Water Use and Water Loss Third-Party Review

Final Report

City of Calgary

60737116

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Prepared for:

City of Calgary
Mandy Lim, P.Eng
Utilities Project Development - Water

Prepared by:

AECOM Canada Ltd.
48 Quarry Park Boulevard SE
Suite 300
Calgary AB, T2C 5P2
Canada

T: 403.254.3301
F: 403.351.1678

aecom.com

Quality information

Prepared by	Engineer of Record / Reviewer	Verified by
	PROFESSIONAL ENGINEER ALBERTA GORDON GEOFFREY ID 47061 03 February 2025	
Melissa LeRose, P.Eng. Project Engineer	Gordon Geoffrey, P.Eng. Senior Project Engineer	Nancy Hill, P.Eng., IAM Cert. Senior Project Engineer

PERMIT TO PRACTICE
AECOM CANADA ULC

RM SIGNATURE: ____

RM APEGA ID #: 86360

DATE: 03 February 2025

PERMIT NUMBER: P010450
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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Executive Summary

AECOM was retained by the City of Calgary (The City) to support a third-party review of water use and water loss reporting and management practices. Reviewing water use and water loss is essential for ensuring sustainable water management. Proper management practices can help mitigate water scarcity issues, optimize water resources, enhance water conservation efforts, and defer new capital infrastructure.

As part of this report, a review was completed of several sources which cover topics related to water use and water loss. The following sources of literature were reviewed:

- American Water Works Association (AWWA) M36 Water Audits and Loss Control Programs
- International Water Association
- Alberta Water and Wastewater Operators Association (AWWOA)
- Canadian Water & Wastewater Association (CWWA)

To be able to better understand how The City's water use and water loss reporting and management practices compared to other municipalities, a list of comparable municipalities was determined. Different factors, such as size of the municipality, average water consumption, geotechnical conditions, and types of watermain were used to determine if a municipality was comparable to The City. With the list finalized, a survey was developed and administered to the selected municipalities. A summary of the survey results can be found in Section 5 of this report, with observations found in Section 6.

During the review of the survey responses, key observations were made and are summarized below.

- In regards to water use forecasting, The City's ADD (Average Day Demand) and MDD (Maximum Day Demand) values that they use for water use forecasting are comparable with the group average. The City uses an ADD value of 350 L/cap/day (survey respondents' average was 333 L/cap/day) and a MDD value of 585 L/cap/day (survey respondents' average was 593 L/cap/day). The City updates these values every 5-10 years, similar to other municipalities. They forecast out to the year 2076 to ensure that long-term infrastructure requirements are included. Five of the participating municipalities use different future ADD/MDD values for new development/greenfield and established areas, whereas The City currently does not. The five municipalities rely on historical data to establish ADD/MDD values in existing areas and rely on the municipality's design standards for ADD/MDD values in newly developed/greenfield areas.
- For water consumption, the survey data did not show a clear relationship between a municipality's system age and its water consumption. Municipalities with more pipe installed between 1950-1975, which has shown to be more susceptible to breaks and leaks, did not necessarily have higher annual consumption rates. Similarly, the data did not show a direct link between pipe material and real losses. Municipalities with higher percentages of cast iron, ductile iron, and asbestos cement pipe did not necessarily have higher losses. This indicates that there are more reasons for a municipality to have high consumption rates and real losses than the age and material of its system.
- The City, along with other municipalities, have seen their water loss increase slightly. Therefore, an increase in water loss is not specific to The City but is also experienced by other municipalities in North America.
- Most municipalities noted service connections as a significant source of water loss. Service connections typically have a publicly owned portion (responsibility of the municipality) and a privately owned portion (responsibility of the property owner). A municipality can perform maintenance and upgrades to the public portion, but it is more challenging to properly manage

any potential water loss on the private side as that will be the property owner's responsibility. It is also worth noting that service connections typically have a shorter service life, on average, than watermains, therefore as a system ages, it is likely that service connections will leak/fail before a watermain.

- The City, along with other municipalities, has a proactive leak detection program. The survey data did not show a clear correlation between having a leak detection program and the percent of real losses. It was shown that some municipalities with no leak detection program had similar losses to those with a leak detection program.
- The City is in line with the group median in regards to number of service connection breaks per total number of service connections and number of watermain breaks per kilometer length of system.

