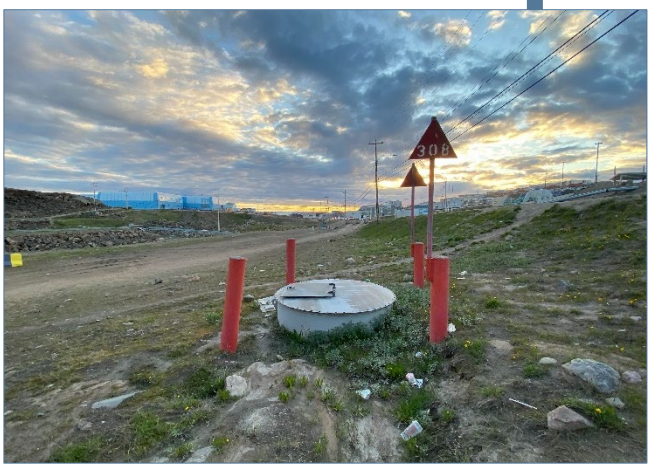
IQALUIT LONG-TERM WATER PROJECT

WATER LOSS INVESTIGATION

DRAFT REPORT
PREPARED FOR CITY OF IQALUIT



1600 Buffalo Place
Winnipeg, MB
Canada R3T 6B8

T: +1 204 477-6650
F: +1 204 474-2864
wsp.com

WSP PROJECT NO. CA0023312.3294

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1600 Buffalo Place
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Canada R3T 6B8

T: +1 204 477-6650
F: +1 204 474-2864
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November 14, 2024

Draft Report

City of Iqaluit

Attention: **City of Iqaluit**

Subject: **Long-Term Water Project Owner's Engineer - Water Loss Investigation**

Dear City of Iqaluit,

WSP Canada Inc. (WSP) is pleased to submit the attached Draft Report on the Water Loss Investigation as a preliminary submission, in partial satisfaction of the Phase 2 Scope of Work Packages for the Iqaluit Long-Term Water Project.

The purpose of this report is to identify potential sources of non-revenue water loss, assess the likelihood and severity of each source, and propose strategies for mitigating or eliminating them. The findings in this draft are based on WSP's site investigation conducted during the week of July 8th, 2024, interviews with City staff, and a review of information provided to date. However, the final conclusions and recommendations will be refined once all outstanding data from the City is received.

These findings will inform the priority matrix, a subsequent Phase 2 deliverable, in accordance with the City's funding requirements under the Disaster Mitigation and Adaptation Fund.

We look forward to your response and to incorporating any additional data or comments into the final version of this report.

Yours sincerely,

Ian Moran, B.Eng., PMP

Technical Project Manager, WSP Canada Inc.

Neil Noble-Pattinson, B.Sc., B.A., P.Eng., PMP

Project Manager, WSP Canada Inc.

WSP Project #: CA0023312.3294

1600 Buffalo Place
Winnipeg, MB
Canada R3T 6B8

T: +1 204 477-6650
F: +1 204 474-2864
wsp.com

REVISION HISTORY

REV	DESCRIPTION	PREPARED BY	REVIEWED BY	APPROVED BY	DATE
0	Issued as Draft	Ian Moran Technical Project Manager	Dr. Charles Goss Senior QA/QC Consultant	Neil Noble-Pattinson Project Manager	2024-11-14

SIGNATURES

PREPARED BY

Ian Moran, B.Eng., PMP
Technical Project Manager

November 14, 2024

REVIEWED BY

Dr. Charles Goss, Ph.D., PMP, P.Chem.
Quality Control Lead

November 14, 2024

APPROVED BY

Neil Noble-Pattinson, B.Sc., B.A., P.Eng., PMP
Project Manager

November 14, 2024

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The content and opinions contained in the present report are based on the observations and/or information available to WSP at the time of preparation, using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by WSP and other engineering/scientific practitioners working under similar conditions, and subject to the same time, financial and physical constraints applicable to this project.

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This limitations statement is considered an integral part of this report.

CONTRIBUTORS

City of Iqaluit

Chief Administrative Officer	Steve England
Director of Engineering	Kevin Kerr
Project Officer	Tamilore Adeleke
Project Officer	Ugboduma Oghenerugba
Project Officer	Amoyide Oyefoso
Director of Public Works	Simon Doiron
Water & Wastewater Superintendent	Shane Turner
Senior Advisor Engineering and Capital Planning	Murray Amirault

Colliers Project Leaders

Project Manager	Richard Sithole
Assistant Project Manager	Abdalla Ambar

WSP

Project Sponsor	Justin Rak-Banville, M.Sc., MBA, P.Chem., P.Eng. (NAPEG), EP
Project Manager	Neil Noble-Pattinson, B.Sc., B.A., P.Eng., PMP
Technical Project Manager	Ian Moran, B.Eng. (NAPEG), PMP
Quality Control Lead	Charles Goss, Ph.D., PMP, P.Chem
Telemetry / SCADA / Automation Team Lead	Matthew Sider, B.Eng., PMP
SCADA Designer	Kenneth Brezinski, M.Sc., CIT
Civil Engineer	Lawrence Bakelaar, P.Eng.

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EXECUTIVE SUMMARY

The purpose of the Water Loss Investigation is to identify potential sources of non-revenue water loss, assess the estimated degree of each source, and propose strategies for mitigating or eliminating them. This report, based on available data, will be used to inform the priority matrix – a Phase 2 deliverable – in accordance with the City's funding requirements through the Disaster Mitigation and Adaptation Fund.

WSP was onsite in Iqaluit during the week of July 8th, 2024. During the site visit, WSP personnel engaged with City of Iqaluit representatives and inspected several key water infrastructure sites. Through these site visits and interviews, several potential sources of non-revenue water loss were identified, per the **Figure 1** below.

