalization Tank 2) controller	PCS Control Output	Command to start/stop P-701
MN-720	Waste Mixer 1 (MXR-720 Waste Equalization Tank 1) controller	PCS Control Output	Command to start/stop MXR-720
MN-721	Waste Mixer 2 (MXR-721 Waste Equalization Tank 2) controller	PCS Control Output	Command to start/stop MXR-721
LIT-710	In Waste Equalization Tank 1	Level Transmitter	Measures the backwash wastewater level in Waste Equalization Tank 1
LSH-710	In Waste Equalization Tank 1	Level Switch	Triggers High level alarm for Waste Equalization Tank 1
LSLL-710	In Waste Equalization Tank 1	Level Switch	Triggers Low Low level alarm for Waste Equalization Tank 1
LIT-711	In Waste Equalization Tank 2	Level Transmitter	Measures the backwash wastewater level in Waste Equalization Tank 2
LSH-711	In Waste Equalization Tank 2	Level Switch	Triggers High level alarm for Waste Equalization Tank 2
LSLL-711	In Waste Equalization Tank 2	Level Switch	Triggers Low Low level alarm for Waste Equalization Tank 2
FSL-700 FSL-701	On discharge of pumps P-700 and P-701	Flow Switch	Indicates absence of backwash waste transfer flow

Identifier	Location	Device Type	Device Function
FIT-700	Downstream of backwash waste pump discharge header	Flow Transmitter	Approximates backwash waste transfer flow to thickeners and logs total flow for pre-determined period
Gravity Thickener and Thickened Backwash Sludge Storage Systems			
MXR-723 VFD	Power feed to Flocculation Mixer 1 in Gravity Thickener 1	Variable Frequency Drive	Controls mixing speed
MXR-725 VFD	Power feed to Flocculation Mixer 2 in Gravity Thickener 2	Variable Frequency Drive	Controls mixing speed
MN-706	Thickened Sludge Pump 1 (P-706) controller	PCS Control Output	Command to start/stop P-706
MN-707	Thickened Sludge Pump 2 (P-707) controller	PCS Control Output	Command to start/stop P-707
FSL-706 FSL-707	On discharge of pumps P-706 and P-707	Flow Switch	Indicates absence of backwash sludge flow
AIT-701	Downstream of thickener supernatant outlet header	Turbidity Analyzer	Measures the turbidity (NTU) in thickener supernatant
XC-710	Downstream of thickener supernatant outlet header	Motorized Valve Operator	Opens/closes ports of three-way valve to deliver supernatant to either Equalization Tanks or Pump House No. 1
FIT-710	Downstream of thickener supernatant outlet header	Flow Transmitter	Approximates supernatant flow to Pump House No. 1 and logs total flow for pre-determined period
XC-712	On inlet to Sludge Storage Tank 1	Motorized Valve Operator	Opens/closes valve to control flow from thickeners to Sludge Storage Tank 1
XC-713	On inlet to Sludge Storage Tank 2	Motorized Valve Operator	Opens/closes valve to control flow from thickeners to Sludge Storage Tank 2
LIT-712	In Sludge Storage Tank 1	Level Transmitter	Measures the thickened sludge level in Sludge Storage Tank 1

Identifier	Location	Device Type	Device Function
LIT-713	In Sludge Storage Tank 2	Level Transmitter	Measures the thickened sludge level in Sludge Storage Tank 2
Backwash Thickener Polymer Dosing Systems			
MN-704	Polymer Pump 1 P-704 controller	PCS Control Output	Command to start/stop P-704
MN-705	Polymer Pump 2 P-705 controller	PCS Control Output	Command to start/stop P-705

3.4.2. Control Philosophy – Backwash Residuals Handling Systems

Equipment contained within the waste equalization tanks and gravity thickeners is run based on level instrument feedback from the equalization tanks. In consideration of demand, the operator can manually select a single or dual thickener operating mode by opening or closing the isolation valves between parallel thickener trains and by selecting the respective mode from the PCS.

The waste mixers in the equalization tanks are called to run when the LOW LOW level switch is deactivated in their respective tanks. During operation in dual thickener mode, both waste pumps in the equalization tanks are utilized to deliver residuals feeds. The first waste pump starts once the HIGH level switches in the tanks are active. At this point, operation of both thickeners and both coagulant pumps will be initiated by the PCS. The second waste pump will come online after the HIGH HIGH level is triggered by the tank level transmitters. In single thickener mode, only one waste pump is required to operate. The waste pump, selected thickener, and respective coagulant pump will all run once the HIGH HIGH level is triggered in the equalization tanks. The speed and dosing rate of the coagulant pumps is proportional to the flow registered by residuals flow meter FIT-700 and the number of online thickeners/coagulant pumps. The waste mixers and waste pumps are shutdown when equalization tank levels drop below LOW and LOW LOW limits respectively.

The supernatant from the thickeners flows by gravity to either a recycle line running back to the equalization tanks or a recirculation line draining to the river raw water booster pump suction header at the head of the WTP. The motorized three-way valve, TWV-710, selects the supernatant flow path based on turbidity measurements (AIT-701). Once supernatant turbidity is below the pre-defined limit for recirculation, the valve opens the port to deliver supernatant to the booster pumps. However, if the booster pumps or membrane systems are offline, the PCS will automatically shut down the waste pumps to avoid an overflow condition at the thickeners.

Each thickener is integrated with a dedicated thickened sludge pump. With the thickener(s) online, the sludge pumps will stop and start intermittently based on an operator-defined time period elapsed. The sludge pumps deliver the thickened product to a tank inlet header equipped with a normally open crossover valve and two motorized flow control valves, one at each sludge storage tank inlet. Both flow control valves are normally closed in automatic mode and both tank inlets are opened simultaneously as the sludge pumps are brought online. Once the level in a storage tank exceeds the HIGH level limit, its respective control valve is automatically closed and the tank with the lower level is prioritized for subsequent filling. If either of the tanks reach a HIGH HIGH level, both thickened sludge pumps are shut down.

Table 10 summarizes several PCS alarms critical to operation of the residuals handling systems. A more detailed list of alarms, actions, and triggering parameters are described in the City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015).

Table 10: Backwash Residuals Handling Systems Alarms and Operator Dial-Out

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
Backwash Waste Equalization Tank Systems			
P-700 FAIL P-701 FAIL Singular occurrence	Stop failed waste pump and start assist pump	Waste pump failure	No
P-700 FAIL P-701 FAIL Concurrent	Shutdown residuals treatment process	Failure of both waste pumps registered by respective pump controllers	Yes
MXR-720 FAIL MXR-721 FAIL	None	Waste mixer failure	No
LIT-710 LOW	Stop Waste Mixer 1 (P-720)	Warning low level limit reached in Waste Equalization Tank 1	No
LIT-710 HIGH	Start duty waste pump	Pump start level limit reached in Waste Equalization Tank 1	No

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
LIT-710 HIGH HIGH	Start assist waste pump; No action in single tank operation mode	Maximum level limit reached in Waste Equalization Tank 1; Indicates overflow in single tank operation mode	No
LIT-710 HIGH HIGH	Start assist waste pump; No action in single tank operation mode	Maximum level limit reached in Waste Equalization Tank 1; Indicates overflow in single tank operation mode	No
LIT-711 LOW LOW	Stop Waste Pump 2 (P-701)	Minimum level limit reached in Waste Equalization Tank 2	No
LIT-711 LOW	Stop Waste Mixer 2 (P-721)	Warning low level limit reached in Waste Equalization Tank 2	No
LIT-711 HIGH	Start duty waste pump	Pump start level limit reached in Waste Equalization Tank 2	No
LIT-711 HIGH HIGH	Start assist waste pump; No action in single tank operation mode	Maximum level limit reached in Waste Equalization Tank 2; Indicates overflow in single tank operation mode	No
LIT-710 FAIL LIT-711 FAIL	None	Level transmitter failure	Yes
LSLL-710 LSLL-711	None	Minimum level limit reached in Waste Equalization Tank	No
LSH-710 LSH-711	None	Overflow level limit reached in Waste Equalization Tank	Yes
FSL-700 FSL-701 with respective pump online	Stop respective waste pump and start assist waste pump	Absence of flow registered by low flow switch yet respective pump is running	No
FIT-700 HIGH HIGH	Stop duty waste pump and start assist waste pump	Maximum backwash waste transfer flow limit reached	Yes
FIT-700 LOW FIT-700 HIGH	None	Backwash waste transfer flow to thickeners measured	No

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
		outside of preferred range of operation	
FIT-700 FAIL	Shutdown residuals treatment process	Flow transmitter failure	Yes
Gravity Thickener and Thickened Backwash Sludge Storage Systems			
MXR-722 FAIL MXR-723 FAIL SK-740 FAIL MXR-724 FAIL MXR-725 FAIL SK-741 FAIL	Gravity thickener integrated PLC selects action	Flocculation mixer / thickener scraper failure	No
Thickener START	Position three-way valve (TWV-710) to return supernatant to Waste Equalization Tanks	Supernatant returned to Waste Equalization Tanks; Thickener unit started and begin start-up period	No
Thickener start-up period elapsed	Position three-way valve (TWV-710) to deliver supernatant to Pump House No. 1 if AIT-710 in range	Supernatant recycled to Pump House No. 1; Position valve after pre-defined period if turbidity in preferred range of operation	No
AIT-701 HIGH HIGH	Position three-way valve (TWV-710) to return supernatant to Waste Equalization Tanks	Maximum turbidity limit reached in supernatant recycled to Pump House No. 1	Yes
AIT-701 HIGH	None	Warning high turbidity limit reached in supernatant recycled to Pump House No. 1	No
AIT-701 FAIL	Shutdown residuals treatment process	Turbidity analyzer failure	Yes
FIT-710 LOW FIT-710 HIGH	None	Thickener supernatant return flow measured outside of preferred range of operation	No
FIT-710 FAIL	None	Flow transmitter failure	No

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
Thickener runtime with respective sludge pump offline	Start thickener-specific sludge pump (P-706 or P-707)	Sludge pump started; Thickener has run for pre-defined duration with respective sludge pump offline	No
Thickener runtime with respective sludge pump online	Stop thickener-specific sludge pump (P-706 or P-707)	Stop sludge pump; Thickener has run for pre-defined duration with respective sludge pump online	No
P-706 FAIL P-707 FAIL Singular occurrence	None	Thickened sludge pump failure	No
P-706 FAIL P-707 FAIL Concurrent	None	Failure of both thickened sludge pumps registered by respective pump controllers	No
FSL-706 FSL-707 with respective pump online	Stop respective thickened sludge pump	Absence of flow registered by low flow switch, yet respective pump is running	No
LIT-712 HIGH LIT-712 FAIL LIT-713 HIGH LIT-713 FAIL	Close inlet valve to tank with high level and open inlet valve to parallel sludge tank (FCV-712 & FCV-713)	Warning high level limit reached in sludge storage tank	No
LIT-712 HIGH HIGH LIT-713 HIGH HIGH	Stop thickened sludge pumps P-706 and P-707	Maximum level limit reached in sludge storage tank	No
LIT-712 LOW LIT-713 LOW	None	Warning low level limit reached in Sludge Storage Tank	Yes

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
Backwash Thickener Polymer Dosing Systems			
P-704 FAIL P-705 FAIL Singular occurrence	None	Polymer dosing pump failure	No

3.4.3. Routine Maintenance and Inspection – Backwash Residuals Handling Systems

On each thickener, sampling ports are arranged at various heights with manual valves. Sludge samples may be extracted from each location for visual inspection. These samples are observed to determine performance of thickeners and sludge settling. The height at which sludge is observed is an indicator of the depth of the sludge blanket contained in the bottom of the thickener. Should this depth exceed the preferred range of operation, the operator should consider adjusting thickened sludge pump runtime and start frequency.

Periodically, the waste equalization tank, gravity thickener, and sludge storage tank trains should be isolated, drained, and cleaned using a pressure washer. Confined space hazards must be identified by supervisors before any worker may enter a residuals/sludge tank or thickener. Safe work procedures are to be undertaken in accordance with Confined Spaces Code of Practice (Northwest Territories & Nunavut Codes of Practice, Workers; Safety & Compensation Commission).

Refer to Section 3.6.3 for a general description of metering pump maintenance tasks.

3.4.4. Chemical Handling – Backwash Residuals Handling Systems

Refer to Section 3.6.4 for a description of general safe chemical handling strategies and precautions for positioning of bulk totes using a forklift.

Should a member of staff be accidentally exposed to the coagulant, an emergency shower and eyewash is integrated with the residuals handling system. A high flow switch, FSH-721, is installed on the emergency eyewash and shower feed. This switch is triggered when the station is in use and it calls the PCS to raise an alarm. The PCS automatically dials out to lead operators/supervisors to alert them of a potential personnel safety issue.

Refer to Section 3.5.4 for a general description on the use of emergency shower and eyewash stations.

3.5. On-Site Sodium Hypochlorite Generation Systems

The following sections provide an overview of operation, maintenance, and operational resilience features built into the on-site sodium hypochlorite generation systems, OSG system PLC, hypochlorite storage tanks, and overall plant Process Control System.

3.5.1. Instrumentation and Controls – On-site Sodium Hypochlorite Generation Systems

Table 11 identifies and describes the function of instrumentation and control systems for the OSG systems and vendor-supplied package PLC. Several instruments and controls are not included in this summary as some of these elements do not communicate directly with the PCS. Refer to vendor-supplied package functional description submittals for controls monitored internally by the OSG PLC.

Table 11: On-site Sodium Hypochlorite Generation Systems Instrumentation and Controls

Identifier	Location	Device Type	Device Function
Water Softener Systems			
AIT-401	On water softener outlet header	Water Hardness Analyzer	Measures the concentration (mg/L as $CaCO_3$) of hardness in softener discharge
MN-410	Off water softener outlet header	Solenoid Valve Operator	Opens/closes solenoid valve to deliver softened to brine saturation tank
Brine Saturation Tank and Transfer Systems			
TIT-410	In Brine Saturation Tank	Temperature Transmitter	Monitors temperature of brine solution
LIT-410A	In Brine Saturation Tank	Level Transmitter	Monitors level of salt in brine saturation tank
LIT-410A	In Brine Saturation Tank	Level Transmitter	Monitors hydrostatic-based level of brine solution in brine saturation tank
P-400 Controller	Hypochlorite Generation PLC	Hypochlorite Generation PLC Output	Automatic command to start/stop Brine Solution Pump 1

Identifier	Location	Device Type	Device Function
P-401 Controller	Hypochlorite Generation PLC	Hypochlorite Generation PLC Output	Automatic command to start/stop Brine Solution Pump 2
P-407 Controller	Softeners’ Brine Pump control panel	Start/Stop Switch	Manual push button to start/stop Softeners’ Brine Pump
LSH-401	In brine containment structure	Level Switch	Triggers High level alarm in brine containment indicating leak or flooding
Electrolytic Cell Systems			
EL-430 Controller	Hypochlorite Generation PLC	Hypochlorite Generation PLC Output	Automatic command to start/stop Electrolyzer
TS-430	Upstream of Electrolyzer	Temperature Switch	Triggers brine solution High temperature alarm
PS-430	Upstream of Electrolyzer	Pressure Switch	Triggers brine solution High pressure alarm
FS-430	Upstream of Electrolyzer	Flow Switch	Triggers brine solution Low flow alarm
Sodium Hypochlorite Storage Systems			
MN-450	Hypochlorite Generation PLC	Hypochlorite Generation PLC Output	Command to start/stop Hydrogen Dilution Air Blower, B-450
MN-451	Hypochlorite Generation PLC	Hypochlorite Generation PLC Output	Command to start/stop Hydrogen Dilution Air Blower, B-451
MN-452	Hypochlorite Generation PLC	Hypochlorite Generation PLC Output	Command to start/stop Hydrogen Dilution Air Blower, B-452
MN-453	Hypochlorite Generation PLC	Hypochlorite Generation PLC Output	Command to start/stop Hydrogen Dilution Air Blower, B-453
LIT-411	Inside Hypochlorite Tank 1	Level Transmitter	Monitors level in Hypochlorite Tank 1
LIT-412	Inside Hypochlorite Tank 2	Level Transmitter	Monitors level in Hypochlorite Tank 2

Identifier	Location	Device Type	Device Function
LIT-413	Inside Hypochlorite Tank 3	Level Transmitter	Monitors level in Hypochlorite Tank 3
LIT-414	Inside Hypochlorite Tank 4	Level Transmitter	Monitors level in Hypochlorite Tank 4
XC-411	On inlet to Hypochlorite Tank 1	Motorized Valve Operator	Opens/closes valve to control flow of stock to Hypochlorite Tank 1
XC-412	On inlet to Hypochlorite Tank 2	Motorized Valve Operator	Opens/closes valve to control flow of stock to Hypochlorite Tank 2
XC-413	On inlet to Hypochlorite Tank 3	Motorized Valve Operator	Opens/closes valve to control flow of stock to Hypochlorite Tank 3
XC-414	On inlet to Hypochlorite Tank 4	Motorized Valve Operator	Opens/closes valve to control flow of stock to Hypochlorite Tank 4
XC-411B	On outlet from Hypochlorite Tank 1	Motorized Valve Operator	Opens/closes valve to control outflow from Hypochlorite Tank 1
XC-412B	On outlet from Hypochlorite Tank 2	Motorized Valve Operator	Opens/closes valve to control outflow from Hypochlorite Tank 2
XC-413B	On outlet from Hypochlorite Tank 3	Motorized Valve Operator	Opens/closes valve to control outflow from Hypochlorite Tank 3
XC-414B	On outlet from Hypochlorite Tank 4	Motorized Valve Operator	Opens/closes valve to control outflow from Hypochlorite Tank 4
PSL-412	On Hypochlorite Tank 1 & 2 vent header	Pressure Switch	Triggers Low pressure alarm for diluted hydrogen venting
PSL-414	On Hypochlorite Tank 3 & 4 vent header	Pressure Switch	Triggers Low pressure alarm for diluted hydrogen venting
FSL-412	On Hypochlorite Tank 1 & 2 vent header	Flow Switch	Triggers Low flow alarm for diluted hydrogen venting
FSL-414	On Hypochlorite Tank 3 & 4 vent header	Flow Switch	Triggers Low flow alarm for diluted hydrogen venting

Identifier	Location	Device Type	Device Function
LSH-402	In sodium hypochlorite containment structure	Level Switch	Triggers High level alarm in hypochlorite containment indicating leak or flooding
Hypochlorite Area Gas Detector Systems			
AIT-430 AIT-431	Sodium Hypochlorite storage area	Hydrogen Gas Detector	Triggers High concentration alarms for unacceptable presence of hydrogen gas in operating area
AAU-430 AAU-431	Sodium Hypochlorite storage area	Hydrogen Gas Detector	Triggers alarm indicating fault of hydrogen detectors

3.5.2. Control Philosophy – On-site Sodium Hypochlorite Generation Systems

With permissions from the PCS, the OSG system PLC controls all operational tasks related to the brine saturation tank, water softeners, brine solution pumps, electrolyzer, hypochlorite tanks and blowers, and associated analytical instruments. The OSG system is initiated automatically by the PCS following enablement by operator and a permissive signal based on a selected time window for operation (usually off-peak hours to reduce electricity charges).