Based off the survey results, common water loss management practices in which The City already engages are quantifying water loss, corrosion protection, district metering and leak detection. Water loss practices conducted by other municipalities that The City may want to consider include more valve cycling, metering water usage from contractor activities such as flushing and commissioning, more proactive copper service replacements, hydrant flow/pressure monitoring, further transmission main inspection and replacement, more expansive leak detection, watermain relining, advance metering infrastructure (AMI), advanced system pressure and flow monitoring, contractor education, resident education and revised water consumption rates.

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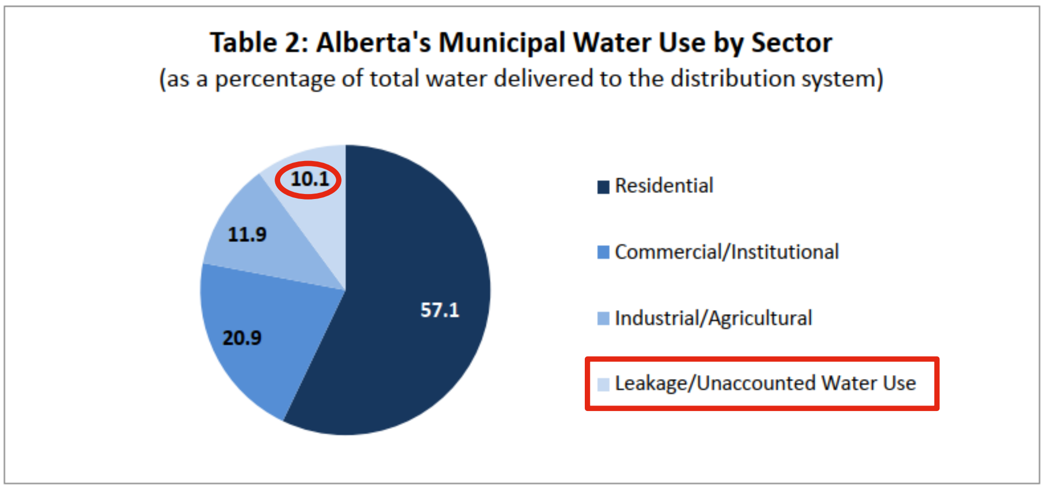
1. Background Review

AECOM was retained by The City to support a third-party review of water use and water loss reporting and management practices. As part of this review, AECOM prepared a summary of background information and literature review of sources related to water use/water loss.

Water conservation has been topic of concern in Alberta for many years. As Alberta's population grows, water continues to be a scarce resource in the province due to limited availability, climate change and costs of maintaining aging water infrastructure. Over the past 20 years, the Government of Alberta has emphasized the importance of water conservation, with a key focus on urban municipalities. Figure 1-1 below shows the distribution of Alberta's municipal water use in 2009, indicating that leakage/unaccounted water use made up approximately 10% of the total water use[1].



Source – Environment Canada Municipal Water and Wastewater Survey (2009)

Figure 1-1: Alberta's Municipal Water Use by Sector in 2009

A 2014 target set out by the Alberta Urban Municipalities Association (AUMA) was to have water loss account for less than 10% of total water use. In 2021, Calgary's water loss was reported to be at 22% [2].

A common cause of water loss in a municipality's water distribution system is pipe degradation because of corrosion, with the most affected pipe materials being cementitious-ferrous metal-based pipes and ferrous metal pipes. Examples of cementitious-ferrous metal-based pipes include prestressed concrete cylinder pipe (PCCP), reinforced concrete cylinder pipe (RCCP), bar-wrapped cylinder pipe and reinforced concrete pipe (RCP). Examples of ferrous metal pipes include ductile iron (DI), cast iron (CI) and steel pipes.

The primary contributing mechanism for failure of CI, DI and steel (i.e. ferrous materials) pipes is overwhelmingly related to corrosion. Corrosion can occur in many different forms in terms of either generalized or localized corrosion processes, with localized corrosion being far more prevalent in water

[1] *(Alberta Urban Municipalities Association Board of Directors, 2014)*
[2] *(Water Canada, 2024)*

distribution systems than generalized corrosion processes. Corrosion is not a diameter sensitive issue; it is a material loss issue and eventually affects all pipes, regardless of size.