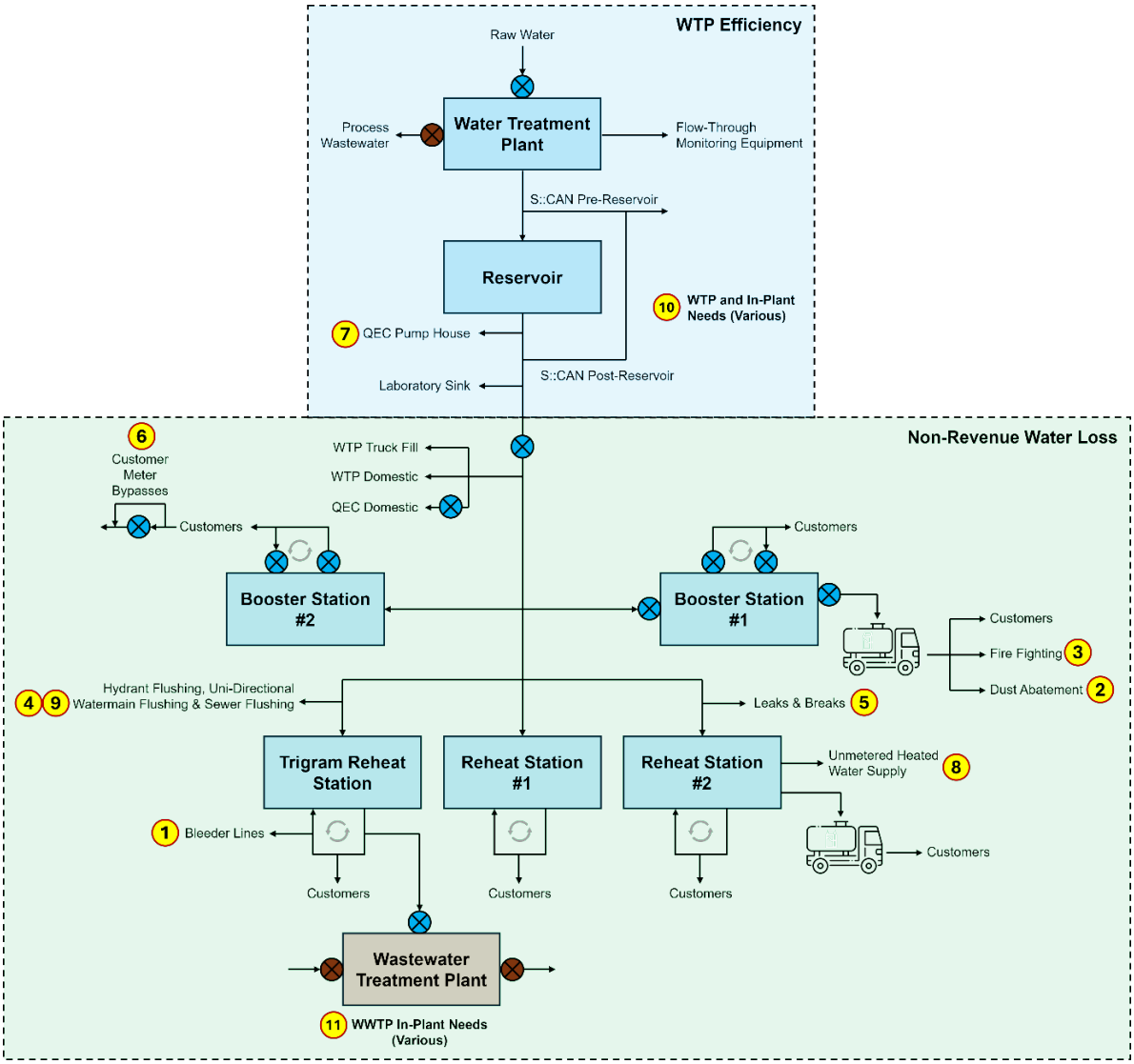

Figure 1: Simplified process flow diagram showing potential sources of non-revenue water loss.

Recommendations for accounting for, mitigating, or eliminating each source were identified and described in the Report. Priority recommendations are summarized below.

INFORMATION AND DATA GATHERING

Knowledge gaps exist for the majority of potential sources of non-revenue water losses. Addressing the following priority knowledge gaps is essential for refining the assessment of non-revenue water losses:

1. Annual quantity of water discharged for bleeder lines.
2. Average/annual quantity of water used for firefighting purposes.
3. Customer meter bypass usage.
4. QEC fire pump house metering infrastructure and water usage.
5. Estimated third-party heated water usage at Reheat Station #2.

POLICIES AND STANDARD OPERATING PROCEDURES

Several existing policies and standard operating procedures (SOPs) may limit data collection and increase the risk of non-revenue water loss. Priority recommendations include:

1. Review SOPs for dust abatement, hydrant flushing and testing, and unidirectional water main and sewer flushing to identify opportunities to reduce water usage. Review and update protocols for accounting for water usage in these activities and ensure centralized recording practices.
2. Review and update protocols for centralized recording of water used for firefighting purposes.
3. Update bylaws and implement administrative penalties for customers who operate their meter bypasses.

INFRASTRUCTURE UPGRADES

Priority recommended infrastructure upgrades include:

1. Install flow meters on all existing and future bleeder lines.
2. Install flow and pressure monitoring equipment at locations based on industry best practices.
3. Replace existing flow meters at the WTP, Booster Station #1, and Booster Station #2 to include instantaneous 4-20mA values, pulse totalizer and where possible include communications using Ethernet/IP protocol to the PLC to capture the required data.
4. If replacement of all flow meters is not possible, it is recommended to repair the faulty flow meters at Booster Station #1, add a supply flow meter at Booster Station #2, add a flow meter on all truckfills (WTP and Reheat 2) and add totalizer pulses from each flow meter to the PLC to increase accuracy.
5. Update the programming to gather the totalizing values from pulses or by using fieldbus communications for the current calculation method with the instantaneous values from the flow meters.
6. Install a flow meter at Reheat Station #2. Consider a pay-per-use system for future third-party use.
7. Install tags or tamper-resistant infrastructure on customer meter bypass lines.

1 INTRODUCTION

1.1 COMMUNITY BACKGROUND

Iqaluit is the capital of the Nunavut Territory, located at the south end of Baffin Island near the end of Frobisher Bay (63°45'N latitude and 68°31'W longitude). Access to Iqaluit is provided year-round by regularly scheduled commercial aircraft, snowmobile trails from other Baffin Island communities in the winter, and sealift from the port of Montreal and Valleyfield in the summer.

1.1.1 GEOLOGY AND TERRAIN

Iqaluit is located above the tree line and within Canada's permafrost zone. The region generally consists of glacially scoured igneous/ metamorphic terrain. In some locations, a thin layer of organic material is found.

1.1.2 CLIMATE

Iqaluit has a tundra climate typical of the Arctic region, although it is well outside the Arctic Circle. The city experiences long, cold winters and brief, cool summers. Average monthly temperatures remain below freezing for eight months of the year. The city's climate is marked by an average January temperature of -21.5°C and an average July temperature of 8°C. The annual precipitation consists of 19.2 cm of rainfall and 255.0 cm of snowfall, totaling 43.0 cm of precipitation. Prevailing winds blow from the northwest at an average speed of 16.7 km/h.

1.1.3 CITY GROWTH AND POPULATION

Iqaluit is the newest capital city in Canada, and as a result, has undergone a period of rapid development and growth. It serves as the seat of government for Nunavut Territory and hosts many federal and territorial government departments. The City is also emerging as a regional center for the territory, with various northern businesses and Inuit organizations establishing their base of operations there. According to the 2021 Census, Iqaluit's population is estimated at approximately 7,500, with an average annual growth rate between three and four percent.

1.1.4 LAND OWNERSHIP SYSTEM

Iqaluit has a unique land ownership system. The major landowners in Iqaluit are the Commissioner of Nunavut, the City, and the regional Inuit associations. These entities lease land to individuals, corporations, and government departments. The City's land is administered through a land acquisition by-law and a Territorial Statute. Generally, there is no private ownership of land.

1.2 PROJECT DESCRIPTION

1.2.1 PROJECT OBJECTIVES

Given the unreliable nature of annual precipitation for replenishing the city's sole reservoir, it is critical to establish a sustainable, long-term water source to mitigate the potential risk of future water shortages. In response, the City of Iqaluit has undertaken several projects in recent years to prepare for the further development of its raw water supply and is now seeking consulting services to advance this goal.

In line with the existing Infrastructure Canada funding agreement through the Disaster Mitigation and Adaptation Fund (DMAF), the three main goals of this Project are:

- Replace and Modernize the Existing Piped Infrastructure
- Develop a New Long-Term Water Source and Supporting Infrastructure
- Construct a New Raw Water Reservoir

WSP has been engaged by the City to provide Owner's Engineer consulting services for the *Replace and Modernize the Existing Piped Infrastructure* component of the Project. This component is broken down into the following five phases:

1. Water Model Development
2. Scope of Work Packages
3. Water Model Maintenance
4. Resiliency Study
5. Specialized Services

The Water Loss Investigation is part of the *Phase 2 Scope of Work Packages*.