Prior to production of sodium hypochlorite solution, the OSG system will automatically select a hypochlorite storage tank in low level condition and open its respective motorized inlet valve. The appropriate hydrogen dilution air blower is initiated to vent the selected tank. Plant service water utilized for dissolution of salt is heated prior to use. Therefore, at least one building boiler must be operational to temper the water and an alarm will be triggered should the supply water temperature drop below 16°C. The OSG system will continue to generate product until the selected tank has been filled.

The hypochlorite tanks feed the chlorination system based on a PLC defined hierarchy and using motorized tank outlet valves. The hypochlorite pumps draw product from one tank at a time. Once the online hypochlorite tank reaches its respective LOW LOW limit, the outlet valve is opened on the next tank in the hierarchy and the empty tank's outlet valve is closed. The empty tank's inlet valve is then opened to accommodate refilling by the OSG system.

Table 3-11 summarizes several PCS alarms critical to operation of the OSG systems. A more detailed list of alarms, actions, and triggering parameters are described in the City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015).

Table 12: On-site Sodium Hypochlorite Generation Systems Alarms and Operator Dial-Out

Alarm Condition Identifiers	PCS Action	Alarm Description	Dial-Out to Operator
AIT-410 HARD	Shutdown Hypochlorite Generation System	Maximum hardness limit reached for plant service and brine solution delivered to softeners	Yes
TIT-410 LOW LOW TIT-410 LOW	None	Brine temperature is measured outside of preferred range of operation	No
LIT-410A HIGH HIGH	Activate alarm annunciator and beacon lights in salt onloading area	Brine saturation tank maximum salt level limit reached	Yes
LIT-410B HIGH HIGH	Activate alarm annunciator and beacon lights in salt onloading area	Brine saturation tank maximum brine solution level limit reached; Approaching tank overflow	Yes
LIT-410A LOW LOW LIT-410A LOW LIT-410A HIGH LIT-410B LOW LOW LIT-410B LOW LIT-410B HIGH	None	Brine/salt level in brine saturation tank is measured outside of preferred range of operation	Yes
TIT-410 FAIL LIT-410A FAIL LIT-410B FAIL	None	Brine saturation tank instrument failure	No
P-400 FAIL P-401 FAIL Singular occurrence	None – Action undertaken by Sodium Hypochlorite Generation PLC	Brine Solution Pump failure; Starting standby pump	No

Alarm Condition Identifiers	PCS Action	Alarm Description	Dial-Out to Operator
P-400 FAIL P-401 FAIL Concurrent	None – Action undertaken by Sodium Hypochlorite Generation PLC	Brine Solution Pump failure; Shutdown Sodium Hypochlorite Generation System	No
EL-430 FAIL	Shutdown Hypochlorite Generation System	Brine solution Electrolyzer failure	Yes
TS-430	None – Action undertaken by Sodium Hypochlorite Generation PLC	Maximum temperature limit reached in brine solution feed to Electrolyzer	No
PS-430	None – Action undertaken by Sodium Hypochlorite Generation PLC	Maximum temperature limit reached in brine solution feed to Electrolyzer	No
AIT-430 HIGH HIGH AIT-431 HIGH HIGH	Shutdown Hypochlorite Generation System	Presence of High High level concentration of hydrogen gas detected in area	Yes
AIT-430 HIGH AIT-431 HIGH	Activate alarm annunciator and beacon lights in hypochlorite storage area	Presence of High level concentration of hydrogen gas detected in area	No
AIT-430 FAIL AIT-431 FAIL	Shutdown Hypochlorite Generation System	Hypochlorite storage area gas detector failure	Yes
AAU-430 AAU-431	Shutdown Hypochlorite Generation System	Hypochlorite storage area gas detector fault	Yes
B-450 FAIL B-451 FAIL B-452 FAIL B-453 FAIL Singular occurrence	None – Action undertaken by Sodium Hypochlorite Generation PLC	Hydrogen Dilution Air Blower failure; Starting standby blower	No
B-450 FAIL B-451 FAIL Concurrent	None – Action undertaken by Sodium Hypochlorite Generation PLC	Both duty and standby Hydrogen Dilution Air Blowers fail in supply to Hypochlorite Tank 1 & 2	Yes

Alarm Condition Identifiers	PCS Action	Alarm Description	Dial-Out to Operator
B-452 FAIL B-453 FAIL Concurrent	None – Action undertaken by Sodium Hypochlorite Generation PLC	Both duty and standby Hydrogen Dilution Air Blowers fail in supply to Hypochlorite Tank 3 & 4	Yes
LIT-411 HIGH HIGH LIT-412 HIGH HIGH LIT-413 HIGH HIGH LIT-414 HIGH HIGH	None	Hypochlorite Tank maximum level limit reached; Approaching tank overflow	Yes
LIT-411 HIGH LIT-412 HIGH LIT-413 HIGH LIT-414 HIGH	None – Sodium Hypochlorite Generation PLC closes tank inlet valve (XC-41#) and shuts down generation system	Hypochlorite Tank maximum level limit reached; Approaching tank overflow	No
LIT-411 LOW LIT-412 LOW LIT-413 LOW LIT-414 LOW	None	Hypochlorite Storage warning low level limit reached	No
LIT-411 LOW LOW LIT-412 LOW LOW LIT-413 LOW LOW LIT-414 LOW LOW	Close tank outlet valve (XC-41#B) and open outlet valve to next (full) storage tank in hierarchy	Hypochlorite tank minimum level limit reached	No
Three (3) Hypochlorite Storage Tanks at LOW LOW	None	Three of four hypochlorite tanks reached minimum level limit; Last storage tank in use	Yes
Four (4) Hypochlorite Storage Tanks at LOW LOW	Shutdown water treatment process	All four hypochlorite tanks reached minimum level limit; Last storage tank in use	Yes
LIT-411 FAIL LIT-412 FAIL	None	Hypochlorite Tank level transmitter failure	No

Alarm Condition Identifiers	PCS Action	Alarm Description	Dial-Out to Operator
LIT-413 FAIL LIT-414 FAIL			
LIT-41# LOW LOW; XC-41#B Closed; Operator-selected tank for filling	Sodium Hypochlorite Generation PLC commands tank inlet valve XC-41# to open and start filling	Hypochlorite Tank in filling mode	No
PSL-412 PSL-414	None – Action undertaken by Sodium Hypochlorite Generation PLC	Hydrogen dilution venting pressure in hypochlorite tank reached minimum limit	No
FSL-412 FSL-414	None – Action undertaken by Sodium Hypochlorite Generation PLC	Hydrogen dilution venting flow from hypochlorite tank reached minimum limit	No

3.5.3. Routine Maintenance and Inspection – On-site Sodium Hypochlorite Generation Systems

A critical inspection task related to the OSG system is continuous monitoring of salt reserves in the brine saturation tank. Proactive scheduling of salt deliveries is to be undertaken to ensure salt is available to generate sufficient volume of disinfectant for peaks in demand.

Inspection and maintenance tasks specific to on-site sodium hypochlorite generation include the following:

- Routine regeneration of water softener ion exchange resins through manual operation of softeners’ brine pump.
- Disassembly of electrolytic cell assembly to inspect cells for hardness scaling or other fouling.
- Inspection of equipment seals, pump connections, fittings, and tubing for leaks.
- Occasional analytical verification of the quality of sodium hypochlorite product to ensure strength is within expected range.
- Periodic calibration of hardness analyzer (AIT-410).

3.5.4. Chemical Handling – On-site Sodium Hypochlorite Generation Systems

Bulk salt deliveries require careful monitoring by water system operators as trucks equipped with pneumatic offloading systems routinely require safe access to the site. Delivery truck operators should be met by plant staff such that the level in the brine saturation tank may be verified at the same time. Should the salt level in the saturation tank exceed the maximum limit, an alarm is triggered to both the PCS and the local annunciator. This alarm will automatically initiate a disruptive strobing beacon light and a loud horn siren to alert the driver and supervising staff to immediately stop filling. This is a critical feature in preventing an overflow of salt in the OSG area which would require a substantial cleanup operation.

Refer to Section 3.6.4 for a description of safe chemical handling strategies related to sodium hypochlorite dosing.

Hydrogen gas is released at the electrolytic cells and in the hypochlorite storage tanks where it is diluted with air and vented by duty-standby blowers. Hydrogen is a flammable gas and is diluted within the tanks to reduce concentrations to below the lower explosion limit (LEL) of hydrogen in air. Hydrogen gas is also an asphyxiant, which can displace oxygen if present at high concentrations. In the event of a tank/venting leak or blower failure, two hydrogen detectors (AIT-430 and AIT-431) in the OSG area will identify the presence of hydrogen. The detectors are equipped with flashing beacon lights and will annunciate the alarm using a loud horn to alert staff working nearby to exercise caution. Once hydrogen gas is detected, the OSG system is automatically shut down.

Should a member of staff be accidentally exposed to the sodium hypochlorite solution, an emergency shower and eyewash is integrated with the OSG system. This fixture provides warm water from the building mechanical system for flushing areas that have been exposed to hypochlorite. The eyewash fixture is utilized after a splash to the face to flush out eyes for a period of at least 15 minutes. The shower is used in a similar manner to rinse chemical from skin and clothing. Contaminated clothing is to be immediately removed and the worker must rinse thoroughly under the shower for a minimum of 15 minutes.

A high flow switch, FSH-400, is installed on the emergency eyewash and shower feed. This switch is triggered when the station is in use and it calls the PCS to raise an alarm. The PCS automatically dials out to lead operators and supervisors to alert them of a potential personnel safety issue.

3.6. Chlorination and Fluoridation Systems

The following sections provide an overview of operation and controls, maintenance tasks, and contingency features associated with the chlorine and fluoride solution dosing systems.

3.6.1. Instrumentation and Controls – Chlorination and Fluoridation Systems

Chlorine and fluoride dosing systems consist of duty-standby, variable speed, peristaltic pump pairs P-402 & P-403 and P-404 & P-405, respectively. A variable speed, peristaltic sampling pump P-406 is utilized to draw a side stream for monitoring of residual concentrations. Table 13 identifies and describes the function of instrumentation and control systems for the chlorine and fluoride dosing subsystems.

Table 13: Chlorination and Fluoridation Systems Instrumentation and Controls

Identifier	Location	Device Type	Device Function
Dosing Related Systems			
FIT-280	On membrane filtrate main upstream of chlorine injection port	Flow Transmitter	Monitors instantaneous filtrate flow and logs total process flow for pre-determined period
MN-406	Sampling Pump P-406 controller	PCS Control Output	Command to start/stop P-406
SC-406	Sampling Pump P-406 controller	PCS Control Output	Controls P-406 speed and facilitates adjustment to pump discharge pressure and/or flow
AIT-401	On Sampling Pump P-406 discharge	Fluoride Analyzer	Measures the concentration (mg/L) of fluoride ions in sampling side stream
AIT-402A/B	On Sampling Pump P-406 discharge	Temperature & pH Analyzer	Measures the temperature and pH in sampling side stream
AIT-403	On Sampling Pump P-406 discharge	Free Chlorine Analyzer	Measures the free chlorine residual concentration (mg/L) in sampling side stream (representing residual at reservoir inlet)
LSH-415	In sodium hypochlorite containment structure	Level Switch	Triggers High level alarm in containment indicating leak or flooding

Identifier	Location	Device Type	Device Function
Chlorination System – Peristaltic Feed Pumps, P-402 & P-403			
MN-402	Pump P-402 controller	PCS Control Output	Command to start/stop P-402
MN-403	Pump P-403 controller	PCS Control Output	Command to start/stop P-403
SC-402	Pump P-402 controller	PCS Control Output	Controls P-402 speed and facilitates adjustment to pump discharge pressure and/or flow
SC-403	Pump P-403 controller	PCS Control Output	Controls P-403 speed and facilitates adjustment to pump discharge pressure and/or flow
Fluoridation System – Peristaltic Feed Pumps, P-404 & P-405			
MN-404	Pump P-404 controller	PCS Control Output	Command to start/stop P-404
MN-405	Pump P-405 controller	PCS Control Output	Command to start/stop P-405
SC-404	Pump P-404 controller	PCS Control Output	Controls P-404 speed and facilitates adjustment to pump discharge pressure and/or flow
SC-405	Pump P-405 controller	PCS Control Output	Controls P-405 speed and facilitates adjustment to pump discharge pressure and/or flow
LIT-415	Inside fluorosilicic acid storage tank	Level Transmitter	Monitors level fluorosilicic acid storage tank
WI-415	Beneath fluorosilicic acid storage tank	Weigh Scale	Monitors remaining fluoride volume based on solution density.
LSH-415	In fluorosilicic acid containment structure	Level Switch	Triggers High level alarm in containment indicating leak or flooding

3.6.2. Control Philosophy – Chlorination and Fluorination Systems

The chlorination system draws sodium hypochlorite solution from a common tank outlet header using duty-standby peristaltic pumps P-402 and P-403. To run the duty chlorine dosing pump, two permissive signals must be input to the PCS: 1. The operator must enable the chlorination system; 2. Flow must be registered by filtrate flow meter FIT-280. Through the PCS, the operator may select which dosing pump will act as the duty unit. The dosing pumps can be stopped by disabling the chlorination system.

The chlorine dosing pumps are variable speed and, therefore, chlorine solution flow can be adjusted based on filtrate flow measured by FIT-280. The PCS will automatically pace the dosing pumps according to the following formula given a sodium hypochlorite stock solution concentration of 0.8% (weight/volume) and a pre-determined adjustment dose to account for the chlorine demand between injection point and treated water reservoir inlet as measured by analyzer, AIT-403:

$$Desired\ chemical\ flow\ \left(\frac{L}{hr}\right) = \frac{Desired\ dose\ \left(\frac{mg}{L}\right) x\ Filtrate\ flow\ \left(\frac{L}{s}\right) x\ 60\ x\ 60}{10^6\ x\ Chlorine\ concentration\ (\frac{kg}{L})}$$

Where

Desired dose = free chlorine setpoint (operator input) + adjustment value

Filtrate flow = the flow of water measured by FIT-280

Chlorine concentration = 0.008

Sodium Hypochlorite Solution Dosing Rate Formula[1]

1. Source: City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015)

The duty-standby fluoride dosing pumps, P-404 and P-405 are started and stopped in a similar manner to the chlorine dosing pumps. These variable speed pumps automatically meter the fluoride dosing rate proportionally to the filtrate flow registered by FIT-280. Feedback from the fluoride analyzer, AIT-401, allows for monitoring of the treated water fluoride concentration delivered to the reservoir.

A variety of alarms are programmed into the PCS for monitoring and automation of the chlorine and fluoride dosing systems. Table 14 summarizes several alarms critical to chlorination and fluoridation operations. The complete list of alarms, actions, and triggering parameters are described in more detail in the City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015).

Table 14: Chlorination and Fluoridation Systems Alarms and Operator Dial-Out

Process Control System Annunciated Alarms			
Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
P-402 FAIL P-403 FAIL P-404 FAIL P-405 FAIL	Stop duty dosing pump and start standby pump	Duty dosing pump failure registered by pump controller	No
P-402 & P-403 FAIL P-404 & P-405 FAIL	Shutdown treatment process	Duty and standby dosing pumps both fail as registered by pump controller	Yes
P-406 FAIL	None	Sampling pump failure registered by pump controller	No
FIT-280 LOW LOW FIT-280 LOW FIT-280 HIGH FIT-280 HIGH HIGH	None	Filtrate flow to reservoir is measured outside of preferred range of operation	No
AIT-401 HIGH HIGH	Shutdown fluoride dosing system	Maximum fluoride limit reached for filtrate delivered to reservoir	Yes
AIT-402A LOW LOW	Shutdown treatment process	Minimum temperature limit reached for filtrate delivered to reservoir	Yes
AIT-403 LOW LOW	Shutdown treatment process	Minimum free chlorine limit reached for filtrate delivered to reservoir	Yes
AIT-403 LOW	Stop duty chlorine dosing pump and start standby pump	Warning low free chlorine limit reached for filtrate delivered to reservoir	No
AIT-403 HIGH HIGH	Stop duty chlorine dosing pump and start standby pump	Maximum free chlorine limit reached for filtrate delivered to reservoir	Yes
LIT-415 HIGH HIGH	None	Maximum level limit reached in fluorosilicic acid storage tank – tank overflowing	Yes

Process Control System Annunciated Alarms			
WE-415 HIGH HIGH	None	Maximum stock weight limit reached for fluorosilicic acid storage tank	Yes
AIT-401 LOW LOW AIT-401 LOW AIT-401 HIGH AIT-402A LOW AIT-402A HIGH AIT-402B LOW AIT-403 HIGH	None	Measured parameter (fluoride, temperature, pH, free chlorine) in filtrate delivered to reservoir outside of preferred range of operation	No
LIT-415 LOW LOW LIT-415 LOW LIT-415 HIGH WE-415 LOW LOW WE-415 LOW WE-415 HIGH	None	Measured fluoride stock parameter (storage weight, tank level) outside of preferred range of operation	No
AIT-401 FAIL	Shutdown fluoride dosing system	Fluoride analyzer failure	Yes
AIT-403 FAIL	Shutdown treatment process	Chlorine residual analyzer failure	Yes
AIT-402A FAIL AIT-402B FAIL AIT-403 HIGH	None	Analyzer failure	No
LIT-415 FAIL WE-415 FAIL	None	Fluorosilicic acid storage tank stock instrument (level, weight) failure	No
LSH-415	None	Fluorosilicic acid containment filling; tank overflowing or leaking	Yes

3.6.3. Routine Maintenance and Inspection – Chlorination and Fluoridation Systems

Bulk stock quantities of fluorosilicic acid should be carefully monitored to ensure adequate supply is available for fluoridation demands. Detailed records of consumption are to be kept on file to facilitate proactive scheduling of chemical deliveries.