1.2.2 SCOPE OF WATER LOSS INVESTIGATION

The Water Loss Investigation aims to identify potential sources of non-revenue water loss, assess the degree of each source, and propose strategies for mitigation or elimination. The findings of this investigation will inform the priority matrix, a Phase 2 deliverable, as per the City's funding requirements under the Disaster Mitigation and Adaptation Fund.

2 REVIEW OF EXISTING DATA AND DOCUMENTATION

2.1 EXISTING SYSTEM OVERVIEW

The City owns and operates the Iqaluit Public Water System (PWS) and Iqaluit Public Wastewater System (PWWS). The PWS includes water treatment and treated water distribution systems. The major PWS components are as follows:

- Water Treatment System
  - Lake Geraldine (the City's raw water source)
  - Raw Water Intake
  - Water Treatment Plant (WTP)
- Treated Water Distribution System
  - Pipes, Valves, Appurtenances, and Access Vaults (AVs)
  - Booster Station #1
  - Booster Station #2
  - Reheat Station #1
  - Reheat Station #2 (also known as Reheat Station 222)

These major PWS components are shown graphically in **Figure 2**.

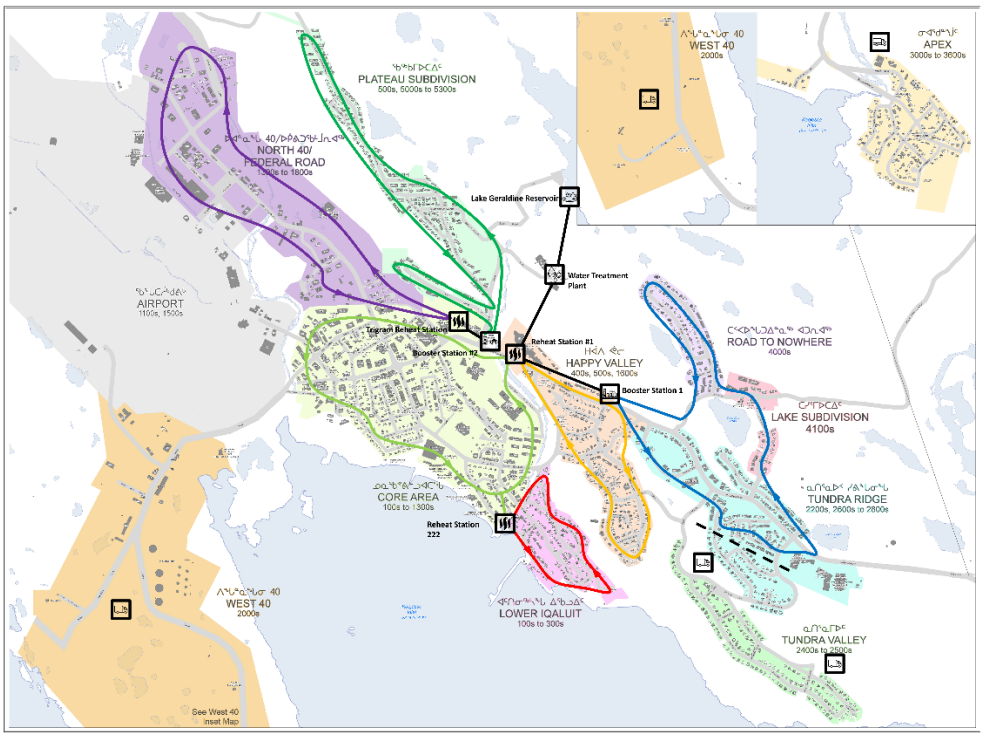

Figure 2: Major Iqaluit Public Water System Components.

Although not directly related to the scope of work, the City's PWWS is comprised of the following major components:

- Wastewater Collection System
  - Pipes, Valves, Appurtenances, and AVs
  - Lift Station #1
  - Lift Station #2
- Wastewater Treatment System
  - Wastewater Treatment Plant
  - Lagoon
  - Outfall

Most PWS and PWWS components are connected to the City's existing Supervisory Control and Data Acquisition (SCADA) system, which provides centralized monitoring and automated control over many electrical and mechanical systems (i.e., pumps, automated valves, monitoring equipment). The SCADA also includes integrated alarms that, depending on the nature and severity of the situation, can issue text or phone-based notifications to key individuals assigned to respond to these situations. When operating normally, the SCADA system automates nearly all processes, minimizing the need for operator intervention.

2.2 EXISTING FLOW MONITORING EQUIPMENT

Several flow monitoring devices are installed in the PWS and PWWS. A visual summary of their respective locations is given in **Figure 3.**