Inspection and maintenance tasks specific to peristaltic metering pump systems include the following:

- Periodic monitoring of condition of tubing in contact with the peristaltic pump rollers.
- Inspection of equipment seals, pump connections, fittings, injection quills, and tubing for leaks.
- Occasional verification of speed vs discharge flow relationship using metering pump skid calibration column.

3.6.4. Chemical Handling – Chlorination and Fluoridation Systems

All staff working near stored or pumped chemicals should exercise caution and be familiar with product-specific Material Safety Datasheets (MSDS).

The fluoride tank is filled from bulk stock totes positioned by a forklift. Chemical totes should be placed within chemical containment structures prior to chemical transfer to prevent accidental spills in operating areas. Forklift operation should be undertaken only by trained personnel and in accordance with the Counterbalanced Forklifts Code of Practice (Northwest Territories & Nunavut Codes of Practice, Workers; Safety & Compensation Commission).

Both sodium hypochlorite and fluorosilicic acid are corrosive and cause irritation to skin and eyes. These chemical solutions are very harmful if ingested and breathing their vapours is extremely dangerous. All staff working at the WTP must familiarize themselves with the MSDS for these feedstocks.

Prior to undertaking any work in chlorination or fluoridation areas, staff members must confirm that room ventilation systems are online. When handling sodium hypochlorite and fluorosilicic acid, personnel should wear protective clothing including gloves, rubber boots, and face protection (shields). When handling 12% sodium hypochlorite a NIOSH/MSHA respirator with an organic vapor cartridge must be utilized. When offloading fluorosilicic acid stock or working near open fluoridation equipment a NIOSH/MSHA respirator with an acid gas/fume cartridge must be donned. These respirators are to be kept readily available near the hypochlorite and fluoride handling areas. Persons onsite are also advised to wear sturdy shoes with toe safety and non-slip soles. Employees are encouraged to report equipment wear and tear, and Supervisors are to schedule and complete repairs as quickly as possible.

Any chemical spills should be immediately washed down with large quantities of water to a containment or depression where they will not drain away to the surrounding environment or stormwater sewers. If a spill cannot be adequately diluted to meet discharge regulations, it should be pumped into containers and disposed of appropriately. For substantial sodium hypochlorite spills, a dechlorination agent must be employed to neutralize chlorine prior to disposal. For information related to chemical spill prevention, procedural responsibilities, and spill response contacts, refer to the *Yellowknife Spill Contingency Plan* (November 2020).

Hypochlorite will react with acids to create chlorine gas fumes, which are extremely toxic. No acid-based or ammonia-based cleaners are to be used near the hypochlorite areas.

Concentrated fluorosilicic acid must not be allowed to come in contact with bases (such as caustic soda), strong oxidizers (such as stock sodium hypochlorite), combustibles, or glass. Fluorosilicic acid will etch and begin to dissolve glass producing a corrosive gas, silicon tetrafluoride.

Should any worker be dangerously exposed to the fluorosilicic acid or sodium hypochlorite solution, an emergency shower and eyewash station at the OSG system is to be used. Refer to Section 3.5.4 for instrumentation related to the emergency shower and eyewash station.

3.7. Treated Water Storage, Distribution, and Backwash Supply System

The following sections provide an overview of operation, maintenance, and operational resilience features built into the treated water storage, distribution systems, and overall plant Process Control System.

3.7.1. Instrumentation and Controls – Treated Water Systems

The treated water systems consist of reservoir storage cells, pump clear wells, distribution pumps, fire pumps, and membrane backwash pumps. Table 15 identifies and describes the function of instrumentation and control systems for the treated water subsystems.

Table 15: Treated Water Systems Instrumentation and Controls

Identifier	Location	Device Type	Device Function
Reservoir Cell and Pump Clear Well Systems			
LIT-501	In Pump Well 1	Level Transmitter	Measures the treated water level in Pump Well 1 and Reservoir 1
LSLL-501	In Pump Well 1	Level Switch	Triggers Low Low level alarm for Pump Well 1 and Reservoir 1
LIT-502	In Pump Well 2	Level Transmitter	Measures the treated water level in Pump Well 2, Reservoir 2, and Reservoir 3
LSLL-502	In Pump Well 2	Level Switch	Triggers Low Low level alarm for Pump Well 2, Reservoir 2, and Reservoir 3
LSH-500	In reservoir inlet valve chamber	Level Switch	Triggers High level alarm for valve chamber indicating water main leak or overflow from reservoirs
Distribution, Membrane Backwash, and Fire Pumping Systems			
P-500 VFD	Power feed to Distribution Pump 1 in Pump Well 1	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
P-501 VFD	Power feed to Distribution Pump 2 Pump Well 1	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
P-502 VFD	Power feed to Distribution Pump 3 in Pump Well 2	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
P-503 VFD	Power feed to Distribution Pump 4 Pump Well 2	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
MN-504	Fire Pump 1 (P-504 Pump Well 1) controller	PCS Control Output	Command to start/stop P-504
MN-505	Fire Pump 2 (P-505 Pump Well 2) controller	PCS Control Output	Command to start/stop P-505

Identifier	Location	Device Type	Device Function
P-506 VFD	Power feed to Membrane Backwash Pump 1 in Pump Well 1	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
P-507 VFD	Power feed to Membrane Backwash Pump 2 in Pump Well 2	Variable Frequency Drive	Controls pump speed and facilitates adjustment to pump discharge pressure and/or flow
FSL-500 FSL-501 FSL-502 FSL-503 FSL-504 FSL-505 FSL-506 FSL-507	On discharge of pumps P-500, P-501, P-502, P-503, P-504, P-505, P-506 and P-507	Flow Switch	Indicates absence of treated water flow
PIT-520	Downstream of distribution and fire pump discharge header	Pressure Transmitter	Monitors combined supply pressure for distribution and fire pumps (P-500, P-501, P-502, P-503, P-504, and P-505)
FIT-520	Downstream of distribution and fire pump discharge header	Differential Pressure Based Flow Transmitter	Approximates treated water discharge flow to distribution based on differential across averaging tube
FIT-610	On distribution main downstream of plant service water connections	Flow Transmitter	Monitors blended treated water and return flow supplied to distribution system and logs total flow for pre-determined period
Treated Water Quality Analytical Systems			
AIT-600	Return water main from distribution system	Free Chlorine Analyzer	Measures the free chlorine residual concentration (mg/L) in return water recirculated to distribution
AIT-601	Treated water distribution main upstream of recirculation connection	Turbidity Analyzer	Measures the turbidity (NTU) in treated water leaving reservoirs

Identifier	Location	Device Type	Device Function
AIT-602	Treated water distribution main upstream of recirculation connection	Free Chlorine Analyzer	Measures the free chlorine residual concentration (mg/L) in treated water leaving reservoirs
AIT-603A/B	Treated water distribution main upstream of recirculation connection	Temperature & pH Analyzer	Measures the temperature and pH of treated water leaving reservoirs
AIT-604	Treated water distribution main upstream of recirculation connection	Fluoride Analyzer	Measures the concentration (mg/L) of fluoride ions in treated water leaving reservoirs
AIT-611	Treated water distribution main downstream of recirculation connection	Free Chlorine Analyzer	Measures the free chlorine residual concentration (mg/L) in blended treated water and return water supplied to distribution system
Treated Water Recirculation Systems			
MN-600 MN-601	Recirculation Pump 1 & 2 (P-600 & P-601) controllers	PCS Control Output	Command to start/stop P-600 & P-601
FSL-600 FSL-601	On discharges of Recirculation Pump 1 & 2 (P-600 & P-601)	Flow Switch	Indicates absence of return water flow
FIT-600	Upstream of Recirculation Pump 1 & 2 (P-600 & P-601) suction header	Flow Transmitter	Monitors return flow supplied to distribution system and logs total flow for pre-determined period
PIT-600	Upstream of Recirculation Pump 1 & 2 (P-600 & P-601) suction header	Pressure Transmitter	Monitors return flow supplied to distribution system and logs total flow for pre-determined period
XC-602	Pump House No. 1 Recirculation Pump Control Panel	START/STOP Switch	Switch to start/stop Pump House No. 1 Recirculation Pump P-602

Identifier	Location	Device Type	Device Function
FSL-602	On discharge of Pump House No. 1 Recirculation Pump P-602	Flow Switch	Indicates absence of recirculation flow and online status of pump

3.7.2. Control Philosophy – Treated Water Systems

The variable speed distribution pumps and fixed speed fire pumps are controlled by the PCS and called to start and stop in a sequence dictated by discharge pressure (PIT-520) and flow (FIT-520) setpoints as well as timers. For a more detailed account of pump sequencing and setpoints, refer to the City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015).

In general, the distribution pumps are started in sequence while pump speeds are adjusted to maintain a distribution pressure above a pre-defined setpoint. The smaller of the four distribution pumps operates alone during low demand and, as demand increases, the PCS shuts down this pump for operation of the three larger, equally sized distribution pumps in sequence. At full capacity of the distribution pumping system, the smaller pump is brought back online for a four-pump operation.

During firefighting demands, the pressure will drop below a lower discharge pressure setpoint with all four distribution pumps running. At this point one of the fixed speed fire pumps is started using its independent controller. Pressure relief valves are installed on the fire pump discharges to bleed flow back to the reservoirs and control fire supply pressure. Programming is in place to shut down the smaller distribution pump and a lag distribution pump to maintain discharge pressure below the fire pump shutoff setpoint. If discharge pressure drops below the minimum setpoint, the second fire pump is started. The fire pump controllers shut down each fire pump after a defined duration as dictated by an integrated run timer. The distribution pumps continue to run but shut down in sequence based on flow setpoints triggered as demand tapers off. Table 16 provides an overview of the distribution and fire pump capacities.

Pumping system overpressure is prevented through automatic shutdown of distribution pumps at the maximum discharge pressure setpoint. In the event that the treated water reservoirs are empty and a LOW LOW level alarm is triggered for these tanks, the distribution pumps are shut down.

Table 16: Treated Water Distribution and Fire Pump Capacities

Pump Identifier	Pump Name	Discharge Flow Range (L/s)
P-500	Distribution Pump 1	20 - 40
P-501	Distribution Pump 2	32 - 75
P-502	Distribution Pump 3	32 - 75
P-503	Distribution Pump 4	32 - 75
P-504	Fire Pump 1	200 - 225
P-505	Fire Pump 2	200 - 225

From the PCS, the fixed speed, recirculation pumps (P-600 and P-601) are started and stopped seasonally to prevent freezing of water mains within the distribution system. During the winter, both recirculation pumps are operated, while a single pump is online during the summer.

Operation of the membrane backwash pumps is generally controlled based on feedback from the membrane system PLC. However, the PCS will stop these pumps should the treated water reservoir levels drop below the minimum tolerable for pump operation.

Table 17 summarizes several alarms critical to operation of the treated water systems. The complete list of alarms, actions, and triggering parameters are described in more detail in the City of Yellowknife Water Treatment Plant Control Philosophy (AECOM, 2015).

Table 17: Treated Water Systems Alarms and Operator Dial-Out

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
Reservoir Cell and Pump Clear Well Systems			
LIT-501 LOW LOW	Stop Membrane Backwash Pump 1 (P-506)	Minimum treated water level limit reached in Pump Well 1 and Reservoir 1	No
LIT-501 HIGH HIGH	Shutdown treatment process	Maximum treated water level limit reached in Pump Well 1 and Reservoir 1; Reservoir 1 overflowing	Yes

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
LSLL-501	Stop distribution and fire pumps in Pump Well 1 (P-500, P-501, P-504)	Pump-specific minimum treated water level limit reached in Pump Well 1 and Reservoir 1; Reservoir empty	Yes
LIT-502 LOW LOW	Stop Membrane Backwash Pump 2 (P-507)	Minimum treated water level limit reached in Pump Well 2, Reservoir 2, and Reservoir 3	No
LIT-502 HIGH HIGH	Shutdown treatment process	Maximum treated water level limit reached in Pump Well 2, Reservoir 2, and Reservoir 3. Reservoirs 2 & 3 overflowing	Yes
LSLL-502	Stop distribution and fire pumps in Pump Well 2 (P-502, P-503, P-505)	Pump-specific minimum treated water level limit reached in Pump Well 2, Reservoir 2, and Reservoir 3; Reservoirs empty	Yes
LIT-501 LOW LIT-501 HIGH LIT-502 LOW LIT-502 HIGH	None	Measured treated water level in reservoir & pump well (from Pump Well 1 & 2) measured outside of preferred range of operation	No
LSH-500	None	Reservoir inlet valve chamber sump overflowing	Yes
Distribution, Membrane Backwash, and Fire Pumping Systems			
P-500 FAIL P-501 FAIL P-502 FAIL P-503 FAIL Singular Occurrence	Stop failed distribution pump and start next pump in programming hierarchy	Distribution pump failure registered by pump controller	No
P-500 FAIL P-501 FAIL P-502 FAIL P-503 FAIL Concurrent	Stop all distribution pumps and start Fire Pump 1 (P-504)	Failure of all distribution pumps registered by respective pump controllers	Yes

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
P-504 FAIL	Stop Fire Pump 1 (P-504) and start Fire Pump 2 (P-505)	Fire Pump 1 failure registered by pump controller	No
P-505 FAIL	Stop Fire Pump 2 (P-505) and start Fire Pump 1 (P-504)	Fire Pump 2 failure registered by pump controller	No
P-504 FAIL P-505 FAIL Concurrent	None	Failure of both fire pumps registered by respective pump controllers	Yes
LIT-501 FAIL LIT-502 FAIL	None	Pump Well level transmitter failure	Yes
FSL-500 FSL-501 FSL-502 FSL-503 with respective pump online	Stop respective distribution pump and start next pump in programming hierarchy	Absence of flow registered by low flow switch, yet respective pump is running	No
PIT-520 LOW LOW	None	Minimum distribution pressure limit reached; Potential water main leak	Yes
PIT-520 HIGH HIGH	Stop all distribution pumps after 20 seconds of	Maximum distribution pressure limit reached; Potential pressure relief valve failure	Yes
PIT-520 LOW PIT-520 HIGH	None	Distribution pressure measured outside of preferred range of operation	No
PIT-520 FAIL	None	Pressure transmitter failure	Yes
FIT-520 LOW FIT-520 HIGH FIT-520 HIGH HIGH	None	Treated water flow upstream of recirculation connection measured outside of preferred range of operation	No

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
FIT-610 LOW FIT-610 HIGH FIT-610 HIGH HIGH	None	Treated water flow downstream of recirculation connection measured outside of preferred range of operation	No
FIT-520 FAIL FIT-610 FAIL	None	Flow transmitter failure	No
Treated Water Quality Analytical Systems			
AIT-602 LOW LOW	None	Minimum free chlorine limit reached upstream of recirculation connection	Yes
AIT-602 HIGH HIGH	None	Maximum free chlorine limit reached upstream of recirculation connection	Yes
AIT-603A LOW LOW	None	Minimum temperature limit reached upstream of recirculation connection	Yes
AIT-603B LOW LOW	None	Minimum pH limit reached upstream of recirculation connection	Yes
AIT-603B HIGH HIGH	None	Maximum pH limit reached upstream of recirculation connection	Yes
AIT-604 HIGH HIGH	Shut down fluoridation system	Maximum fluoride limit reached upstream of recirculation connection	Yes
AIT-611 LOW LOW	None	Minimum free chlorine limit reached downstream of recirculation connection	Yes
AIT-611 HIGH HIGH	None	Maximum free chlorine limit reached downstream of recirculation connection	Yes
AIT-602 FAIL AIT-603A FAIL AIT-611 FAIL	None	Critical analyzer failure	Yes

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
AIT-600 LOW AIT-600 HIGH AIT-601 HIGH AIT-601 HIGH HIGH AIT-602 LOW AIT-602 HIGH AIT-603A LOW AIT-603A HIGH AIT-603A HIGH HIGH AIT-603B LOW AIT-603B HIGH AIT-604 LOW LOW AIT-604 LOW AIT-604 HIGH AIT-611 LOW AIT-611 HIGH	None	Treated water quality measurement outside of preferred operating range	No
AIT-600 FAIL AIT-601 FAIL AIT-603B FAIL AIT-604 FAIL	None	Analyzer failure	No
Treated Water Recirculation Systems			
P-600 FAIL P-601 FAIL Singular Occurrence	Stop duty recirculation pump and start standby pump	Recirculation pump failure registered by pump controller	No
P-600 FAIL P-601 FAIL Concurrent	None	Failure of both recirculation pumps registered by respective pump controllers	Yes
FIT-600 LOW LOW	None	Minimum recirculation flow limit reached	Yes

Alarm Condition Identifiers	Action	Alarm Description	Dial-Out to Operator
PIT-600-D LOW PIT-600-D HIGH	None	Differential pressure between distribution and recirculation (PIT-520 minus PIT-600) outside of preferred operating range	Yes
FIT-600 LOW FIT-600 HIGH	None	Recirculation flow measured outside of preferred range of operation	No
FIT-600 FAIL PIT-600 FAIL	None	Transmitter failure	No
FSL-600 FSL-601 with respective pump online	Stop respective recirculation pump and start standby pump	Absence of flow registered by low flow switch, yet respective pump is running	No
FSL-602	None	Absence of flow through Pump House No. 1 Recirculation Pump P-602 registered by low flow switch	Yes

3.7.3. Routine Maintenance and Inspection – Treated Water Systems

It is recommended that each reservoir cell or pump clear well be cleaned, with a frequency that might range from annually to once every three years. While one cell or pump well is undergoing maintenance, the parallel cell(s) and well can remain in operation.

The cleaning procedure includes the following steps:

- Isolate reservoir and open bypass valves to alternate reservoir cell.
- Drain reservoir using drain valves.
- Conduct visual inspection.
- Hose down walls and floor and pump out sediment-laden water with temporary sump pumps.
- Disinfect by filling the tank with a concentrated sodium hypochlorite solution.
- Allow sufficient holding time based on selected chlorination method and initial calculated/measured chlorine residual.

- After the appropriate contact time, sample water from reservoir drain or associated clear well and perform chlorine residual and coliform test.
- Verify acceptable coliform test result and confirm the free chlorine residual is within the target range for delivery to the user.
- Bring tank back online and deliver held water through normal operation to avoid disposal.

Cleaning and disinfection of treated water tanks is a common maintenance task for water systems. During planning efforts for a treated water tank cleaning, refer to the standard, AWWA C652-19, Disinfection of Water-Storage Facilities (American Water Works Association, 2019) for acceptable disinfection methods.

Confined space hazards must be identified by supervisors before any worker may enter a treated water tank or the buried valve chamber at the reservoir inlets. Safe work procedures are to be undertaken in accordance with Confined Spaces Code of Practice (Northwest Territories & Nunavut Codes of Practice, Workers; Safety & Compensation Commission).

3.7.4. Treated Water Quality Sampling and Monitoring

Treated water quality is currently monitored through routine analysis of samples collected from various locations downstream of the treated water reservoirs. Sample points are available on the discharges of the distribution pumps and recirculation pumps. The current treated water quality monitoring program consists of the same parameters analyzed for raw water. Refer to Section 3.2.4 for analyzed parameters common to both treated water and raw water sampling. For maximum acceptable concentrations, aesthetic objectives, and monitoring guidelines for drinking water quality, refer to the *Guidelines for Canadian Drinking Water Quality Summary Table* (Health Canada, September 2020) and the *Water Supply System Regulations* (Government of Northwest Territories, September 2009). The analyses presented in Table 18 are performed specifically for treated water.

Table 18: Treated Water-Specific Quality Monitoring Parameters – Sample Analyses

Disinfection By-Products			
Haloacetic Acids (HAA) (µg/L)	Bromodichloromethane (mg/L)	Bromoform (mg/L)	Chloroform (mg/L)
Dibromodichloromethane (mg/L)	Total Trihalomethanes (mg/L)		
Bacteriological			
Total Coliforms (CFU)	*E.Coli* (CFU)		

Note that online analyzer instruments are available on the distribution main and downstream of the reservoirs for continuous measurement of treated water parameters including turbidity, free chlorine residual, fluoride, and pH.

3.8. Operational Contingencies and Features for Mitigation

Table 19 presents operational contingencies and mitigation.

Table 19: Contingencies and Mitigations

Contingency	Mitigation	Related Equipment & Instruments
Electric river raw water pumps at Pump House No. 2 fail to start.	Diesel engine-driven raw water pump (at Pump House No 2) may be started remotely from Pump House No. 1 PLC.	Pump House No. 2: • Pumps: P-1, P-2, and P-3 • Low pressure switches: PS1 & PS2 • DI-10007 & DI-10014 (running status)
Loss of power or loss of communication to pumps at Pump House No. 2.	Start bay raw water pumps at Pump House No. 1	Pump House No. 2: • Pumps: P-1, P-2, and P-3 • Pump House No. 1: • Pumps: P-104 and P-105

Contingency	Mitigation	Related Equipment & Instruments
Low pressure detected, indicating major leak along submerged river raw water main from Pump House No. 2 to Pump House No. 1.	• Minimum pressure limit measured by booster pump suction transmitter triggers local and dial-out alarm to operator • Automatically stops river raw water booster pumps • Start bay raw water pumps	Pump House No. 1: • PIT-100 LOW LOW • P-101, P-102, and P-103 • P-104 and P-105
Intake screen clogs and bay raw water wet well is emptied.	• Minimum limit measured by wet well level transmitter triggering local and dial-out alarm to operator • Automatically stop bay raw water pumps • Start river raw water pumps	Pump House No. 1: • LIT-120 LOW LOW or LSLL-120 • P-104 and P-105 Pump House No. 2: • P-1 or P-2
Raw water temperature drops and risk of freezing membranes and distribution piping arises	• Minimum limit measured by raw water temperature transmitter triggers local and dial-out alarm to operator • Water treatment process automatically shuts down • Operator to confirm raw water tempering heat exchanger is operable and adjusted	Membrane Microfiltration System: • TIT-210 LOW LOW • MF-230, MF-231, and MF-232
Chemical tank overflows or leak from membrane chemical cleaning system.	• Dedicated containment structure collects spill • Containment level switch triggers local and dial-out alarm to operator • Spill may be chemically neutralized and pumped manually to sanitary sewer during off-peak hours	Membrane Chemical Cleaning Area: • LSH-203 • P-23

Contingency	Mitigation	Related Equipment & Instruments
Neutralization tank overflows or leak on feed from chemical cleaning system.	• Dedicated containment structure collects spill • Containment level switch triggers local and dial-out alarm to operator • Spill may be transferred by temporary chemical handling pump back into neutralization tanks for disposal by normal means	Membrane Chemical Neutralization Area: • T-216 and T-217 • LSH-204
Backpressure from supernatant recirculation line causes overflow at gravity thickeners or equalization tanks.	• Waste pumps automatically shut down if river raw water booster pumps or membrane system offline • Waste pumps and thickeners automatically shut down if booster pump suction pressure exceeds pre-defined setpoint and duration	Residuals Handling System: • P-700 and P-701 • GT-730 and GT-731 Pump House No. 1: • PIT-100
Rapid fouling of membrane system due to high turbidity in thickener supernatant recirculated to raw water feed.	• Maximum limit measured by supernatant turbidity analyzer triggers local and dial-out alarm to operator • Motorized three-way valve automatically actuates to recycle supernatant to equalization tanks	Residuals Handling System: • AIT-701 HIGH HIGH • TWV-710
Waste equalization tank overflow.	• Maximum tank level limit measured by transmitter triggering local alarm • Backwash water collected in buried valve chamber and level switch triggers local and dial-out alarm to operator. • Contained overflow may be transferred by temporary sump pump to sanitary sewer during off-peak hours	Residuals Handling System: • T-710 and T-711 • LIT-710 and LIT-711 (HIGH HIGH) Treated Water System: • LSH-500

Contingency	Mitigation	Related Equipment & Instruments
Sludge storage tanks overflow.	• Maximum tank level limit measured by transmitter triggers local and dial-out alarm to operator • Thickened sludge pumps automatically shut down	Residuals Handling System: • T-712 and T-713 • LIT-712 and LIT-713 (HIGH HIGH) • P-706 and P-707
Saturation tank salt or brine overflow.	• Maximum tank level limit measured by redundant transmitters, both triggering local and dial-out alarm to operator • Loud horn siren and strobing beacon alert local staff and salt delivery truck driver • Salt/brine collected in containment structure and level switch triggers local and dial-out alarm to operator • If free of dirt/sediment, brine spill may be transferred by temporary chemical handling pump back into tank.	Sodium Hypochlorite Generation: • T-410 • LIT-410A and LIT-410B • LSH-401
Hydrogen gas leaks from sodium hypochlorite generation system or storage tanks	• High and maximum hydrogen concentration limit measured by two transmitters, both triggering local alarms and maximum concentration triggers dial-out alarm to operator • Loud horn sirens and strobing beacons (2) alert local staff of hazard	Sodium Hypochlorite Generation: • AIT-430 and AIT-431 (HIGH and HIGH HIGH)

Contingency	Mitigation	Related Equipment & Instruments
Hypochlorite tank overflow.	• Maximum tank level limit measured by redundant transmitter triggering local and dial-out alarm to operator • Hypochlorite collected in containment structure and level switch triggers local and dial-out alarm to operator. • Spill may be neutralized using sodium bisulphite and transferred by temporary sump pump to sanitary sewer during off-peak hours	Sodium Hypochlorite Generation: • T-411, T-412, T-413, and T-414 • LIT-411, LIT-412, LIT-413, and LIT-414 (HIGH HIGH) • LSH-402
Sodium hypochlorite generation system unavailable/offline for maintenance.	• Dilution panel may be used to manually generate sodium hypochlorite stock from 12% concentrated solution and store in hypochlorite tanks • Two (2) 1000 L totes of 12% sodium hypochlorite stored onsite	Sodium Hypochlorite Generation: • DP-440 • T-411, T-412, T-413, and T-414
Fluoride (fluorosilicic acid) tank overflow.	• Maximum tank level limit measured by redundant transmitter and weigh scale triggering local and dial-out alarms to operator • Fluorosilicic acid collected in containment structure and level switch triggers local and dial-out alarm to operator. • Spill may be transferred by temporary chemical handling pump into appropriate container for reuse or hazardous waste disposal.	Fluoridation System: • T-415 • LIT-415 HIGH HIGH • WE-415 HIGH HIGH • LSH-415

Contingency	Mitigation	Related Equipment & Instruments
Treated water reservoir overflow.	• Maximum reservoir level limit measured by transmitter triggering local and dial-out alarms to operator and automatically shuts down treatment process • Treated water collected in buried valve chamber and level switch triggers local and dial-out alarm to operator. • Contained overflow may be transferred by temporary sump pump to sanitary sewer during off-peak hours	Treated Water System: • Reservoir 1, 2, 3, Pump Clear Well 1 and 2 • LIT-501 and LIT-502 (HIGH HIGH) • LSH-500
Treated water reservoir empty.	• Warning reservoir low level limit measured by transmitter triggering local alarm and membrane backwash pumps are automatically stopped • Minimum reservoir level limit measured by switch triggers local and dial-out alarm to operator and distribution pumps are automatically stopped	Treated Water System: • Reservoir 1, 2, 3, Pump Clear Well 1 and 2 • LIT-501 and LIT-502 (LOW LOW) • LSLL-501 and LSH-502
Fluoride is overdosed to treated water	• Maximum level concentration measured by fluoride analyzer triggering local and dial-out alarm to operator • Fluoridation system is automatically shut down	Treated Water System: • AIT-604 HIGH HIGH Fluoridation System: • P-404 and P-405

CERTIFICATION PAGE

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Permit Holder

APPENDIX A

Water Treatment Plant Record Drawings

EQUIPMENT SYMBOLS

- BIN
- BLOWER OR FAN
- BOILER
- BURNER, WASTE GAS
- CENTRIFUGE
- CHEMICAL POT FEEDER
- CHILLER
- COMPRESSOR
- CYCLONE
- DIFFUSER HEADER
- DRY HOPPER
- EXPANSION TANK
- GENERATOR
- GRINDER/MACERATOR
- GRIT CLASSIFIER
- HEAT EXCHANGER
- MIXER, INLINE
- MIXER, PROPELLER
- MOTOR
- POLYMER WETTING ASSEMBLY
- ROTARY SCREEN
- SHOWER
- SIDE STEAM FILTER
- ROTARY SEPARATOR
- SCREEN, BAR
- SCREEN, MANUAL
- SCREENING CONVEYOR
- SCREENING WASHER/COMPACTOR
- SCRUBBER
- SCUM COLLECTOR
- SILENCER
- SLUDGE SKIMMER
- TANK
- TRAVELLING SCREEN
- UV
- VESSEL
- VESSEL, JACKETED
- VESSEL (PRESSURE)
- WAS BOX
- WATER SOFTENER
- WEIGH SCALE

PIPE LINE DEVICES

- AUTOMATIC AIR VENT
- AIR GAP
- ANNUBAR
- BLIND FLANGE
- CALIBRATION CHAMBER
- CAP OR PLUG
- CONNECTION, PURGE OR FLUSHING
- CONNECTOR, QUICK
- DIFFUSER OR SPRAY NOZZLE
- DRAIN
- EDUCTOR
- EXPANSION JOINT
- EYE WASH/SHOWER STATION
- FLAME ARRESTER
- FLEXIBLE CONNECTION
- FLOWMETER, MAGNETIC
- FLUME
- HOSE REEL
- INSULATION AND HEAT TRACING
- LEVEL
- ORIFICE PLATE
- UNION
- PRESSURE SENSOR, IN-LINE
- PULSATION DAMPENER
- REDUCER
- SAMPLER, AUTOMATIC
- SAMPLE POINT, MANUAL
- SEPARATOR, AIR
- SEPARATOR, LIQUID
- SIGHT GLASS
- SPECTACLE BLIND
- SPRAYBAR
- STRAINER
- STRAINER, BASKET
- TRAP
- UTILITY CONNECTION, HARD PIPE
- UTILITY STATION
- VENT, AIR
- VENT, STEAM
- VENTURI
- WEIR

VALVE SYMBOLS

- 3 WAY VALVE
- 4 WAY VALVE
- AIR PRESSURE AND VACUUM RELIEF VALVE
- AIR RELIEF VALVE
- ANGLE VALVE
- BACKFLOW PREVENTER
- BACK PRESSURE REGULATOR VALVE – EXTERNAL PRESSURE TAP
- BACK PRESSURE REGULATOR VALVE – SELF CONTAINED
- BALANCING DAMPER, CIRCULAR
- BALL VALVE, CLOSED
- BALL VALVE, OPEN
- BALL CHECK VALVE
- BUTTERFLY VALVE
- CHECK VALVE
- CHECK VALVE, DOUBLE LEAF
- CHECK VALVE, DUCKBILL
- DIAPHRAGM VALVE
- FLOAT VALVE
- FOOT VALVE
- GATE VALVE
- GLOBE VALVE
- KNIFE GATE VALVE
- MIXING VALVE
- MUD VALVE
- NEEDLE VALVE
- PINCH VALVE
- PLUG VALVE, CLOSED
- PLUG VALVE, OPEN
- PRESSURE REDUCING REGULATOR VALVE – EXTERNAL PRESSURE TAP
- PRESSURE REDUCING REGULATOR VALVE – SELF CONTAINED
- RUPTURE DISC PRESSURE RELIEF VALVE
- RUPTURE DISC VACUUM RELIEF VALVE
- RUPTURE DISC VACUUM RELIEF VALVE
- TELESCOPIC VALVE
- PRESSURE SAFETY VALVE (LIQUID)
- 2-VALVE MANIFOLD

GENERAL ABBREVIATIONS

B.O.P.	BOTTOM OF PUMP	MAX.	MAXIMUM
C/L	CENTRE LINE	MIN.	MINIMUM
EL.	ELEVATION	N.T.S.	NOT TO SCALE
HWL	HIGH WATER LEVEL	T.O.C.	TOP OF CONCRETE
INV.	INVERT	T.W.L.	TOP WATER LEVEL
LWL	LOW WATER LEVEL		

VALVE ACTUATORS/OPERATOR

- DIAPHRAGM (PRESSURE)
- DIAPHRAGM (SPRING)
- DIGITAL
- MOTOR
- PISTON
- SOLENOID

GATE SYMBOLS

- FLAP GATE
- LEVEL CONTROL GATE
- SLIDE GATE OR DIVERTER GATE
- SLUICE GATE
- STOP LOG
- WEIR GATE

PUMP SYMBOLS

- PUMP, CENTRIFUGAL
- PUMP, DIAPHRAGM
- PUMP, DRUM
- PUMP, GEAR
- PUMP, METERING
- PUMP, PERISTALTIC
- PUMP, PLUNGER
- PUMP, DIAPHRAM METERING
- PUMP, PROGRESSING CAVITY
- PUMP, ROTARY LOBE
- PUMP, SUBMERSIBLE
- PUMP, VERTICAL
- PUMP, SUBMERSIBLE PROPELLER

AS	ADJUSTABLE SPEED
CS–1	CONSTANT SPEED (SINGLE SPEED)
CS–2	CONSTANT SPEED (TWO SPEED)
CS–R	CONSTANT SPEED (REVERSIBLE)

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RECORD DRAWING

Do not scale this document.
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I/R	YY/MM/DD	ISSUE/REVISION DESCRIPTION	DRN	CHK	DES	ENG	IDR	APP
2	2015.11.16	ISSUED FOR RECORD	EF	CMC	CMC	LER		
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Legend and Abbreviations

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P001	2

PLOT: 11/13/2015 1:41:41 PM
D SIZE 22" x 34" (558.8mm x 863.6mm)
BY:FEHRE
FILE NAME: 60147475-P001.DWG

WATER COMMODITY ABBREVIATIONS

BW	BACKWASH WATER
BWW	BACKWASH WASTE WATER
CA	COMPRESSED AIR
CCD	CLEAN IN PLACE DRAIN
CCR	CLEAN IN PLACE RETURN
CCS	CLEAN IN PLACE SUPPLY
CCW	CLEAN IN PLACE WASTE
CDR	CONDENSER WATER RETURN
CDS	CONDENSER WATER SUPPLY
CEN	CENTRATE
CW	CLARIFIED WATER
DCW	DOMESTIC COLD WATER
DHW	DOMESTIC HOT WATER
DMW	DEMINERALIZED WATER
DRA	DRAIN
DRW	SATURATED RECYCLE WATER
DSW	DISTILLED WATER
EXR	EXCESS RECIRCULATION
FAS	FILTER AIR SCOUR
FLI	FILTER INFLUENT
FLW	FLOCCULATION BASIN EFFLUENT
FT	FILTRATE
FTR	FILTER TO RECYCL
FW	FILTER TO WASTE
GCR	GAC TRANSFER WATER RECOVERY
GCW	GAC TRANSFER WATER
HCO	HYDRAULIC OIL
HCF	HYDRAULIC FLUID
IA	AIR–INSTRUMENT
IXE	ION EXCHANGE EFFLUENT
OF	OVERFLOW
OW	OZONATED WATER
PAC	ACTIVATED CARBON – SLURRY
PSW	PLANT SERVICE WATER
PTW	PARTIALLY TREATED WATER
REC	RECYCLE WATER
RFS	REVERSE FLUSH SUPPLY
RFW	REVERSE FLUSH WASTE
RME	RAPID MIX BASIN EFFLUENT
RW	RAW WATER
SAM	SAMPLE
SAN	SANITARY DRAINAGE
SLU	SLUDGE SLURRY
SN	SUPERNATANT OR SUBNATANT
SOW	SOFTENED WATER
STE	STEAM
SW	SEAL WATER
TEMP	TEMPERED WATER
TW	TREATED WATER
UVW	UV DISINFECTED WATER
VNT	VENT