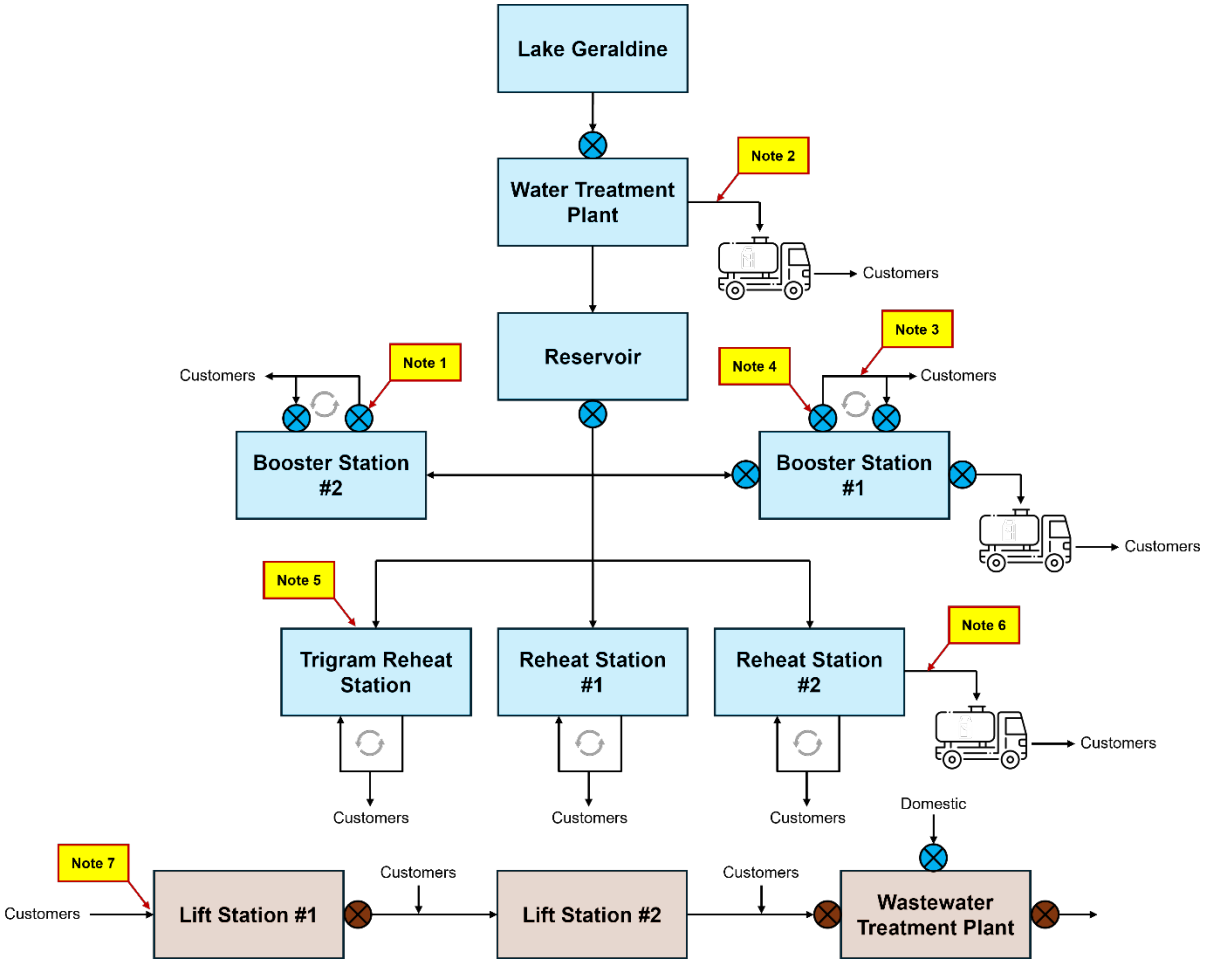

Figure 3: Existing flow monitoring devices in the Iqaluit Public Water System and Public Wastewater System.

Regarding **Figure 3,** the following points should be noted:

1. The supply-side flow meter at Booster Station #2 is located on the discharge side of the fire flow pump and on the discharge side of the main distribution pumps. The total usage is calculated by the following equation: (Discharge Flow + Fire Flow) - Return Flow. The totalization of this, however, is calculated via average from the instantaneous which lead to inaccuracy, it is best to obtain the totalized value from the flow meter using fieldbus.
2. The truck fill station at the WTP is not currently equipped with a flow meter. The City recently installed it in approximately 2022 for use in the event of downtime at the truck fill station at Booster Station #1. According to Public Works staff, the truck fill station at the WTP has not yet been used.

3. The flow meters on the recirculation side of Booster Stations #1 and #2 are located upstream of the supply-side meters (**Figure 4**). As a result, the supply-side meters are counting both water supply and recirculation. The SCADA system applies a water balance calculation to correct for this inaccuracy.

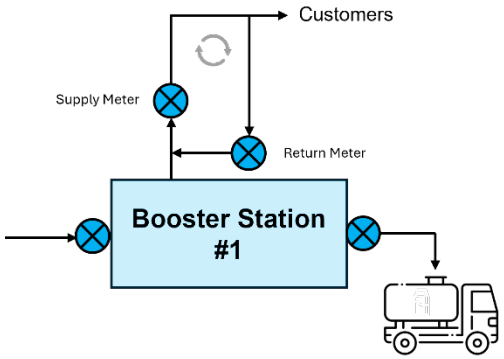

Figure 4: Flow meters installed at Booster Station #1.

4. The flow meter on the discharge side of Booster Station #1 is currently non-functional.
5. No flow meters (supply or return) are installed at the Trigram Reheat Station, Reheat Station #1, or Reheat Station #2. Although a water balance calculation (Reservoir outflow minus Booster Station #1 and Booster Station #2 supply) could theoretically determine the collective water supply to the Reheat Stations, the lack of accurate supply flow measurements at Booster Station #2 (see Note 1) makes this calculation unreliable.
6. The Reheat Station #2 truck fill line lacks a flow meter. However, the City has not operated this truck fill line recently due to its lack of safety features, which do not comply with Occupational Health and Safety (OHS) requirements. As the truck fill line is effectively obsolete, non-revenue water loss associated with it is not considered a current issue.
7. Flow monitoring equipment is absent in Lift Station # 1 (supply) and Lift Station #2 (supply & discharge). Although this is not directly related to the scope of work, installing flow monitoring equipment at these locations would improve operator visibility of system performance and allow for better assessment of localized water usage.

2.2.1 FLOW METER LOCATIONS

Industry best practices recommend installing pressure and flow monitoring equipment on the supply, discharge, and return lines of all major water & wastewater infrastructure. Therefore, it is recommended that the City install pressure and flow monitoring devices at the following locations:

- WTP Truck Fill Station
- WTP Discharge to Reservoir
- Booster Station #2 Supply

- Trigram Reheat Station Supply (this is being moved to BS2)
- Trigram Reheat Station Return (this is being moved to BS2)
- Reheat Station #1 Supply (not connection to SCADA)
- Reheat Station #1 Return (not connection to SCADA)
- Reheat Station #2 Supply (not connection to SCADA)
- Reheat Station #2 Return (not connection to SCADA)
- Reheat Station #2 Truck Fill Station (not connection to SCADA)ss
- Lift Station #1 Supply (flow only)
- Lift Station #2 Supply (flow only)
- Lift Station #2 Discharge (flow only)

The combination of pressure and flow monitoring equipment at these stations would significantly improve the visibility of system performance and reduce response times in the event of a leak or break. For example, a break occurring in Lower Iqaluit (serviced through Reheat Station #2) would currently be indistinguishable from breaks occurring in the Plateau, Federal Road, Core Area, or Happy Valley districts. Functional pressure and flow monitoring equipment at the recommended locations would narrow the search to the affected district, inform the response strategy, and reduce response times.

2.2.2 FLOW MEASUREMENTS

The existing flow meters provides an instantaneous flow value via a 4-20mA signal to the PLC. The PLC calculates the totalized volume by calculating the volume over 1 sec and adding it to a total. The estimated flow rate within this interval is estimated as follows:

$$\text{Estimated Flow Rate} = \Delta(\text{Totalized Flow}) / \Delta(\text{Time})$$

Calculating volume using flow rate no matter how little the interval will create error over time and introduces a higher degree of error against the onboard totalizer. To capture flow rates more accurately, it is recommended that the City replace its existing flow meters with flow meters that provide instantaneous flow rates using 4-20mA, pulse rate using a dry contact and a fieldbus connection (using Ethernet/IP or Modbus TCP). It is also recommended that the City utilizes the same type of flow meter so that the operators are familiar with how each one works.

2.2.3 DATA ACQUISITION AND CENTRALIZED STORAGE

Some of existing flow meters are not connected to the City's SCADA system. Consequently, collating and comparing flow rates across the City is time-consuming and requires manual data collection. Furthermore, the absence of active data upload to the SCADA system prevents real-time performance comparisons between City infrastructures. The lack of active monitoring can lead to longer response times in the event of leaks, breaks, or pressure loss events. Therefore, it is recommended that the City upgrade its flow meters to be able to connect to the local PLC's using Ethernet/IP communication

protocol. In addition, the personal water meter program can likely export a file that could be imported into the SCADA providing up to date water usage.

Similarly, it is recommended that future flow meters be equipped with proper Ethernet/IP communications protocol so the PLC can gather the totalized value directly from the flow meter (see *Flow Meter Locations* discussion above).

2.2.4 DATA GAPS AND LIMITATIONS

During the review of existing data and documentation, several knowledge gaps were identified. These gaps limit the current ability to assess certain potential sources of non-revenue water loss accurately and will need to be addressed in order to refine future recommendations. The following data gaps were identified:

Annual quantity of water discharged from bleeder lines: data on the total volume of water lost through bleeder lines is not available.

Average/annual water used for firefighting purposes: information on the amount of water used during firefighting operations is not systematically recorded.

Customer meter bypass usage: usage of customer meter bypasses is not regularly monitored, making it difficult to assess its contribution to non-revenue water loss.

QEC fire pump house metering infrastructure and water usage: Details on whether metering infrastructure is in place at the QEC fire pump house and how much water is being used are currently unknown.

Estimated third-party heated water usage at Reheat Station #2: There is no precise data on how much water is being drawn by third parties from Reheat Station #2.

These gaps will require further investigation and data collection to accurately quantify non-revenue water loss and implement appropriate mitigation strategies.

3 SITE INVESTIGATION FINDINGS

3.1 OVERVIEW

WSP was onsite in Iqaluit during the week of July 8th, 2024. The purposes of the site visit were as follows:

- Gather operational insights by engaging with the experienced staff responsible for the day-to-day management of the Public Water System (PWS).
- Identify existing system deficiencies and considerations for addressing these deficiencies.
- Identify opportunities for minimizing non-revenue water loss.
- Address outstanding queries from other phases of the OE project.

During the site visit, WSP personnel engaged with the Director of Engineering, Public Works Superintendent, Water Treatment Plant (WTP) Operator, and the City's project management representative from Colliers Project Leaders (Colliers). Key sites attended as part of the site visit include:

- Lake Geraldine
- Raw Water Intake
- WTP
- Booster Station #1
- Booster Station #2
- Reheat Station #1
- Reheat Station #2 (also known as Reheat Station 222)
- Lift Station #1
- Lift Station #2

For brevity, this report does not discuss each station in detail but focuses on findings related to potential sources of non-revenue water loss.

3.2 POTENTIAL SOURCES OF NON-REVENUE WATER LOSS

Several potential sources of non-revenue water loss were identified. These sources, in no particular order, are as follows:

- Bleeder Lines
- Dust Abatement
- Fire Fighting
- Hydrant Flushing and Testing

- Leaks and Breaks
- Meter Bypasses
- QEC Fire Pump Station
- Reheat Station #2 Unmetered Heated Water Supply
- Uni-Directional Watermain and Sewer Flushing
- WTP In-Plant and Other Needs
- WWTP In-Plant Needs

More information on each of these identified sources is provided below.

3.2.1 BLEEDER LINES

Bleeder lines are commonly installed for water stagnation prevention, air removal, temperature control, system flushing and pressure regulation. There are approximately 11 bleeder lines around the City. Their locations are summarized in **Table 1** and shown in **Figure 5**.

Table 1: Locations of bleeder lines and their attributes.

Access Vault	District	Metered?	Purpose
TAC 04	Happy Valley	Metered	To keep the sewer flowing at the airport
MH 89	Happy Valley	Unmetered	To keep the end of water main from freezing
AV 213	Federal Road / North 40	Unmetered	To keep from freezing the water main
AV 227	Happy Valley	Unmetered	To keep the loop from freezing
AV 229	Happy Valley	Unmetered	To keep the loop from freezing
AV 235	Happy Valley	Metered	End of sewer and water main
AV 239	Happy Valley	Metered	End of sewer line and water main
AV 240	Happy Valley	Metered	End of sewer line and water main
AV 271	Federal Road / North 40	Unknown	To prevent freezing water main
AV 523	Tundra Ridge	Metered	For sewer main to prevent freezing
AV 629	Plateau	Metered	End of sewer Main to prevent freezing

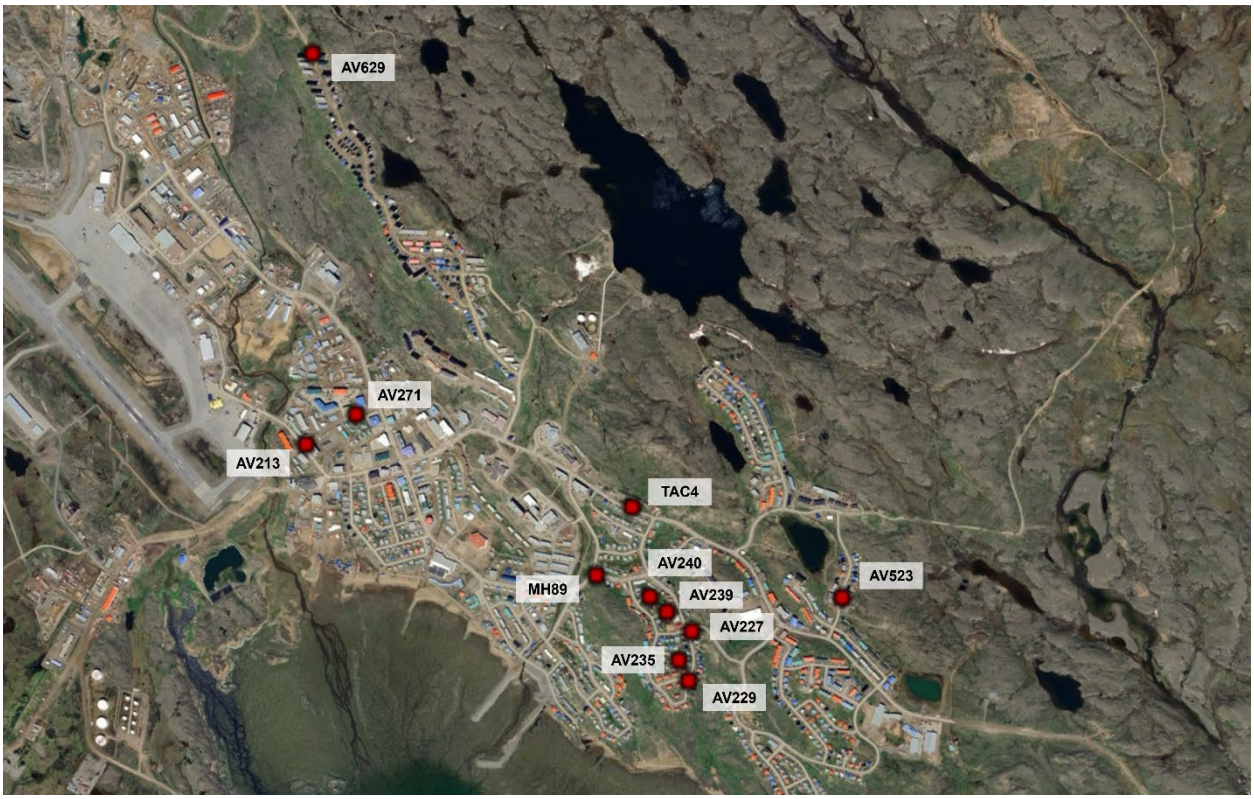

Figure 5: Locations of existing bleeder lines in Iqaluit.

In Happy Valley, several bleeder lines located in cul-de-sacs or at dead ends have been identified as potential risks due to undersized return lines, which have historically contributed to leaks and breaks. In response to this, the City installed bleeder lines to mitigate this risk.

Although some of the above AVs are equipped with meters, it is not standard practice for Public Works personnel to collect and record meter data.

To better assess and address potential non-revenue water loss from bleeder lines, WSP recommends the following:

- Install meters on bleeder lines that currently lack meters.
- Review existing SOPs to identify opportunities to limit bleeder line usage (i.e., seasonal/temperature thresholds).
- Investigate opportunities to eliminate bleeder lines, such as upgrading return piping in Happy Valley cul-de-sacs.
- Review and update protocols for meter reading and data recording.