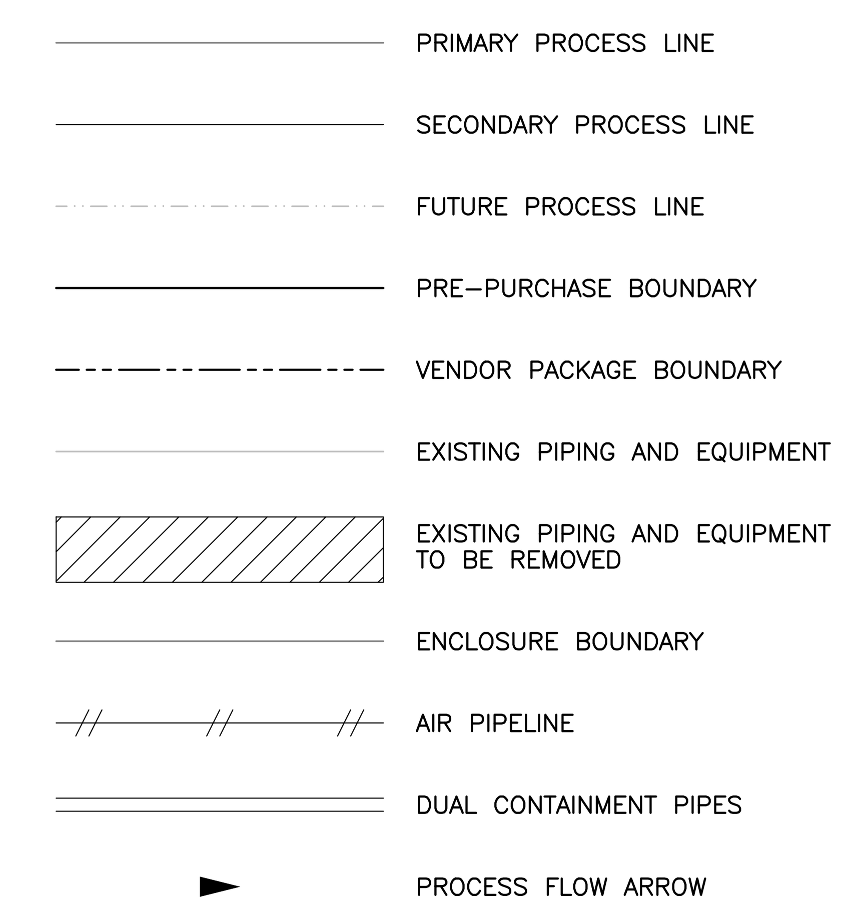
WATER CHEMICAL ABBREVIATIONS

AAG	ANHYDROUS AMMONIA GAS
AAL	ANHYDROUS AMMONIA LIQUID
AAS	AMMONIUM HYDROXIDE SOLUTION
ACS	ACTIVATED SILICA
AIR	AIR
ALU	ALUM
AS	AIR SOUR
ASH	ASH
AW	ACID WASTE
BBD	BOILER BLOWDOWN
BRR	BRINE RETURN
BRS	BRINE SOLUTION
BRW	BRINE WASTE
CAO	LIME – QUICKLIME
CAH	LIME – HYDRATED
CDG	CARBON DIOXIDE GAS
CDL	CARBON DIOXIDE LIQUID
CDS	CHLORINE DIOXIDE, SOLUTION
CHS	CHEMICAL SLUDGE
CI	SODIUM HEXAMETAPHOSPHATE
CIT	CITRIC ACID
CLD	CHLORINE DIOXIDE
CLG	CHLORINE GAS
CLL	CHLORINE LIQUID
CLS	CHLORINE SOLUTION
CS	CAUSTIC SODA
CUS	COPPER SULPHATE
FC	FERRIC CHLORIDE
FEC	FERROUS CHLORIDE
FES	FERROUS SULFATE
FS	FERRIC SULFATE
FSS	FERROUS SULFATE
GAC	ACTIVATED CARBON – GRANULAR
GCR	GAC TRANSFER WATER RECOVERY
GCW	GAC TRANSFER WATER
GLY	GLYCERIN
GOX	GASEOUS OXYGEN
HCL	HYDROCHLORIC ACID
HCO	HYDRAULIC OIL
HEL	HELIUM
HF	HYDRAULIC FLUID
HFS	FLUOSILICIC ACID
HG	HYDROGEN GAS
HL	LIQUID HYDROGEN
HP	HYDROGEN PEROXIDE
ICA	INSTRUMENT/CONTROL AIR
IXE	ION EXCHANGE EFFLUENT
LM	LIME, DRY
LMS	LIME SLURRY
LOX	OXYGEN, LIQUID
MET	METHANOL
N2	INERT (NITROGEN)
NAAL	SODIUM ALUMINATE
NASF	SODIUM SILICOFLUORIDE
NG	NATURAL GAS
NOX	NITROUS OXIDE
OIA	OZONE IN AIR
OIO	OZONE IN OXYGEN
OOG	OZONE OFF–GAS
OS	OZONE SOLUTION
PA	PHOSPHORIC ACID
PAC	ACTIVATED CARBON – SLURRY
PCL	POLYALUMINUM CHLORIDE
PEA	POLYMER, ANIONIC
PEC	POLYMER, CATIONIC
PEN	POLYMER, NON–IONIC
PLY	POLYMER
PP	POTASSIUM PERMANGANATE
SA	SULPHURIC ACID
SAS	SODA ASH SOLUTION
SAT	SALT
SBC	SODIUM BICARBONATE
SBS	SODIUM BISULPHITE
SC	SODA ASH
SDG	SULFUR DIOXIDE, GAS
SDL	SULFUR DIOXIDE, LIQUID
SDS	SULFUR DIOXIDE SOLUTION
SHC	SODIUM HYPOCHLORITE (12%)
SHCL	SODIUM HYPOCHLORITE LOW STRENGTH 0.8%
SLT	SODIUM CHLORIDE
SOW	SOFTENED WATER
SS	SODIUM SILICATE
STE	STEAM

WATER EQUIPMENT ABBREVIATIONS

ACR	ACCESS CARD READER
ACU	AIR CONDITIONING UNIT
AD	AIR DRYER
ARV	AIR RELEASE VALVE
ATS	AUTOMATIC TRANSFER
AVV	AIR VACUUM VALVE
BAT	SWITCH BATTERY
BB	BASEBOARD HEATER
BFP	BACK FLOW PREVENTER
BKR	BREAKER
BLR	BOILER
BLW	BLOWER
BPV	BACK–PRESSURE VALVE
CAL	CALIBRATION COLUMN
CBD	CENTRIFUGE BACK DRIVE
CC	COOLING COIL
CCTV	CLOSED CIRCUIT TELEVISION
CDR	CONDENSER
CDU	CATALYTIC DESTRUCT UNIT
CE	CENTRIFUGE
CFR	CHEMICAL FEEDER
CHLR	CHILLER
CHR	BATTERY CHARGER
CMD	CENTRIFUGE MAIN DRIVE
CMP	COMPRESSOR
CON	CONVEYOR
CP	CONTROL PANEL
CPR	COPPER
CPU	COMPUTER
CRN	CRANE OR HOIST
CS	CARBON STEEL
CTS	CATHODIC TEST STATION
CV	CHECK VALVE
D	DRAIN
DC	DOOR CONTACT
DEM	DEMISTER
DES	DESICCANT DRYER
DF	DAF SKIMMER
DG	DIVERTER GATE
DIF	DIFFUSER
DP	DILUTION PANEL
DS	DISCONNECT SWITCH
DI	DUCTILE IRON
E	ENGINE
EF	EXHAUST FAN
EL	ELECTROLYZER
EPR	EVAPORATOR
ETM	ELAPSED TIME METER
ETNK	EXPANSION TANK
F	FAN
FAP	FIRE ALARM ANNUNICATOR PANEL
FC	FLOCCULATION CHAMBER
FCV	FLOW CONTROL VALVE (MODULATING)
FF	FORCE FLOW HEATER
FG	FLAP GATE
FLC	FLOCCULATOR
FLT	FILTER
FV	FLOW CONTROL VALVE(OPEN/CLOSE)
GCS	GALVANIZED CARBON STEEL
GEN	GENERATOR
GF	GAS FILTER
GP	GLYCOL PUMP
GT	GRAVITY THICKENER
GV	GATE VALVE
HC	HEAT COIL
HEX	HEAT EXCHANGER
HRC	HEAT RECOVERY COIL
HTR	ELECTRIC HEATER
HV	HAND VALVE
HWH	HOT WATER HEATER
HWP	HOT WATER PUMP
IMP	INSTRUMENT MARSHALLING PANEL
KP	KEY PAD
LCG	LEVEL CONTROL GATE
LCP	LOCAL CONTROL PANEL
LCV	LEVEL CONTROL VALVE (MODULATING)
LJB	LOCAL JUNCTION BOX
LOP	LUBE OIL PUMP
LP	LAMELLA PLATE
LV	LEVEL CONTROL VALVE (OPEN/CLOSE)
M	MOTOR
MCC	MOTOR CONTROL CENTRE
MD	MOTION DETECTOR
MDV	MUD VALVE
MP	METERING PUMP
MXR	MIXER
OP	ORIFICE PLATE
P	PUMP
PCT	PARTICLE COUNTER
PCU	POLYMER BULK BAG UNLOADER
PCV	PRESSURE CONTROL VALVE
PFC	POWER FACTOR CORRECTION
PFLT	POWER FILTER (LINE REACTOR, ETC)
PLC	PROGRAMMABLE LOGIC CONTROLLER
PMS	POLYMER MAKE DOWN SYSTEM
PNL	PANEL BOARD
PPU	POLYMER PREPARATION UNIT
PRV	PRESSURE REGULATING / REDUCING VALVE
PSU	POWER SUPPLY UNIT
PV	PRESSURE VESSEL RELIEF VALVE
PVC	POLY VINYL CHLORIDE
PVCC	POLY VINYL CHLORIDE (CLEAR)
RV	RUPTURE DISC VALVE
SCR	SCREEN
SCRB	SCRUBBER
SE	SAMPLER ELEMENT
SF	SUPPLY FAN
SG	SLIDE GATE
SL	STOP LOG
SK	SCRAPER
SLG	SLUICE GATE
SLR	SILENCER
SMP	SUMP PUMP
SOL	SOLENOID ACTUATOR
SP	SAMPLE PUMP
SPS	SUPERNATANT PUMP STATION
SPT	SAMPLE POINT
SS	STAINLESS STEEL
STA	STATIC MIXER
STL	STEEL
STR	STRAINER
SUB	SUBSTATION
SWGR	SWITCHGEAR
SWP	SWASH PLATE
T	TANK
TCV	TEMPERATURE CONTROL VALVE
TNK	TANK
TOTE	TOTE TANK
TURB	TURBIDITY METER
TV	TEMPERATURE / VIBRATION MONITOR
UH	UNIT HEATER ELECTRIC AND NON–ELECTRIC
UPS	UNINTERRUPTIBLE POWER SUPPLY
UVR	ULTRA–VIOLET LIGHT REACTOR
V	VALVE
VFD	VARIABLE FREQUENCY DRIVE
VP	VAPORIZER
VSD	VARIABLE SPEED DRIVE
W	WEIR
WE	WEIGHT SCALE
WG	WEIR GATE
WP	WELL PUMP
WRT	WASHWATER RECOVERY TANK
WSF	WATER SOFTENER
XFMR	TRANSFORMER

PROCESS LINE CODES



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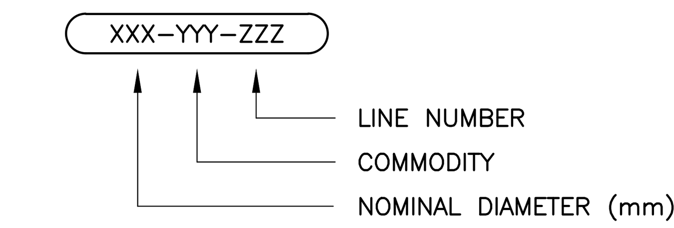

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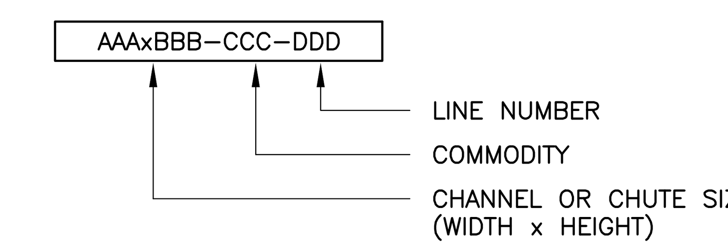

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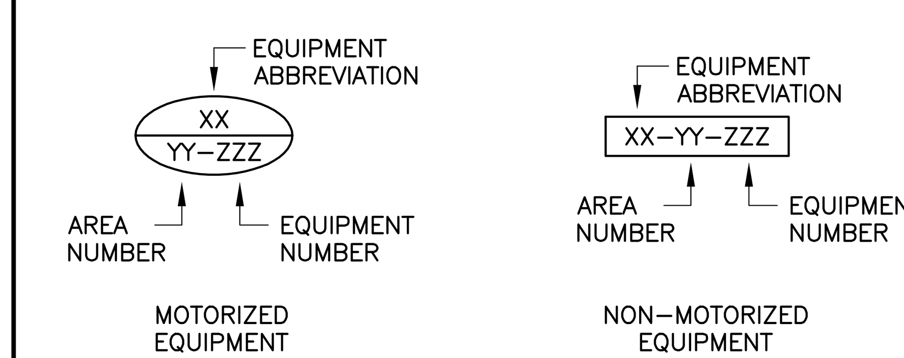

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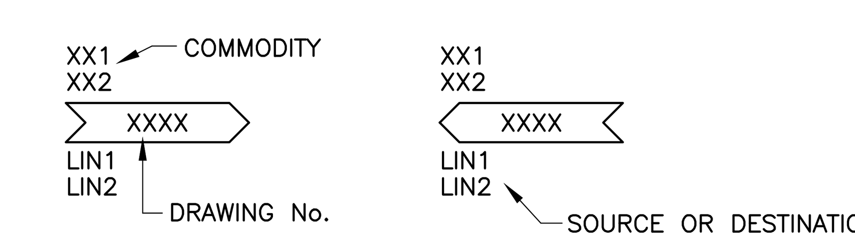

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RECORD DRAWING

PROFESSIONAL SEALS

PROFESSIONAL ENGINEER
LICENSEE
NWT/NU
L.E. RAWE
Nov 13/15

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AECOM Canada Ltd.
Signature
Date Nov 13, 2015
PERMIT NUMBER: P639
NWT/NU Association of Professional Engineers and Geoscientists

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2	2015.11.16	ISSUED FOR RECORD	EF	CMC	CMC	LER		
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Legend and Abbreviations

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P002	2

FUNCTIONAL IDENTIFICATION / DESCRIPTION

	FIRST LETTER (4)		SUCCEEDING–LETTERS (3)			I/O TYPES
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER	TYPICAL ASSOCIATED CDACS
A	ANALYSIS		ALARM			DI
B	BURNER, COMBUSTION			CLOSE–STOP DECREASE		DO
C	CONDUCTIVITY, pH (ACIDITY)		CLOSE	CONTROL OR CONTROLLER		DI/AO
D	DENSITY	DIFFERENTIAL		OPEN–START–INCREASE		DO
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)			
F	FLOW RATE	RATIO (FRACTION)			FAIL	DI
G	GAS		GLASS VIEWING DEVICE			
H	HAND				H–HIGH–(ALARM) HH–HIGH–(SHUTDOWN)	DI
I	CURRENT (ELECTRICAL)		INDICATE			AI
J	POWER	SCAN				DO/AI
K	TIME, TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION		DO/AO
L	LEVEL		LIGHT		L–LOW–(ALARM) LL–LOW–(SHUTDOWN)	DI
M	MOTOR	MOMENTARY	ON OR OPERATE		MIDDLE, INTERMEDIATE	DI
N	MOISTURE					DO
O	UNCLASSIFIED		OPEN ORIFICE, RESTRICTION POINT TEST) CONNECTION		OVERLOAD	DO
P	PRESSURE, VACUUM			PNEUMATIC		
Q	QUANTITY	INTEGRATE, TOTALIZE		INTEGRATE OR TOTALIZE		DI/AI
R	RADIATION		RECORD			AI
S	SPEED, FREQUENCY, SOLENOID	SAFETY		SWITCH, OR SAFETY		DI/DO
T	TEMPERATURE			TRANSMIT		AI
TQ	TORQUE					
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION	DI
V	VIBRATION, MECHANICAL ANALYSIS			VALVE, DAMPER, LOUVRE		
W	WEIGHT, FORCE		WELL			
X	ON/OFF	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	DI/DO
Y	EVENT, STATE, PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT		
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR, UNCLASSIFIED – FINAL CONTROL ELEMENT		

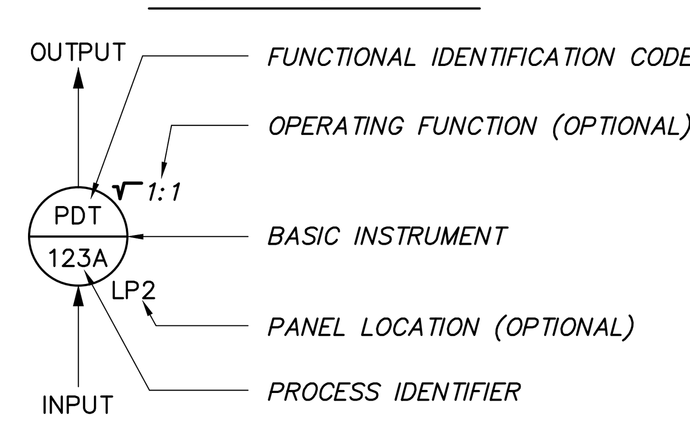
TYPICAL INSTRUMENT IDENTIFICATION

NOTE: IN ADDITION TO THE REQUIREMENTS DETAILED BELOW, REFER TO SCADA POINT NAMING CONVENTIONS WHEN INSTRUMENT INTERFACES TO SCADA.

FIELD TAG IDENTIFICATION

POSITION 1 2 3 4 5 6 7 8
- IF REQUIRED
- PROCESS IDENTIFIER
- FUNCTIONAL IDENTIFICATION CODE

SCHEMATIC IDENTIFICATION



a) FUNCTIONAL IDENTIFICATION CODE – (UP TO 4 CHARACTERS) *
- REFER TO DRAWING STD 1 FOR LISTING
- * NOTE THAT SCADA POINTS CAN ONLY HAVE 3 CHARACTERS

b) PROCESS IDENTIFIER – (3 NUMBERALS AND 1 CHARACTER)
- REFER TO DRAWING STD 1 FOR PROCESS IDENTIFIER NUMBERING CONVENTION.
- CHARACTER SUFFIX IN POSITION 8 DIFFERENTIATES SIMILAR DEVICES WITHIN A LOOP PROVIDED THAT THEY ARE NOT WIRED INTO SCADA – REFER TO SCADA POINT NAMING CONVENTION.