3.2.2 DUST ABATEMENT

The City uses water to mitigate dust on dirt and gravel roads. Depending on weather conditions, a single watering can be effective for hours or days. Industry best practices suggest regular, light watering as more efficient than less frequent, heavy watering.

WSP recommends the following for dust abatement:

- Review SOPs to identify opportunities to reduce water usage (i.e., prevent over-application).
- Update protocols for meter reading and centralized data recording.

3.2.3 FIRE FIGHTING

Approximately 5-7 fires occur per month in Iqaluit. Water is either drawn from hydrants (typical of communities on piped service) or delivered by water trucks (typical of communities on truck services). Public Works personnel noted that the amount of water drawn for fire fighting purposes is not recorded, and water used for training purposes is also not tracked.

According to Public Works personnel, the fire trucks are equipped with flow monitoring equipment, however the amount of water drawn for fire fighting purposes is not recorded. For the supply of water from trucked services for a fire event, it is not understood to be recorded by Public Works personnel. Although this water is indirectly 'recorded' by the Booster Station #1 truck fill meter, it may be difficult to accurately differentiate between customer usage and other municipal purposes.

In light of this, WSP recommends:

- Review and update protocols for meter reading and centralized data recording for the Fire Department (including training) and trucked services.
- Explore opportunities to extend hydrant coverage, such as extending the piped distribution system to customers currently supplied by trucked services.

3.2.4 HYDRANT FLUSHING AND TESTING

Hydrant flushing and testing has historically been performed on an irregular basis, without clear SOPs for documenting water usage. According to Public Works personnel, a formal annual program is planned to begin in 2024. WSP recommends that:

- Newly create or updated SOPs include documentation of water usage during hydrant flushing and testing.
- Opportunities for optimizing water usage during hydrant flushing and testing are investigated and implemented.

3.2.5 LEAKS AND BREAKS

Leaks and breaks can vary in severity but contribute significantly to non-revenue water loss. The amount of non-revenue water loss is a function of the severity of the leak or break and the time required to respond to it. Major breaks can release a significant amount of water in short period of time and are likely to be responded more quickly. However, small leaks can remain undetected for extended periods, and in the long run, can be just as impactful as major breaks. Further to this, prolonged system downtime limits the ability to generate revenue from the supply of water to customers.

Public Works personnel noted that most leaks and breaks occur in older parts of the City, with pipes made from obsolete materials (e.g. ductile iron, asbestos cement) or high age. Ground shifting also contributes to breaks, particularly around pipe saddles near access vaults.

WSP recommends the following:

- Install pressure and flow monitoring equipment at strategic locations to identify leaks or breaks during pressure loss events (see **Section 2.2**).
- Replace obsolete and aged piping with modern piped infrastructure. The City could also consider installing flexible couplings to better accommodate ground shifting.
- Review and update existing leak and break response protocols to reduce response times.

3.2.6 METER BYPASSES

Meter bypasses, installed in every customer connection, allow unmetered flow of water to the customer during meter servicing. However, they lack tamper-resistant features, and it is possible that some customers use bypasses without detection. Furthermore, there is no current City bylaw or administrative penalty for consumers.

To address this gap, WSP recommends the following actions:

- Create and execute a program to assess meter bypass usage.
- Retrofit tags or tamper-resistant devices on existing bypasses.
- Enact a City bylaw and corresponding administrative penalties for illegal bypass use.

3.2.7 QEC FIRE PUMP STATION

Qulliq Energy Corporation (QEC) owns and operates a fire pump house next to the reservoir (**Figure 6**). Accounts from previous City personnel suggest that QEC's construction of the pump house in the early 2010s was in response to the absence of fire protection, which was removed from the WTP in approximately 1995.

Figure 6: Qulliq Energy Corporation fire pump house adjacent to Iqaluit Water Treatment Plant detached Treated Water Reservoir.

In reviewing historical photos of the fire pump house and its connection to the City's treated water supply, it is suspected that this connection is unmetered. It is important to note that the connection point to the City's infrastructure is located downstream of the reservoir, but before the meter (**Figure 7**). In light of this, QEC's treated water usage through the fire pump house would not be compared to distribution system non-revenue water loss (which compares water at and after the reservoir meter) but rather to the efficiency of the WTP in converting raw water to treated water.

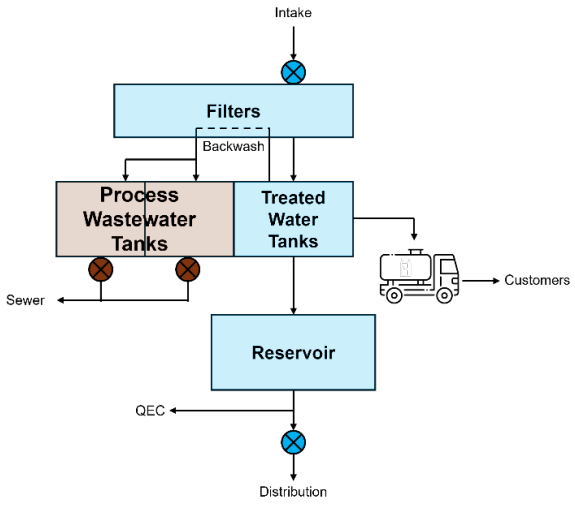

Figure 7: Water Treatment Plant process flow and metering diagram.

In light of this, WSP recommends:

- Request further information from QEC regarding metering and usage records.

3.2.8 REHEAT STATION #2 UNMETERED HEATED WATER SUPPLY

Historically, contractors had keyed access to an unmetered heated water supply at Reheat Station #2 (**Figure 8**). In its earliest stages of contractor usage, the 'honour system' was implemented, where contractors were encouraged to log their estimated water draw on a clipboard form available next to the water supply. However, contractors did not use this clipboard form as intended, which led to indeterminate non-revenue water loss associated with its use, prompting Public Works to restrict access to Reheat Station #2. This prompted several assumed break-ins for access to the unmetered heated water supply.

Figure 8: Unmetered heated water supply in Reheat Station #2.

The City has expressed their discontent with further allowing third parties (contractors or otherwise) to utilize the unmetered heated water supply in Reheat Station #2 without prior consent and expressed interest in a metered pay-per-use system.

With respect to the unmetered heated water supply at Reheat Station #2, WSP recommends to the City the following:

- Effectively communicating with third parties the City's interest in no longer providing unrestricted access to the heated water supply and upgrading site security measures accordingly.
- Install water meters at the supply points.

- Consider installing a pay-per-use metered system at the preferred supply point. It is recommended that the supply point be the currently unused truck fill arm, and contractors operate it at their own risk.

3.2.9 UNI-DIRECTIONAL WATERMAIN & SEWER FLUSHING

Historically, unidirectional watermain and sewer flushing have been performed informally and on an irregular basis. It is unclear whether SOPs exist and, if so, whether they include processes for documenting and recording non-revenue water usage. According to Public Works personnel, a formal uni-directional watermain and sewer flushing program is to commence in 2024 and will be formalized as an annual activity. In light of this, WSP recommended the following:

- Newly created or updated SOPs include processes for documenting and recording water usage.
- Opportunities for optimizing water usage during uni-directional watermain and sewer flushing should be investigated and implemented.

3.2.10 WTP IN-PLANT AND OTHER NEEDS

The WTP utilizes treated water for several in-plant processes. The process that consumes the highest volume of treated water is the backwashing operation for the filters, which includes both backwash and filter-to-waste sequences. During the backwash sequence, high volumes of treated water are pushed backwards through the filters to fluidize the filter media and remove particulate matter. The backwash water is discharged to the Backwash Waste Tank and subsequently to the City sewer system.

Following the backwash, a filter-to-waste sequence is operated, in which raw water is moved forward through the filter to rinse the filter media before it is returned to service. The filter-to-waste water is stored in the Filter-to-Waste Tank (also known as the Surge Tank) before being discharged to the City sewer. Both the Backwash Waste Tank and Filter-to-Waste Tank discharge outlets have orifice plates that restrict flow to the sewer to prevent surging, and both outlets are metered, however those flow rates are instantaneous and thus the same recommendation of replacing the flow meters to provide instantaneous, pulse and fieldbus communication (**Figure 7**).

The WTP also uses treated water for various domestic purposes, including toilets, sinks, faucets, and hoses. Additionally, some of the water monitoring equipment operates with a flow-through cell that draws and discharges small volumes of water on a continuous basis. The treated water supply line for QEC is connected to the domestic water supply line to the WTP. Although the QEC water supply line is metered, it is unclear whether the meter data is regularly recorded. It is recommended that both the WTP domestic water and the QEC Water flow meters be replaced and connected to the PLC.

There are several different connection points for the supply of treated water to the WTP and QEC for their various purposes, and understanding the locations of these connection points is important for assessing non-revenue water loss. These connection points are shown in **Figure 9**.

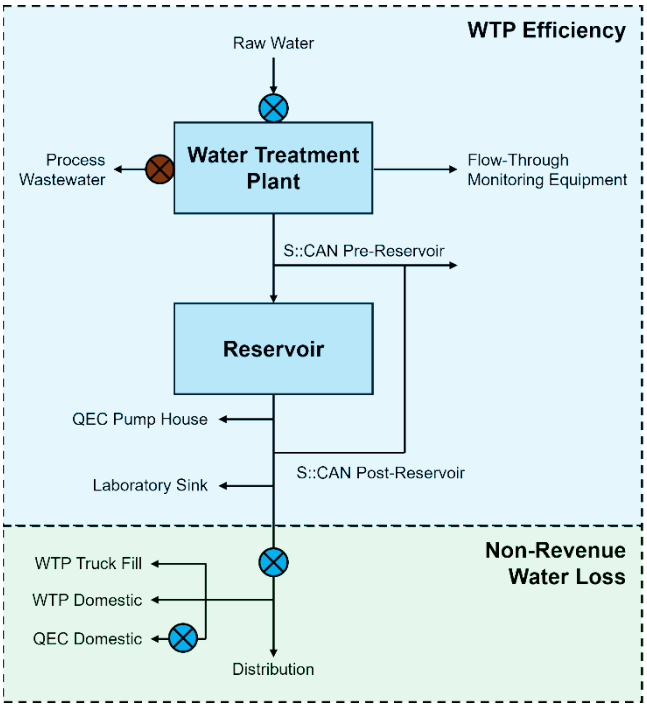

Figure 9: Connection points for treated water at the Water Treatment Plant and Reservoir.

As outlined in Section 3.2.7, two key performance indicators (KPIs) are essential when assessing water loss.

- The efficiency of the WTP in converting raw water into treated water (upstream of the post-reservoir flow meter).
- The non-revenue water loss (downstream of the post-reservoir flow meter), which is the primary focus of this investigation.

Although only the non-revenue water loss KPI is within the scope of this investigation, both KPIs are crucial for identifying opportunities to reduce the volume of raw water drawn from Lake Geraldine, an indirect driver of the overall project.

The truck fill at the WTP, installed in 2022 as a backup for the truck fill station at Booster Station #1, is not metered and could potentially contribute to non-revenue water loss, as shown in Figure 9, However, Public Works staff indicated that the truck fill at the WTP has not yet been used, so it has not contributed to historical non-revenue water loss.

WSP recommends the following to the City regarding WTP in-plant and other needs:

- Consider installing a meter on the domestic supply header to the WTP and QEC to improve visibility on non-revenue water losses from these sources.

3.2.11 WWTP IN-PLANT NEEDS

Similarly, the WWTP uses treated water for in-plant needs, including washing, cleaning, flushing, and other domestic purposes. A detailed review of all water uses at the WWTP is beyond the scope of this investigation.

A meter is installed on the supply line to the WWTP, but it is unclear whether meter readings are collected in a manner consistent with those for typical customer connections. In light of this, WSP recommends the following:

- Confirm the meter reading procedures at the WWTP and ensure centralized data storage for the readings.

3.3 SITE INVESTIGATION SUMMARY

Several potential sources of water loss were identified, including:

- Non-revenue water loss, which compares metered water usage to water entering the distribution system (the focus of this investigation), and
- WTP efficiency, which measures the plant's net efficiency in converting raw water to treated water (outside the scope of this investigation).

A visual summary of all potential sources of water loss is given in **Figure 10**. Based on these findings, the next section prioritizes recommendations for immediate action.