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RECORD DRAWING

INSTRUMENT OPERATING FUNCTIONS

ANALYTICAL FUNCTIONS

RES Cl_2	RESIDUAL CHLORINE
SO_2	SULFUR DIOXIDE
COMB	COMBUSTIBLE GAS
H_2S	HYDROGEN SULFIDE
pH	pH
DO	DISSOLVED OXYGEN
O_2	OXYGEN

SWITCHING FUNCTIONS

HA	HAND–AUTO SELECTION
HOA	HAND–OFF–AUTO SELECTION
JOA	JOG–OFF–AUTO SELECTION
S/S	START–STOP
L/L	LEAD–LAG SELECTION
F/S	FAST–SLOW SELECTION
OCA	OPEN–CLOSE–AUTO SELECTION
OSC	OPEN–STOP–CLOSE SELECTION
SEL	SELECTOR SWITCH
O/O	ON–OFF SELECTION
M/A	MANUAL–AUTO SELECTION
L/R	LOCAL–REMOTE SELECTION
ESD	EMERGENCY SHUTDOWN
ACK	ACKNOWLEDGE (ALARM)
FOR	FORWARD–OFF–REVERSE
LOR	LOWER–OFF–REVERSE

OTHER FUNCTIONS

D/P	DIFFERENTIAL PRESSURE
IXP	CURRENT TO PRESSURE
IBD	INBOARD BEARING
OBD	OUTBOARD BEARING
VIB	VIBRATION

INSTRUMENT AND FUNCTION SYMBOLS

- FIELD MOUNTED INSTRUMENT
- INSTRUMENT WITH TWO SERVICE OR FUNCTION
- LOCAL PANEL – MOUNTED INSTRUMENT. ACCESSIBLE
- INSTRUMENT MOUNTED BEHIND LOCAL CONTROL PANEL. NOT READILY ACCESSIBLE
- INSTRUMENT MOUNTED ON MAIN PANEL. ACCESSIBLE
- INSTRUMENT MOUNTED BEHIND MAIN PANEL. NOT READILY ACCESSIBLE
- FIELD MOUNT ANNUNCIATOR POINT (OPTIONAL ARROW TO INDICATE ROTATING BEACON)
- MAIN PANEL MOUNT ANNUNCIATOR POINT
- LOCAL PANEL MOUNT ANNUNCIATOR POINT
- SCADA: SCADA (SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM) INPUT, OUTPUT, OR FUNCTION.
- SCADA: SCADA INPUT, OUTPUT, OR FUNCTION. ACCESSIBLE
- SPECIAL PURPOSE DIGITAL DEVICE FOR PROCESSING MAINLY ANALOG INFORMATION. EG. SLDC (SINGLE LOOP DIGITAL CONTROLLER)
- SPECIAL PURPOSE DIGITAL DEVICE FOR PROCESSING MAINLY ANALOG INFORMATION. ACCESSIBLE
- SPECIAL PURPOSE DIGITAL DEVICE FOR PROCESSING MAINLY DIGITAL INFORMATION. EG. PLC (PROGRAMMABLE LOGIC CONTROLLER)
- SPECIAL PURPOSE DIGITAL DEVICE FOR PROCESSING MAINLY DIGITAL INFORMATION. ACCESSIBLE
- COMPUTER – INTERNAL SYSTEM FUNCTION (i.e. COMPUTATION/SIGNAL CONDITIONING)
- COMPUTER – INTERNAL SYSTEM FUNCTION NORMALLY ACCESSIBLE TO OPERATOR

PRIMARY ELEMENT SYMBOLS

- ORIFICE PLATE
- VENTURI OR FLOW TUBE
- FLUME
- WEIR
- VARIABLE AREA FLOW INDICATOR (ROTAMETER)
- FLOW ELEMENT INTEGRAL WITH TRANSMITTER (MASS FLOW, ETC)
- DIAPHRAGM SEAL
- IN–LINE PRESSURE SENSOR
- VORTEX FLOW SENSOR
- IN–LINE CAPACITANCE FLOW ELEMENT
- MAGNETIC FLOWMETER
- SONIC FLOWMETER (DOPPLER OR TRANSIT TIME)
- POSITIVE DISPLACEMENT METER
- THERMAL MASS FLOW ELEMENT
- AVERAGING PITOT TUBE
- PITOT TUBE
- PROPELLER, POSITIVE DISPLACEMENT OR TURBINE METER
- CORIOLIS MASS FLOWMETER
- FLOAT LEVEL ELEMENT
- DISPLACEMENT LEVEL ELEMENT
- BUBBLER LEVEL TUBE
- ULTRASONIC/MICROWAVE LEVEL ELEMENT
- RADIO FREQUENCY LEVEL ELEMENT
- VIBRATING TUNING FORK LEVEL SWITCH
- THERMAL SENSING RTD STRIP

INSTRUMENT SIGNAL SYMBOLS

- INSTRUMENT SUPPLY, PROCESS TAPS
- PNEUMATIC SIGNAL
- ELECTRIC SIGNAL
- CAPILLARY TUBE OR FILLED SYSTEM
- ELECTROMAGNETIC OR SONIC SIGNAL (GUIDED)
- ELECTROMAGNETIC OR SONIC SIGNAL (UNGUIDED)
- SOFTWARE OR DATA LINK
- MECHANICAL LINK
- HYDRAULIC

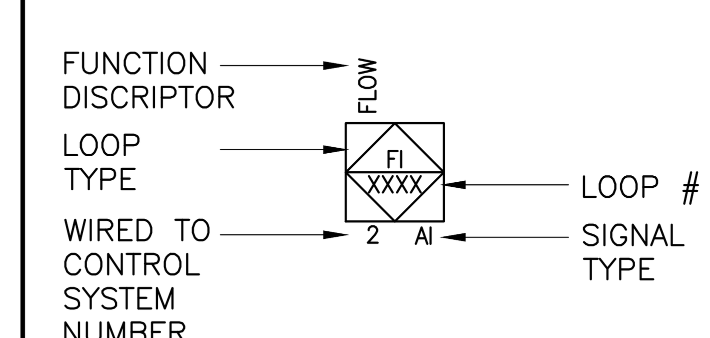
MISCELLANEOUS SYMBOLS

- INTERLOCK – SEE CONTROL STRATEGY DESCRIPTION
- RESET FOR LATCH–TYPE OPERATOR
- ANNUNCIATOR HORN
- GROUND
- INSTRUMENT LOOP SHIELD GROUND
- BOND

LINE DESIGNATIONS

- ES – ELECTRIC POWER SUPPLY 120 VAC 60 HZ (UNLESS OTHERWISE NOTED)
- SA – SERVICE AIR SUPPLY
- IA – INSTRUMENT QUALITY AIR SUPPLY
- C2 – WATER SUPPLY C1, C2, C3, ETC.

GENERAL NOTES



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PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER L.E. RAWE LICENSEE NWT/NU
Nov 13/15

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AECOM Canada Ltd.
Signature
Date Nov 13, 2015
PERMIT NUMBER: P639
NWT/NU Association of Professional Engineers and Geoscientists

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2	2015.11.16	ISSUED FOR RECORD	EF	CMC	CMC	LER		
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

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The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Legend and Abbreviations

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P003	2

BY:FEHRE

FILE NAME: 60147475-P003.DWG

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COMMODITY	RAW WATER	PRE-TREATED WATER	STRAINER BW WASTEWATER	CIP/EFM SUPPLY & DRAIN	CIP RETURN	BACKWASH SUPPLY	EXCESS RECIRCULATION	MEMBRANE FILTRATE	NEUTRALIZED CHEMICAL WASTE	FL/AS/BW WASTEWATER	ARSENIC FILTER BW SUPPLY	ARSENIC FILTER BW WASTEWATER	TOTAL NON-CHEMICAL WASTEWATER	TREATED WATER	TREATED WATER	SETTLED WASTEWATER	SLUDGE
MAXIMUM (MLD)	23.25	23.25	0.003	0.086	0.086	0.57	2.07	20.74	0.086	1.01	0.08	0.08	1.09	1.98	20	0.98	0.12
MINIMUM (MLD)	6.07	6.07	0.003	0	0	0.32	0.53	5.29	0	0.56	0.08	0.08	0.65	1.90	4.9	0.65	0.001
20 YEAR AVERAGE (MLD)	13.31	13.31	0.003	0.061	0.061	0.33	1.19	11.87	0.061	0.58	0.08	0.08	0.66	1.90	11.4	0.66	0.003
INSTANT MAX. FLOW (L/s)	329	315	14	21	21	68	28	280	4.4	110	88	88	212	23	406	14.5	7

NOTES:

1. FEED AND REVERSE FLUSH PUMPS WILL BE SUPPLIED BY GENERAL CONTRACTOR BUT DESIGNED AND CONTROLLED BY MEMBRANE SUPPLIER.
2. FLOW #10 (AS/BW WASTE WATER) INCLUDES TREATED WATER (BACKWASH) AND RAW WATER (FLUSH).

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Nov 13/15

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1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

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Yellowknife Water Treatment Plant

P&ID
Process Flow Diagram

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P004	3

PLOT: 11/13/2015 1:39:42 PM W:\work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client D SIZE 22" x 34" (558.8mm x 863.6mm)

BY:FEHRE

FILE NAME: 60147475-P004.DWG

NOTES:

1. ALL SAMPLE POINTS TO BE 6mm STAINLESS STEEL. REFER TO STANDARD DETAIL.
2. DUAL FUNCTION TO ALLOW DEPRESSURIZATION OF PIPEWORK FOR MAINTENANCE.
3. PRESSURE RELIEF VALVE AND AIR VALVES TO DISCHARGE TO WET WELL.
4. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELEASE VALVES SIZE.
5. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.

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RECORD DRAWING

RAW WATER BOOSTER PUMP P-101

EQUIP. No.: P-101
SPEC.: 43 21 13.01
TYPE: HORIZONTAL END SUCTION
CAPACITY: 165 L/s
HEAD: 37.4 m TDH
POWER: 150 HP
VOLTAGE: 575V, 3ϕ, 60Hz

RAW WATER BOOSTER PUMP P-102

EQUIP. No.: P-102
SPEC.: 43 21 13.01
TYPE: HORIZONTAL END SUCTION
CAPACITY: 165 L/s
HEAD: 37.4 m TDH
POWER: 150 HP
VOLTAGE: 575V, 3ϕ, 60Hz

RAW WATER BOOSTER PUMP P-103

EQUIP. No.: P-103
SPEC.: 43 21 13.01
TYPE: HORIZONTAL END SUCTION
CAPACITY: 165 L/s
HEAD: 37.4 m TDH
POWER: 150 HP
VOLTAGE: 575V, 3ϕ, 60Hz

PROFESSIONAL SEALS

L.E. RAWE LICENSEE NWT/NU
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NWT/NU Association of Professional Engineers and Geoscientists

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3	2015.11.16	ISSUED FOR RECORD	EF	CMC	CMC	LER		
2	2014.04.09	ISSUED FOR CCN 009	EL	CLM	CLM	LER	-	-
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Pumphouse 1 - River Water Supply

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P010	3

NOTES:

1. ALL SAMPLE POINTS TO BE 6mm STAINLESS STEEL. REFER TO STANDARD DETAIL.
2. DUAL FUNCTION TO ALLOW DEPRESSURIZATION OF PIPEWORK FOR MAINTENANCE.
3. PRESSURE RELIEF VALVE AND AIR VALVES TO DISCHARGE TO WET WELL.
4. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELEASE VALVES SIZE.
5. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.

NOTICE:
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RECORD DRAWING

BAY RAW WATER PUMP 1

EQUIP. No.: P – 104
SPEC.: 43 21 13.02
TYPE: VERTICAL TURBINE WITH VFD
CAPACITY: 65 – 165 L/s
HEAD: 29.6m – 49.1m OF WATER
POWER: 150HP
VOLTAGE: 575V, 3ϕ

BAY RAW WATER PUMP 2

EQUIP. No.: P – 105
SPEC.: 43 21 13.02
TYPE: VERTICAL TURBINE WITH VFD
CAPACITY: 65 – 165 L/s
HEAD: 29.6m – 49.1m OF WATER
POWER: 150HP
VOLTAGE: 575V, 3ϕ

PLOT: 11/13/2015 1:43:28 PM Work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client D SIZE 22" x 34" (558.8mm x 863.6mm)

BY:FEHRE

FILE NAME: 60147475-P011.DWG

PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER
L.E. RAWE
LICENSEE
NWT/NU
Nov 13/15

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AECOM Canada Ltd.
Signature
Date Nov 13, 2015
PERMIT NUMBER: P639
NWT/NU Association of Professional Engineers and Geoscientists

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1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CLM	CLM	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CLM	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Pumphouse 1 - Bay Water Supply

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P011	3

NOTES:

1. THIS EXISTING LINE IS CURRENTLY THE CHLORINATED WATER SUPPLY TO THE RESERVOIR.
2. THIS EXISTING LINE IS CURRENTLY THE TREATED WATER RETURN FROM THE RESERVOIR TO PUMPHOUSE 1.
3. PIPEWORK TO AND FROM EXISTING RESERVOIR.
4. ONCE NEW PIPEWORK IS INSTALLED, EXISTING UNUSED LINES CAN BE DECOMMISSIONED OR CAPPED.
5. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
6. PRESSURE RELIEF VALVE PIPED TO WETWELL.
7. AIR VALVE TO DISCHARGE TO FLOOR DRAIN.
8. PUMP STOPS AFTER ADJUSTABLE TIME

RECYCLE PIPE DRAIN PUMP

EQUIP. No.:	P – 106
SPEC.:	43 21 13.04
TYPE:	END SUCTION
CAPACITY:	2 L/s
HEAD:	4.5m
POWER:	0.33 HP, c/w CORDSET
VOLTAGE:	120V, 1ϕ

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REGISTERED PROFESSIONAL ENGINEER L.E. RAWE LICENSEE NWT/NU
Nov 13/15

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0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

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The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Pumphouse 1 to WTP Pipelines

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P012	3

FILE NAME: 60147475-P012.DWG BY:FEHRE PLOT: 11/13/2015 1:35:26 PM Work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client D SIZE 22" x 34" (558.8mm x 863.6mm)

NOTES:

1. FOR DETAILED INFORMATION, REFER TO PALL P&ID's.
2. ALL MATERIAL OF CONSTRUCTION TO BE SUITABLE FOR MATERIALS BEING CONVEYED.
3. PVC PIPEWORK LARGER THEN 25mm DIAMETER TO BE SCHEDULE 80. PVC. PIPEWORK 25mm DIAMETER OR LESS TO BE FLEXIBLE TUBING. RUN TUBING INSIDE 100mm SCHEDULE 40 CLEAR PVC PIPE WHEN OUTSIDE OF CONTAINMENT AREA. ALL SUCTION PIPEWORK TO PUMPING EQUIPMENT TO HARD PVC PIPEWORK.
4. CONNECTION FOR GRAVITY FILLING FROM CHEMICAL TOTE CONTAINERS.
5. ALL VENTS TO BE DIRECTED OUTSIDE OF BUILDING. REFER TO MECHANICAL PROCESS STANDARD DETAIL DRAWINGS FOR PENETRATION AND ARRANGEMENT DETAILS. ALL STOCK TANK VENTS TO BE 50 mm PVC PIPE.
6. SUPPLIED BY MEMBRANE VENDOR.
7. ALL INTERCONNECTING PIPING, TUBING, HARDWARE, FLEXIBLE CONNECTORS AND FIELD WIRING BETWEEN MEMBRANE VENDOR SUPPLIED COMPONENTS ARE TO BE PROVIDED BY CONTRACTOR. THE CONTRACTOR IS RESPONSIBLE FOR THE INSTALLATION OF THE PALL SUPPLIED EQUIPMENT AND THE INTERCONNECTING COMPONENTS MENTIONED PREVIOUSLY.
8. MANUAL PUSH BUTTON TO STOP/START.
9. DRAINS TO BE DIRECTED TO LOCAL CONTAINMENT.
10. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.

NOTICE:
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RECORD DRAWING

CITRIC ACID STOCK TANK

EQUIP. No.: T-210
SPEC.: 43 41 43
TYPE: HDPE
DIAMETER: 1.143 m
VOLUME: 1515 L

CAUSTIC SODA STOCK TANK

EQUIP. No.: T-211
SPEC.: 43 41 43
TYPE: HDPE
DIAMETER: 1.143 m
VOLUME: 1515 L

SODIUM BISULFITE STOCK TANK

EQUIP. No.: T-212
SPEC.: 43 41 43
TYPE: HDPE
DIAMETER: 1.143 m
VOLUME: 1515 L

SODIUM HYPOCHLORITE STOCK TANK

EQUIP. No.: T-213
SPEC.: 43 41 43
TYPE: HDPE
DIAMETER: 1.22 m
VOLUME: 2650 L

CIP ROOM SUMP PUMP

EQUIP. No.: P-23
SPEC.: 22 13 00

BY:FEHRE

FILE NAME: 60147475-P020.DWG

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PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER — J.E. RAWE — LICENSEE — NWT/NU
Nov 13/15

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0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
CIP and Neutralization Systems

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P020	3

NOTES:

1. FOR DETAILED DRAWINGS, REFER TO PALL P&ID's.
2. ALL MATERIAL OF CONSTRUCTION TO BE SUITABLE FOR MATERIALS BEING CONVEYED.
3. ALL PVC PIPEWORK TO BE SCHEDULE 80.
4. NON-CHEMICAL WASTE ONLY.
5. CONNECTIONS FOR FUTURE TREATMENT STAGES.
6. SUPPLIED BY MEMBRANE VENDOR.
7. ALL INTERCONNECTING PIPING, TUBING, HARDWARE, FLEXIBLE CONNECTORS AND FIELD WIRING BETWEEN MEMBRANE VENDOR SUPPLIED COMPONENTS ARE TO BE PROVIDED BY CONTRACTOR. THE CONTRACTOR IS RESPONSIBLE FOR THE INSTALLATION OF THE PALL SUPPLIED EQUIPMENT AND THE INTERCONNECTING COMPONENTS MENTIONED PREVIOUSLY.
8. CONNECT DRAIN TO SANITARY AS SHOWN ON H400. DO NOT DISCHARGE TO SANITARY SUMP PIT.
9. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY WITH SPECIFICATIONS.

NOTICE:
AS-CONSTRUCTED DIMENSIONS, MEASUREMENTS AND OTHER DETAILS CONTAINED IN THIS RECORD DRAWING HAVE BEEN OBTAINED BY AECOM CANADA LTD. ("AECOM") FROM VARIOUS SOURCES. SUCH INFORMATION REPRESENTS THE BEST INFORMATION AVAILABLE TO AECOM AT THE TIME OF PREPARATION OF THIS RECORD DRAWING. AECOM DOES NOT IN ANY WAY REPRESENT OR WARRANT THAT SUCH INFORMATION IS ACCURATE AND ASSUMES NO RESPONSIBILITY FOR ANY ERRORS OR OMISSIONS CONTAINED THEREIN.