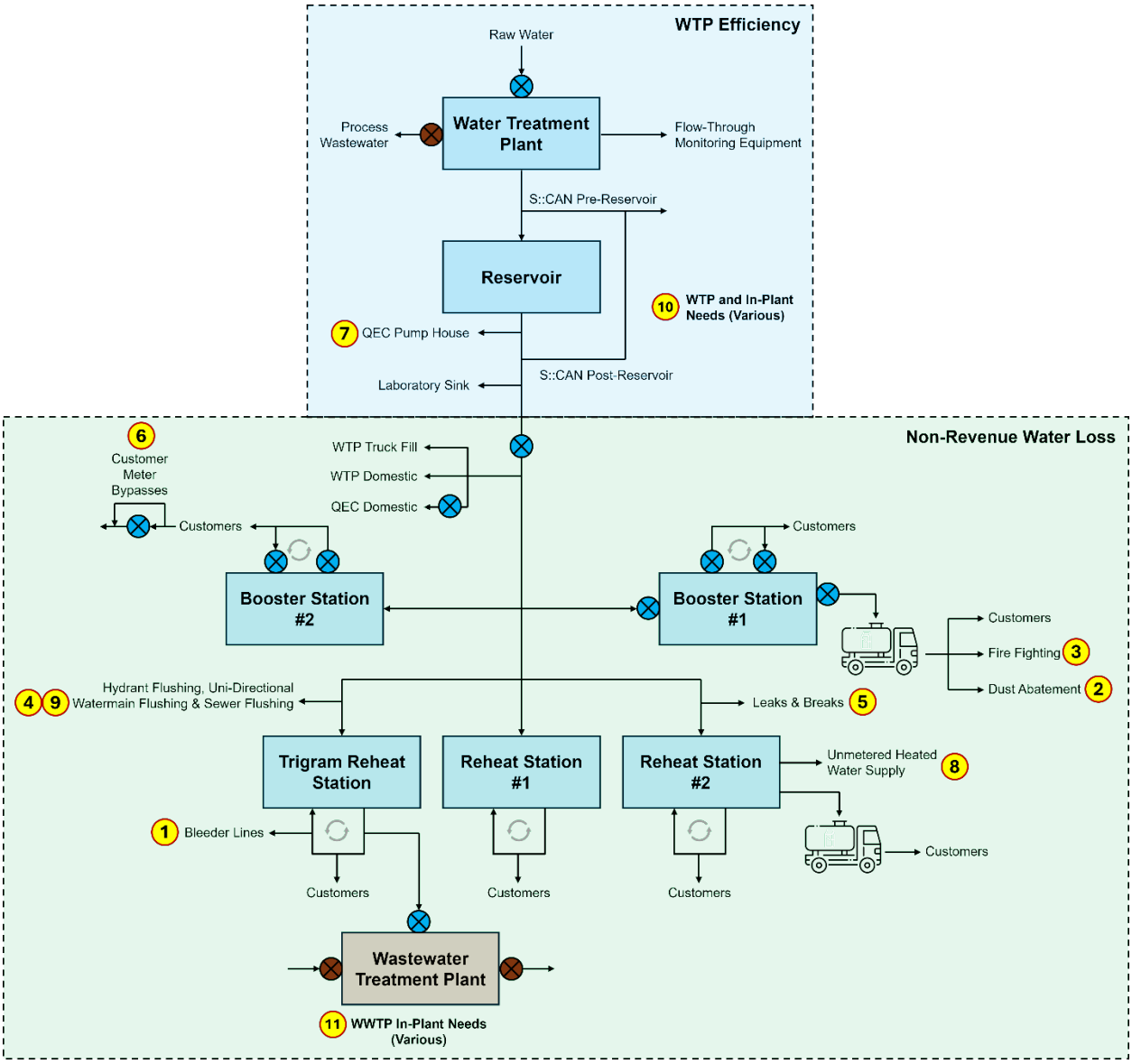

Figure 10: Simplified process flow diagram showing potential sources of non-revenue water loss.

4 ASSESSMENT AND RECOMMENDATIONS

Pending further investigations or the receipt of additional information, the estimated relative degree of each of potential source of non-revenue water loss is provided in **Table 2**, along with corresponding recommendations where supporting information is limited.

Table 2: Relative estimated degree of potential sources of non-revenue water loss.

No.	Potential Source	Relative Estimated Degree	Recommendations
1	Bleeder Lines	Moderate	➢ Install meters on the bleeder lines that are not currently equipped with meters. ➢ Review existing SOPs to identify opportunities to limit bleeder line usage (i.e., seasonal/temperature thresholds). ➢ Identify and take advantage of opportunities to eliminate bleeder lines. Upgrading the return piping in the Happy Valley cul-de-sacs may be one of such opportunities. ➢ Review and update protocols for meter reading and centralized recording practices.
2	Dust Abatement	Low	➢ Review SOPs to identify opportunities to reduce water usage (i.e., preventing over-application). ➢ Review and update protocols for meter reading and centralized recording practices.
3	Fire Fighting	Medium to High	➢ Review and update protocols for meter reading and centralized recording practices for the Fire Department (including training) and trucked services. ➢ Explore opportunities to increase hydrant coverage, including expanding the piped distribution system to customers currently who are currently dependant on trucked services for water.
4	Hydrant Flushing and Testing	Low	➢ Newly created or updated SOPs include descriptions for documenting and recording water usage.

No.	Potential Source	Relative Estimated Degree	Recommendations
			➢ Opportunities for optimizing water usage during hydrant flushing and testing are investigated and implemented.
5	Leaks and Breaks	Moderate to High	➢ Install pressure and flow monitoring equipment at strategic locations throughout the City to better inform the location of a leak or break during a pressure loss event (see **Section 2.2**). ➢ To mitigate the risk and severity of leaks and breaks, obsolete pipe material and aged piping should be replaced with modern piped infrastructure (this is addressed, in part, by the Long-Term Water Project). The City could also consider installing flex couplings to better account for ground shifting. ➢ Review existing leak and break response protocols to identify opportunities for reducing response times.
6	Meter Bypasses	Low to High	➢ Create and execute a program to assess (directly or indirectly) the frequency and severity of customer meter bypass usage. ➢ Retrofit tags and/or tamper-resistant equipment on existing meter bypasses and install new meters with equivalent equipment. ➢ Enact a City bylaw and corresponding administrative penalty for customers that illegally operate their meter bypass.
7	QEC Fire Pump Station	Unknown	➢ Request further information from QEC regarding potential metering infrastructure and usage records. Actionable follow-ups are dependent on this information or its availability thereof.
8	Reheat Station #2 Unmetered Heated Water Supply	Low to Moderate	➢ Effectively communicating with third parties the City's interest in no longer providing unrestricted access to the heated water supply and upgrading site security measures accordingly. ➢ Install water meters at the supply point(s). ➢ Consider installing a metered pay-per-use system at the preferred supply point. It is

No.	Potential Source	Relative Estimated Degree	Recommendations
			recommended that the supply point be the currently unused truck fill arm, and contractors operate it at their own risk.
9	Uni-Directional Watermain and Sewer Flushing	Low to Moderate	➢ Newly created or updated SOPs include descriptions for documenting and recording water usage. ➢ Opportunities for optimizing water usage for uni-directional watermain and sewer flushing are investigated and implemented.
10	WTP In-Plant and Other Needs	Low	➢ Consider installing a meter on the domestic supply header to the WTP/QEC to provide visibility on non-revenue water losses from these sources.
11	WWTP In-Plant Needs	Moderate	➢ Confirm meter reading procedures at the WWTP and corresponding centralized data storage.

4.1 PRIORITY RECOMMENDATIONS

Priority recommendations for addressing non-revenue water loss are summarized below.

4.1.1 INFORMATION AND DATA GATHERING

Several knowledge gaps must be addressed to improve understanding of potential non-revenue water losses. The Priority gaps include:

1. Annual quantity of water discharged for bleeder lines.
2. Average/annual quantity of water used for firefighting purposes.
3. Customer meter bypass usage.
4. QEC fire pump house metering infrastructure and water usage.
5. Estimated third-party heated water usage at Reheat Station #2.

4.1.2 POLICIES AND STANDARD OPERATING PROCEDURES

Several policies or SOPs may hinder data collection or increase the risk of ongoing non-revenue water loss. Priority recommendations include:

1. Review SOPs for dust abatement, hydrant flushing and testing, and unidirectional water main and sewer flushing. Identify opportunities to reduce water usage, and update protocols for accounting for respective water usage and centralized recording practices.
2. Review and update protocols for the centralized recording of water used for firefighting purposes.
3. Update bylaws and establish administrative penalties for customers who operate their meter bypasses.

4.1.3 INFRASTRUCTURE UPGRADES

Targeted infrastructure upgrades will improve system performance visibility and understanding of water flow. Priority upgrades include:

1. Install flow meters on all existing and future bleeder lines.
2. Install flow and pressure monitoring equipment at industry-standard locations (as described in **Section 2.2**).
3. Repair and calibrate existing faulty flow meters. Specifically, for the flow meter at Booster Station #2, either relocate the meter or modify system operations to obtain accurate flow data.
4. Replace existing totalizing flow meters with instantaneous flow meters.
5. Upgrade Ethernet and ICPs to improve the centralized storage of flow meter data.
6. Install a flow meter at Reheat Station #2 and consider a pay-per-use system for future third-party use.
7. Install tamper-resistant infrastructure or tags on customer meter bypass lines.