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LICENSEE
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0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Membrane Filtration

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P021	3

PLOT: 11/13/2015 11:39:1 LAWork\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client D SIZE 22" x 34" (558.8mm x 863.6mm)

BY:FEHRE

FILE NAME: 60147475-P021.DWG

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NOTES:

1. ALL PVC PIPEWORK TO BE SCHEDULE 80.
2. PIPE SIZES FOR CONNECTING PARTS OF VENDOR SUPPLIED PACKAGE TO BE COORDINATED WITH VENDOR.
3. VALVES, DRAIN, ETC REQUIRED FOR HARDNESS MONITOR (NOT SHOWN). VENDOR AND CONTRACTOR TO PROVIDE ITEMS NEEDED FOR PROPER OPERATION OF INSTRUMENT.
4. PART OF SHG VENDOR SUPPLIED PACKAGE.
5. CONNECTIONS FOR FUTURE SECOND ELECTROLYZER SKID.
6. COMBINATION ALARM STROBE WITH HORN. FEDERAL SIGNAL AUDIBLE AND VISUAL SIGNAL. MODEL AV1ST-024A. LIGHT/SOUNDER COMBINATION, STROBE, 24VDC.
7. PUMP TO BE SUPPLIED WITH START/STOP SWITCHES FOR CONTROL OF THE PUMP.
8. ~~PIPED SUPPLY AND DICHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELIEF VALVE SIZE.~~
9. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
10. ALL INTERCONNECTING PIPING, TUBING, HARDWARE, FLEXIBLE CONNECTORS AND FIELD WIRING BETWEEN VENDOR SUPPLIED COMPONENTS ARE TO BE PROVIDED BY CONTRACTOR. THE CONTRACTOR IS RESPONSIBLE FOR THE INSTALLATION OF THE VENDOR SUPPLIED EQUIPMENT AND THE INTERCONNECTING COMPONENTS MENTIONED PREVIOUSLY.

WATER SOFTENER 1
EQUIP. No.: WSF-420
SPEC. 46 33 13

WATER SOFTENER 2
EQUIP. No.: WSF-421
SPEC. 46 33 13

BRINE SATURATION TANK
EQUIP. No.: T-410
SPEC. 43 41 45
CAPACITY: 27,216 Kg (30 Ton)
DIAMETER: 3.05 m
TYPE: FIBREGLASS REINFORCED PLASTIC

BRINE SOLUTION PUMP 1
EQUIP. No.: P-400
SPEC. 46 33 13
TYPE: GEAR

BRINE SOLUTION PUMP 2
EQUIP. No.: P-401
SPEC. 46 33 13
TYPE: GEAR

SOFTENERS' BRINE PUMP
EQUIP. No.: P-407
SPEC. 46 33 13
TYPE: MAGNETICALLY – COUPLED CENTRIFUGAL

SOFTENER REGENERATION BRINE TANK
EQUIP. No.: T-416
SPEC. 46 33 13
TYPE: HDPE
CAPACITY: AS NEEDED FOR SOFTENERS (ESTIMATED 190L)

PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER — L.E. RAWE — LICENSEE — NWT/NU
Nov 13/15

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0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

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The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Brine and Softening Systems

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P040	3

BY: FEHRE
FILE NAME: 60147475-P040.DWG

NOTES:

1. ALL PVC PIPEWORK TO BE SCHEDULE 80.
2. NUMBER OF CELLS TO BE DETERMINED BY VENDOR. PROVIDE A LEVEL SWITCH AND TEMPERATURE SWITCH FOR EACH CELL.
3. PART OF SHG VENDOR SUPPLIED PACKAGE.
4. CONNECTIONS FOR FUTURE SECOND ELECTROLYZER SKID.
5. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
6. ALL INTERCONNECTING PIPING, TUBING, HARDWARE, FLEXIBLE CONNECTORS AND FIELD WIRING BETWEEN VENDOR SUPPLIED COMPONENTS ARE TO BE PROVIDED BY CONTRACTOR. THE CONTRACTOR IS RESPONSIBLE FOR THE INSTALLATION OF THE VENDOR SUPPLIED EQUIPMENT AND THE INTERCONNECTING COMPONENTS MENTIONED PREVIOUSLY.

RECORD DRAWING

ELECTROLYZER

EQUIP. No.: EL-430
SPEC. 46 33 13

DILUTION PANEL

EQUIP. No.: DP-440
SPEC. 46 33 13

NOTICE:
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LICENSEE
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City of Yellowknife

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The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Sodium Hypochlorite Generation

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P041	2

FILE NAME: 60147475-P041.DWG BY:FEHRE

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RECORD DRAWING

HYDROGEN
DILUTION AIR BLOWERS

EQUIP. NO.: B-450, B-451, B-452, B-453
SPEC: 46 33 13

	HYPOCHLORITE (0.8%) TANK 1	HYPOCHLORITE (0.8%) TANK 2	HYPOCHLORITE (0.8%) TANK 3	HYPOCHLORITE (0.8%) TANK 4
EQUIP. NO.:	T-411	T-412	T-413	T-414
SPEC:	43 41 43	43 41 43	43 41 43	43 41 43
VOLUME:	7192 L	7192 L	7192 L	7192 L
DIAMETER:	1.63 m	1.63 m	1.63 m	1.63 m
HEIGHT:	3.43 m	3.43 m	3.43 m	3.43 m
TYPE:	HDPE	HDPE	HDPE	HDPE

NOTES:

1. ALL PVC PIPEWORK TO BE SCHEDULE 80.
2. ALL VENTS ARE TO BE DIRECTED OUTSIDE OF BUILDING. REFER TO MECHANICAL PROCESS STANDARD DETAIL DRAWINGS FOR PENETRATION AND ARRANGEMENT DRAWINGS.
3. ALL CONTAINMENT AREAS TO BE EPOXY LINED TO WITHSTAND CHEMICALS CONTAINED WITHIN.
4. BYPASS VALVE FOR ISOLATING TANK
5. DISCHARGE TO LOCAL CONTAINMENT.
6. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
7. OVERFLOW PIPEWORK TO BE PVC AND MATCH SIZE OF TANK CONNECTIONS.

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City of Yellowknife

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The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Sodium Hypochlorite Storage

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P042	3

D SIZE 22" x 34" (558.8mm x 863.6mm)
BY: FEHRE
FILE NAME: 60147475-P042.DWG

NOTES:

1. CONNECTION FOR WATER FOR FLUSHING.
2. PVC PIPEWORK FROM TANKS AND ON SKID TO BE SCHEDULE 80. PIPEWORK FROM SKID TO INJECTION AREA TO BE REINFORCED FLEXIBLE TUBING.
3. ALL CHEMICAL PIPEWORK EXTERNAL TO CONTAINMENT AREA AND EXCLUDING INJECTION POINT AREA MUST BE INSIDE 100mm SCHEDULE 40 CLEAR PVC PIPE.
4. USE RETRACTABLE INJECTION QUILLS. REFER TO STANDARD DETAILS.
5. ENSURE ALL MATERIALS ARE COMPATIBLE WITH PROCESS FLUIDS.
6. 100mm CARRIER PIPEWORK (CLEAR SCH 80 PVC) THROUGH WHICH TWO PVC TUBES ARE PASSED.
7. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELEASE VALVE SIZE.
8. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
9. END OF PIPE OPEN TO ROOM, ELEVATION HIGHER THAN STORAGE TANKS OVERFLOW.

NOTICE:
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RECORD DRAWING

SODIUM HYPOCHLORITE DOSING PUMP 1

EQUIP. No.: P-402
SPEC.: 46 33 44
TYPE: PERISTALTIC
CAPACITY: 23 – 410 L/hr
HEAD: 9m OF WATER
POWER: 0.25 HP
VOLTAGE: 120V, 1ϕ

SODIUM HYPOCHLORITE DOSING PUMP 2

EQUIP. No.: P-403
SPEC.: 46 33 44
TYPE: PERISTALTIC
CAPACITY: 23 – 410 L/hr
HEAD: 9m OF WATER
POWER: 0.25 HP
VOLTAGE: 120V, 1ϕ

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PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER
L.E. RAWE
LICENSEE
NWT/NU
Nov 13/15

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City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Sodium Hypochlorite Dosing

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P043	3

FILE NAME: 60147475-P043.DWG BY:FEHRE PLOT: 11/13/2015 11:47:42 AM ...\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client D SIZE 22" x 34" (558.8mm x 863.6mm)

NOTES:

1. ALL SAMPLE POINTS TO BE 6mm STAINLESS STEEL.
2. CONNECTION FOR WATER FLUSHING.
3. CONSTANT HEAD DEVICE TO ENSURE PERFORMANCE OF INSTRUMENTATION. REFER TO STANDARD DETAILS OF INSTRUMENT PANEL CONTENTS AND ARRANGEMENT.
4. CONNECTION FOR GRAVITY FILLING FROM CHEMICAL TOTE CONTAINERS. PIPEWORK TO BE 50mm PVC SCH80.
5. ALL CHEMICAL PIPEWORK EXTERNAL TO CONTAINMENT AREA AND EXCLUDING INJECTION POINT AREA MUST BE INSIDE 100mm SCHEDULE 40 CLEAR PVC PIPE.
6. USE RETRACTABLE INJECTION QUILLS. REFER TO STANDARD DETAILS.
7. ALLOW AT LEAST 5m OF PIPE LENGTH BETWEEN THE MIXER AND SAMPLE POINT.
8. SAMPLE QUILL TO BE USED TO OBTAIN WATER SUPPLY FOR INSTRUMENT/SAMPLE POINT. REFER TO STANDARD DETAIL.
9. 50 mm DIAMETER PVC VENT TO BE DIRECTED OUTSIDE OF BUILDING.
10. ENSURE ALL MATERIALS ARE COMPATIBLE WITH PROCESS FLUIDS.
11. 100mm CARRIER PIPEWORK (CLEAR SCH 80 PVC) THROUGH WHICH TWO PVC TUBES ARE PASSED.
12. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELEASE VALVE SIZE.
13. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
14. TANK OVERFLOW TO MATCH FILL LINE SIZE.

NOTICE:
AS-CONSTRUCTED DIMENSIONS, MEASUREMENTS AND OTHER DETAILS CONTAINED IN THIS RECORD DRAWING HAVE BEEN OBTAINED BY AECOM CANADA LTD. ("AECOM") FROM VARIOUS SOURCES. SUCH INFORMATION REPRESENTS THE BEST INFORMATION AVAILABLE TO AECOM AT THE TIME OF PREPARATION OF THIS RECORD DRAWING. AECOM DOES NOT IN ANY WAY REPRESENT OR WARRANT THAT SUCH INFORMATION IS ACCURATE AND ASSUMES NO RESPONSIBILITY FOR ANY ERRORS OR OMISSIONS CONTAINED THEREIN.

RECORD DRAWING

FLUORIDE TANK
EQUIP. NO.: T–415
SPEC.: 43 41 43
TYPE: HDPE
DIAMETER: 1.22 m
VOLUME: 1515 L

FLUORIDE WEIGH SCALE
EQUIP. No.: WE–415
SPEC.: 40 96 21
VOLTAGE: 120V, 1ϕ

FLUORIDE DOSING PUMP 1
EQUIP. No.: P–404
SPEC.: 46 33 44
TYPE: PERISTALTIC
CAPACITY: 0.27 – 3.48 L/hr
HEAD: 7m OF WATER
POWER: 0.25 HP
VOLTAGE: 120V, 1ϕ

FLUORIDE DOSING PUMP 2
EQUIP. No.: P–405
SPEC.: 46 33 44
TYPE: PERISTALTIC
CAPACITY: 0.27 – 3.48 L/hr
HEAD: 7m OF WATER
POWER: 0.25 HP
VOLTAGE: 120V, 1ϕ

SAMPLE WATER PUMP
EQUIP. No.: P–406
SPEC.: 46 33 44
TYPE: PERISTALTIC
CAPACITY: 153 L/Hr
HEAD: 7m OF WATER
POWER: 0.25 HP
VOLTAGE: 120V, 1ϕ

PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER L.E. RAWE LICENSEE NWT/NU
Nov 13/15

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Signature
Date Nov 13, 2015
PERMIT NUMBER: P639
NWT/NU Association of Professional Engineers and Geoscientists

I/R	YY/MM/DD	ISSUE/REVISION DESCRIPTION	DRN	CHK	DES	ENG	IDR	APP
3	2015.11.16	ISSUED FOR RECORD	EF	CMC	CMC	LER		
2	2014.09.26	ISSUED FOR CCN 031	JC	-	CLM	LER	-	-
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Fluoridation

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P044	3

FILE NAME: 60147475-P044.DWG
PLOT: 11/13/2015 11:49:41 AM BY: FEHRE
D SIZE 22" x 34" (558.8mm x 863.6mm)

NOTES:

1. THIS EXISTING LINE IS CURRENTLY THE CHLORINATED WATER SUPPLY TO THE RESERVOIR.
2. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.

NOTICE:
AS-CONSTRUCTED DIMENSIONS, MEASUREMENTS AND OTHER DETAILS CONTAINED IN THIS RECORD DRAWING HAVE BEEN OBTAINED BY AECOM CANADA LTD. ("AECOM") FROM VARIOUS SOURCES. SUCH INFORMATION REPRESENTS THE BEST INFORMATION AVAILABLE TO AECOM AT THE TIME OF PREPARATION OF THIS RECORD DRAWING. AECOM DOES NOT IN ANY WAY REPRESENT OR WARRANT THAT SUCH INFORMATION IS ACCURATE AND ASSUMES NO RESPONSIBILITY FOR ANY ERRORS OR OMISSIONS CONTAINED THEREIN.

RECORD DRAWING

PLOT: 11/13/2015 11:53:24 AM Work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client D SIZE 22" x 34" (558.8mm x 863.6mm)

BY: FEHRE

FILE NAME: 60147475-P050.DWG

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LICENSEE
NWT/NU
Nov 13/15

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2	2015.11.16	ISSUED FOR RECORD	EF	CMC	CMC	LER		
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Existing Reservoirs

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P050	2

NOTES:

1. ALL SAMPLE POINTS TO BE 6mm STAINLESS STEEL.
2. DUAL FUNCTION TO ALLOW DEPRESSURIZATION OF PIPEWORK FOR MAINTENANCE.
3. ALL WATER FROM AIR VACUUM/RELEASE VALVES TO BE RETURNED TO RESERVOIR.
4. EXISTING PIPEWORK WITHIN WELL TO BE REMOVED TO ALLOW PUMP INSTALLATION. REFER TO MECHANICAL PROCESS DRAWINGS.
5. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELEASE VALVE SIZE.
6. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
7. CHECK VALVES WITH 2 mm ORIFICES IN CLAPPER, PER NFPA 20.

MEMBRANE BACKWASH PUMP 2

EQUIP. No.: P-507
SPEC.: 43 21 13.02
TYPE: SUBMERSIBLE VERTICAL TURBINE
CAPACITY: 56 L/s
HEAD: 30.8m OF WATER
POWER: 40HP
VOLTAGE: 575V, 3ϕ

DISTRIBUTION PUMP 3

EQUIP. No.: P-502
SPEC.: 43 21 13.02
TYPE: VERTICAL TURBINE
CAPACITY: 40–75 L/s
HEAD: 60m OF WATER
POWER: 75HP
VOLTAGE: 575V, 3ϕ

DISTRIBUTION PUMP 4

EQUIP. No.: P-503
SPEC.: 43 21 13.02
TYPE: VERTICAL TURBINE
CAPACITY: 40–75 L/s
HEAD: 60m OF WATER
POWER: 75HP
VOLTAGE: 575V, 3ϕ

FIRE PUMP 2

EQUIP. No.: P-505
SPEC.: 43 21 13.02
TYPE: UL LISTED / FM LABELED VERTICAL TURBINE
CAPACITY: 202 L/s
HEAD: 73.5 m TOH
POWER: 250 HP
VOLTAGE: 575V, 3ϕ

NOTICE:
AS-CONSTRUCTED DIMENSIONS, MEASUREMENTS AND OTHER DETAILS CONTAINED IN THIS RECORD DRAWING HAVE BEEN OBTAINED BY AECOM CANADA LTD. ("AECOM") FROM VARIOUS SOURCES. SUCH INFORMATION REPRESENTS THE BEST INFORMATION AVAILABLE TO AECOM AT THE TIME OF PREPARATION OF THIS RECORD DRAWING. AECOM DOES NOT IN ANY WAY REPRESENT OR WARRANT THAT SUCH INFORMATION IS ACCURATE AND ASSUMES NO RESPONSIBILITY FOR ANY ERRORS OR OMISSIONS CONTAINED THEREIN.

RECORD DRAWING

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REGISTERED PROFESSIONAL ENGINEER
J.E. RAWE
LICENSEE
NWT/NU
nov 13/15

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0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
High Lift Pumps

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P051	3

PLOT: 11/13/2015 11:55:33 AM Work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client
D SIZE 22" x 34" (558.8mm x 863.6mm)
BY:FEHRE
FILE NAME: 60147475-P051.DWG

NOTES:

1. ALL SAMPLE POINTS TO BE 6mm STAINLESS STEEL.
2. DUAL FUNCTION TO ALLOW DEPRESSURIZATION OF PIPEWORK FOR MAINTENANCE.
3. ALL WATER FROM AIR VACUUM/RELEASE VALVES TO BE RETURNED TO RESERVOIR.
4. EXISTING PIPEWORK TO BE REMOVED.
5. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELEASE VALVE SIZE.
6. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
7. CHECK VALVES WITH 2 mm ORIFICE IN CLAPPER, PER NFPA 20.

MEMBRANE BACKWASH PUMP 1

EQUIP. No.: P-506
SPEC. 43 21 13.02
TYPE: SUBMERSIBLE VERTICAL TURBINE
CAPACITY: 56 L/s
HEAD: 30.8m OF WATER
POWER: 40HP
VOLTAGE: 575V, 3ϕ

DISTRIBUTION PUMP 1

EQUIP. No.: P-500
SPEC. 43 21 13.02
TYPE: VERTICAL TURBINE
CAPACITY: 26-40 L/s
HEAD: 60m OF WATER
POWER: 40 HP
VOLTAGE: 575V, 3ϕ

DISTRIBITION PUMP 2

EQUIP. No.: P-501
SPEC. 43 21 13.02
TYPE: VERTICAL TURBINE
CAPACITY: 40-75 L/s
HEAD: 60m OF WATER
POWER: 75HP
VOLTAGE: 575V, 3ϕ

FIRE PUMP 1

EQUIP. No.: P-504
SPEC. 43 21 13.02
TYPE: UL LISTED / FM LABELED VERTICAL TURBINE
CAPACITY: 202 L/s
HEAD: 73.5 m TOH
POWER: 250 HP
VOLTAGE: 575V, 3ϕ

NOTICE:
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REGISTERED PROFESSIONAL ENGINEER
L.E. RAWE
LICENSEE
NWT/NU
Nov 13/15

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1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

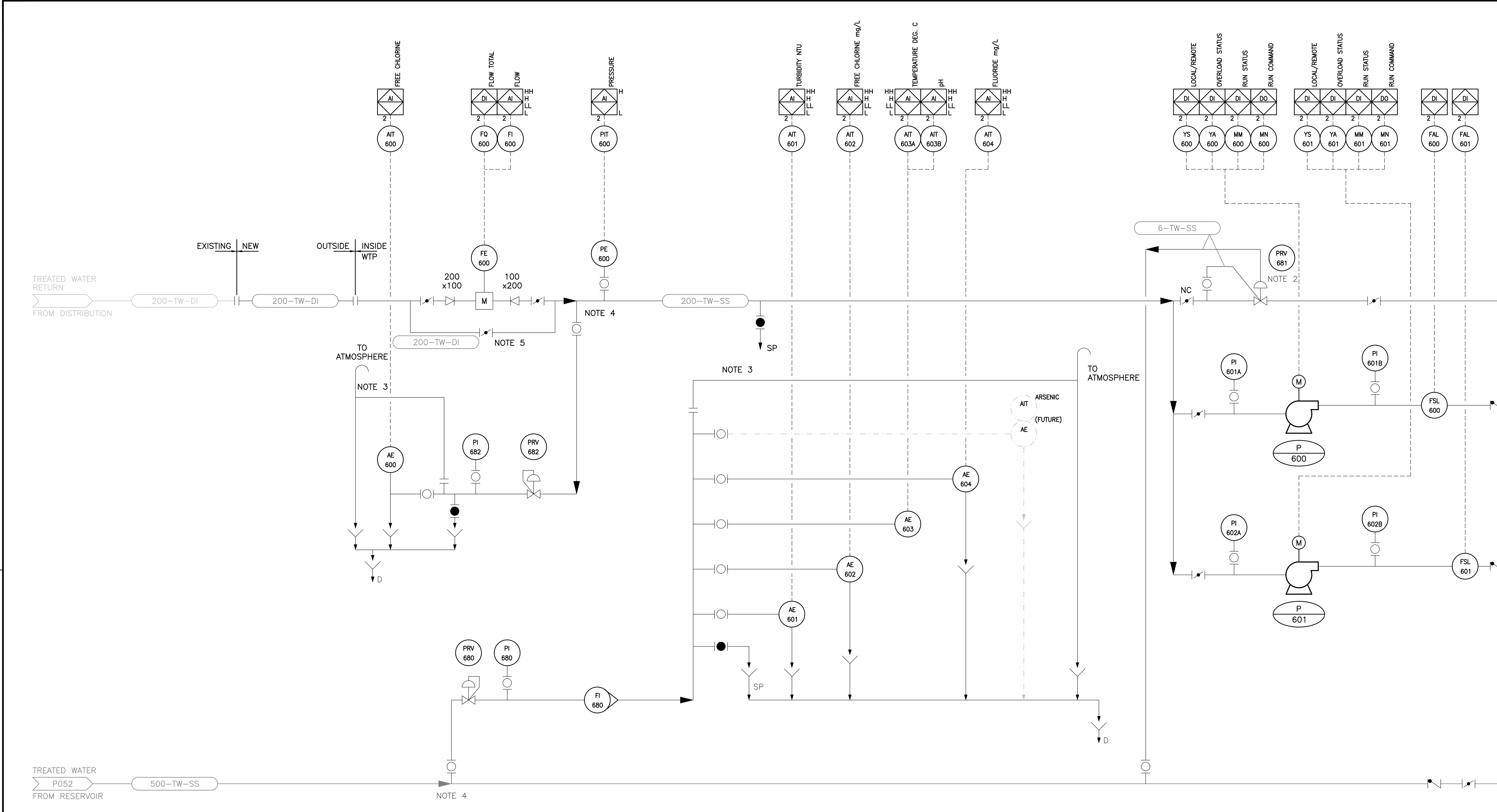
AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
High Lift Pumps

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P052	3

D SIZE 22" x 34" (558.8mm x 863.6mm)
PLOT: 11/13/2015 11:57:08 AM
BY: FEHRE
FILE NAME: 60147475-P052.DWG



NOTES:

1. ALL SAMPLE POINTS TO BE 6mm STAINLESS STEEL.
2. PRESSURE MODULATING VALVE TO MAINTAIN RECIRCULATION LINE AT A PRESSURE THAT IS 138 kPa LESS THAN THE TREATED WATER LINE.
3. CONSTANT HEAD DEVICE TO ENSURE PERFORMANCE OF INSTRUMENTATION. REFER TO STANDARD DETAILS FOR INSTRUMENT PANEL ARRANGEMENT.
4. SAMPLE QUILL TO BE USED TO OBTAIN WATER SUPPLY FOR INSTRUMENT/SAMPLE POINT. REFER TO STANDARD DETAIL.
5. BYPASS TO FACILITATE FLOW METER REMOVAL.
6. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.

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RECORD DRAWING

RECIRCULATION PUMP 1

EQUIP. No.:	P-600
SPEC.	43 21 13.03
TYPE:	INLINE CENTRIFUGAL
CAPACITY:	22.7 L/s
HEAD:	18.6m
POWER:	7.5 HP
VOLTAGE:	575V, 3ϕ

RECIRCULATION PUMP 2

EQUIP. No.:	P-601
SPEC.	43 21 13.03
TYPE:	INLINE CENTRIFUGAL
CAPACITY:	22.7 L/s
HEAD:	18.6m
POWER:	7.5 HP
VOLTAGE:	575V, 3ϕ

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REGISTERED PROFESSIONAL ENGINEER
L.E. RAWE
LICENSEE
NWT/NU
Nov 13/15

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1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Potable Water System

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P060	2

FILE NAME: 60147475-P060.DWG BY:FEHRE PLOT: 11/13/2015 11:58:40 AM D SIZE 22" x 34" (558.8mm x 863.6mm)

PLOT: 11/13/2015 12:00:08 PM Work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client D SIZE 22" x 34" (558.8mm x 863.6mm)

NOTES:

1. ALL SAMPLE POINTS TO BE 6mm STAINLESS STEEL.
2. PRESSURE MODULATING VALVE TO MAINTAIN RETURN LINE AT A PRESSURE THAT IS 20 psi LESS THAN THE DISCHARGE PRESSURE FROM HIGH LIFT PUMPS.
3. CONSTANT HEAD DEVICE TO ENSURE PERFORMANCE OF INSTRUMENTATION. REFER TO STANDARD DETAILS OF INSTRUMENT PANEL ARRANGEMENT.
4. SAMPLE QUILL TO BE USED TO OBTAIN WATER SUPPLY FOR INSTRUMENT/SAMPLE POINT. REFER TO STANDARD DETAIL.
5. REFER TO PLUMBING AND DOMESTIC WATER DRAWINGS FOR HEAT EXCHANGER DETAILS.
6. BYPASS TO FACILITATE FLOW METER REMOVAL.
7. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELEASE VALVE SIZE.
8. LOCATE FIELD FIT P.S.W. SUPPLIES TO SUIT LOCAL CONSTRAINTS.
9. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.

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RECORD DRAWING

PUMPHOUSE 1 RECIRCULATION PUMP

EQUIP. No.:	P–602
SPEC.	43 21 13.05
TYPE:	CANNED MOTOR CENTRIFUGAL
CAPACITY:	4.3 L/s
HEAD:	1.3m
POWER:	0.33 HP
VOLTAGE:	575V, 3ϕ

BY: FEHRE

FILE NAME: 60147475-P061.DWG

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PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER
J.E. RAWE
LICENSEE
NWT/NU
Nov 13/15

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Date Nov 13, 2015
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0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Potable Water System

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P061	2

NOTES:

1. ALL SAMPLE POINTS TO BE 12 mm STAINLESS STEEL
2. VENTS OPEN TO ROOM. PROVIDE 24 MESH S.S. SCREEN OVER PIPE END.
3. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.

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RECORD DRAWING

WASTE EQUALIZATION TANK 1

EQUIP. No.: T-710
SPEC. DIVISION 3
TYPE: CONCRETE
LENGTH: 15.9 m
WIDTH: 6.7 m
DEPTH: 3 m
VOLUME: 275 m3

WASTE EQUALIZATION TANK 2

EQUIP. No.: T-711
SPEC. DIVISION 3
TYPE: CONCRETE
LENGTH: 15.9 m
WIDTH: 6.7 m
DEPTH: 3 m
VOLUME: 275 m3

WASTE MIXER 1

EQUIP. No: MXR-720
SPEC. 46 41 23
TYPE: SUBMERSIBLE
POWER: 4.3HP
VOLTAGE: 575V, 3ϕ

WASTE MIXER 2

EQUIP. No: MXR-721
SPEC. 46 41 23
TYPE: SUBMERSIBLE
POWER: 4.3HP
VOLTAGE: 575V, 3ϕ

WASTE PUMP 1

EQUIP. No.: P-700
SPEC. 43 21 39
TYPE: SUBMERSIBLE PUMP
CAPACITY: 7.25 L/s
HEAD: 4.5 m
POWER: 2.2HP
VOLTAGE: 575V, 3ϕ

WASTE PUMP 2

EQUIP. No.: P-701
SPEC. 43 21 39
TYPE: SUBMERSIBLE PUMP
CAPACITY: 7.25 L/s
HEAD: 4.5 m
POWER: 2.2HP
VOLTAGE: 575V, 3ϕ

PROFESSIONAL SEALS

REGISTERED PROFESSIONAL ENGINEER
L.E. RAWE
LICENSEE
NWT/NU
Nov 13/15

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0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Backwash Waste Equalization

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P070	2

D SIZE 22" x 34" (558.8mm x 863.6mm)
PLOT: 11/13/2015 1:27:57 PM ...work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client
BY:FEHRE
FILE NAME: 60147475-P070.DWG

NOTES:

1. ALL SAMPLE POINTS TO BE 12mm STAINLESS STEEL.
2. CONSTANT HEAD DEVICE TO ENSURE PERFORMANCE OF INSTRUMENTATION. REFER TO STANDARD DETAILS OF INSTRUMENT PANEL ARRANGEMENT.
3. USE RETRACTABLE INJECTION QUILLS. REFER TO STANDARD DETAILS.
4. 200mm DIAMETER PVC VENTS TO BE DIRECTED OUTSIDE OF BUILDING.
5. 80mm TANK DRAIN. LOCATE DISCHARGE CLOSE TO FLOOR DRAIN.
6. PROVIDE QUICK COUPLING WITH END CAP TO MATCH VACUUM TRUCKS.
7. PIPED SUPPLY AND DISCHARGE CONNECTIONS, PIPE TAPPING/CONNECTION AND ISOLATION VALVE TO MATCH RELEASE VALVE.
8. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
9. LOCATE POLYMER INJECTION POINT AS CLOSE TO THICKENER INLET AS POSSIBLE
10. TIDEFLEX "CHECKMATE" DOWNSTREAM FLANGED RUBBER CHECK VALVE TO BE INSTALLED BY CITY IN DECEMBER 2015.

NOTICE:
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RECORD DRAWING

WASTE GRAVITY THICKENER 1
EQUIP. No.: GT-730
SPEC. 46 71 13
CAPACITY: 7.25 L/s

GRAVITY THICKENER RAPID MIXER 1
EQUIP. No.: MXR-722
SPEC. 46 71 13
POWER: 0.25 HP
VOLTAGE: 575V, 3ϕ

GRAVITY THICKENER FLOCCULATION MIXER 1
EQUIP. No.: MXR-723
SPEC. 46 71 13
POWER: 0.5 HP
VOLTAGE: 575V, 3ϕ

GRAVITY THICKENER SCRAPER 1
EQUIP. No.: SK-740
SPEC. 46 71 13
POWER: 0.25 HP
VOLTAGE: 575V, 3ϕ

WASTE GRAVITY THICKENER 2
EQUIP. No.: GT-731
SPEC. 46 71 13
CAPACITY: 7.25 L/s

GRAVITY THICKENER RAPID MIXER 2
EQUIP. No.: MXR-724
SPEC. 46 71 13
POWER: 0.25 HP
VOLTAGE: 575V, 3ϕ

GRAVITY THICKENER FLOCCULATION MIXER 2
EQUIP. No.: MXR-725
SPEC. 46 71 13
POWER: 0.5 HP
VOLTAGE: 575V, 3ϕ

GRAVITY THICKENER SCRAPER 2
EQUIP. No.: SK-741
SPEC. 46 71 13
POWER: 0.25 HP
VOLTAGE: 575V, 3ϕ

THICKENED SLUDGE PUMP 1
EQUIP. No.: P-706
SPEC. 43 21 36
TYPE: ROTARY LOBE PUMP
CAPACITY: 3.5 L/s
HEAD: 4.3 m
POWER: 3HP
VOLTAGE: 575V, 3ϕ

THICKENED SLUDGE PUMP 2
EQUIP. No.: P-707
SPEC. 43 21 36
TYPE: ROTARY LOBE PUMP
CAPACITY: 3.5 L/s
HEAD: 4.3 m
POWER: 3HP
VOLTAGE: 575V, 3ϕ

SLUDGE STORAGE TANK 1
EQUIP. No.: T-712
SPEC. 43 41 43
TYPE: HDPE
DIAMETER: 2.286 m
VOLUME: 11400 L

SLUDGE STORAGE TANK 2
EQUIP. No.: T-713
SPEC. 43 41 43
TYPE: HDPE
DIAMETER: 2.286 m
VOLUME: 11400 L

PROFESSIONAL SEALS

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Signature
Date Nov 13, 2015
PERMIT NUMBER: P639
NWT/NU Association of Professional Engineers and Geoscientists

L.E. RAWE
LICENSEE
NWT/NU
Nov 13/15

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2	2014.06.04	ISSUED FOR CCN 021	JC		CLM	LER		-
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Backwash Waste Thickening

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P071	4

FILE NAME: 60147475-P071.DWG
BY:FEHRE
D SIZE 22" x 34" (558.8mm x 863.6mm)

PLOT: 11/13/2015 1:30:56 PM   Work\60147000\60147475\02a-CAD\WAT\Drawing\Issued\2015.10.13 Issued for Record\4-CAD to Client   D SIZE 22" x 34" (558.8mm x 863.6mm)

NOTES:

1. ~~CHEMICAL PIPEWORK EXTERNAL TO POLYMER CONTAINMENT AREA TO BE REINFORCED FLEXIBLE TUBING.~~
2. RETURN VENT/OVERFLOW/DRAIN TO AGING TANK USING CHEMICALLY COMPATIBLE FLEXIBLE TUBE.
3. ENSURE ALL MATERIALS ARE COMPATIBLE WITH PROCESS FLUIDS.
4. PIPED SUPPLY AND DISCHARGE CONNECTIONS AND ISOLATION VALVE TO MATCH RELIEF VALVE SIZE.
5. WITH REGARDS TO ALARM REQUIREMENTS FOR THE PLC TERMINATIONS, REFER TO CONTROL PHILOSOPHY.
6. PROVIDE LOWER HOUSING FLUSHING CONNECTION ON DIAPHRAGM SEALS

NOTICE:
AS-CONSTRUCTED DIMENSIONS, MEASUREMENTS AND OTHER DETAILS CONTAINED IN THIS RECORD DRAWING HAVE BEEN OBTAINED BY AECOM CANADA LTD. ("AECOM") FROM VARIOUS SOURCES. SUCH INFORMATION REPRESENTS THE BEST INFORMATION AVAILABLE TO AECOM AT THE TIME OF PREPARATION OF THIS RECORD DRAWING. AECOM DOES NOT IN ANY WAY REPRESENT OR WARRANT THAT SUCH INFORMATION IS ACCURATE AND ASSUMES NO RESPONSIBILITY FOR ANY ERRORS OR OMISSIONS CONTAINED THEREIN.

RECORD DRAWING

POLYMER MIXER/AGING TANK 1
EQUIP. No.: T-714
SPEC. CCN 035
TYPE: HDPE
DIAMETER: 1.05 m
VOLUME: 1248 L

POLYMER MIXER/AGING TANK 2
EQUIP. No.: T-715
SPEC. CCN 035
TYPE: HDPE
DIAMETER: 1.05 m
VOLUME: 1248 L

POLYMER DILUTION MIXER 1&2
EQUIP. No.: MXR-726&727
SPEC. CCN 035
POWER: 0.50 HP
VOLTAGE: 120V, 1ϕ

POLYMER PUMP 1
EQUIP. No.: P-704
SPEC. 46 33 44
TYPE: PERISTALTIC
CAPACITY: 0.02-192 L/HR
HEAD: 20m (MAX)
POWER: 0.25 HP
VOLTAGE: 120V, 1ϕ

POLYMER PUMP 2
EQUIP. No.: P-705
SPEC. 46 33 44
TYPE: PERISTALTIC
CAPACITY: 0.02-192 L/HR
HEAD: 20m (MAX)
POWER: 0.25 HP
VOLTAGE: 120V, 1ϕ

BY: FEHRE

Do not scale this document.
All measurements must be obtained from stated dimensions.

PROFESSIONAL SEALS

PROFESSIONAL ENGINEER L.E. RAWE LICENSEE NWT/NU
Nov 13/15

PERMIT TO PRACTICE
AECOM Canada Ltd.
Signature
Date Nov 13, 2015
PERMIT NUMBER: P639
NWT/NU Association of Professional Engineers and Geoscientists

I/R	YY/MM/DD	ISSUE/REVISION DESCRIPTION	DRN	CHK	DES	ENG	IDR	APP
5	2015.11.16	ISSUED FOR RECORD	EF	CMC	CMC	LER		
4	2014.10.01	ISSUED FOR CCN 035	JC	-	CMC	LER		-
3	2014.09.26	ISSUED FOR CCN 031	JC	-	CLM	LER	-	-
2	2014.06.04	ISSUED FOR CCN 021	JC		CLM	LER		
1	2013.07.24	ISSUED FOR CONSTRUCTION	SKY	CMC	CMC	LER	-	-
0	2013.05.08	ISSUED FOR TENDER	JC	RT	CMC	RT	-	-

City of Yellowknife

AECOM

The City of Yellowknife
Yellowknife Water Treatment Plant

P&ID
Backwash Waste Treatment Chemicals

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60147475	P072	5

FILE NAME: 60147475-P072.DWG

CITY OF YELLOWKNIFE

PUMPHOUSE No.2 UPGRADE
PROCESS
PIPING & INSTRUMENTATION DIAGRAM—WATER SUPPLY

REV	Y	M	D	REVISION DESCRIPTION	DRN	SUPV	DES	CHK	ENG
1	94	03	28	ISSUE FOR TENDER	MIL		KN	KN	KN
0	94	02	10	PRELIMINARY REVIEW	MIL				

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
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uma 4202-027-00-03 YELLOWKNIFE

CODE	DRAWING	REV
CD-00-32-A1	402	1