To slow the effects of corrosion on pipes, cathodic protection can be used to help protect materials from exposure. Cathodic protection was introduced in the 1970's and has played a prominent role in failure mitigation for post-1950 CI and DI pipes in numerous municipalities across North America.

The concept of cathodic protection is not to completely stop the corrosion, but to manage it. When applying cathodic protection, corrosion is simply redirected from the pipe to a predetermined anode. The quantity of corrosion activity remaining at the pipe is dependent on the voltage (polarization) level of the pipe and the current condition or timing within the deterioration cycle of the pipe. Cathodic protection does not replace lost mass and can have limited effectiveness in areas with reduced or limited pathways for electrical current to flow.

Several Canadian cities have demonstrated massive reductions in failures using anode retrofit techniques. Numerous case studies have shown that cathodic protection programs varying from purely opportunistic programs (e.g. installing anodes at failure repairs) to comprehensive cathodic protection have markedly reduced future failure rates.

1.1 Literature Review

The following sources which cover topics related to water use and water loss were reviewed.

- American Water Works Association (AWWA) M36 Water Audits and Loss Control Programs [3]
- International Water Association [4]
- Alberta Water and Wastewater Operators Association (AWWOA) [5]
- Canadian Water & Wastewater Association (CWWA) [6]

The AWWA M36 Water Audits and Loss Control Programs is a manual focused on accountability and efficiency of water management supplies by utilities. The manual describes the AWWA water audit methodology and provides an overview of techniques to control water loss for future sustainability.

The International Water Association outlines a variety of indicators to track real losses/leakage including but not limited to volume per year, litres per service connection or billed property per day and m^3/km of mains. These specific three indicators are starting to become increasingly accepted worldwide as volumetric performance indicators for target setting and progress tracking with the infrastructure leakage index (ILI) being used for technical performance comparisons between systems.

AWWOA and CWWA were reviewed however no information regarding water use and water loss was found at the time of this literature review.

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[3] *(American Water Works Association, 2016)*
[4] *(Internation Water Association, 2017)*
[5] *(AWWOA, 2024)*
[6] *(Canadian Water & Wastewater Association, 2019)*

2. Selected Municipalities

The municipalities who were selected to participate in the survey were based on two items:

- Factors that made them comparable to the City of Calgary
- Calgary's Regional Potable Water Customers

The following factors were used to identify municipalities that may have similar water loss issues as the City of Calgary:

- Types of watermain (e.g. era and pipe material)
- Average water consumption
- Presence of corrosive soils
- Size of system
- Extent of water metering
- Amount of water loss (e.g. ILI)
- Leak detection program

As a result, the following municipalities were selected to participate in the survey:

- City of Burnaby
- City of Edmonton (EPCOR)
- Halifax Regional Municipality
- City of Hamilton
- City of Lethbridge
- City of Red Deer
- City of Regina
- City of Saskatoon
- City of Surrey
- City of Winnipeg
- City of Denver, Colorado

In addition to the municipalities selected based on comparable factors to the City of Calgary, the following regional potable water customers of Calgary were also selected to participate:

- City of Airdrie
- City of Chestermere
- Town of Cochrane
- Town of Strathmore
- Tsuut'ina Nation

3. Survey

3.1 Survey Topics

AECOM, with feedback from The City, developed a survey to be issued to the selected participants. The survey topics include:

- Water Use Forecasting
- Water Loss Management
- Basic Water Distribution System Information
- Customer Billing
- Environmental Considerations

3.2 Finalized Survey

The finalized survey can be found in Appendix A.

4. Survey Results

The following section summarizes the results of each question in the survey, with observations provided in Section 6. Please note that Question 1 asked for each participant to provide their contact information and is not included in the results.

The data of the municipalities who participated in the survey is anonymized and are each given a letter (e.g. Municipality A, Municipality B, etc.). This was done to encourage participation in the survey by alleviating any concerns that a municipality's data would be made public by others (e.g., where they aren't controlling the messaging or the audience). For each of the graphs shown below, letters A through P each represent a different municipality. If a letter is not shown, that municipality did not provide enough data to answer that question.

4.1 Question 2: Have you forecast your future water use for the purpose of large infrastructure planning?

- 100% of participants answered "yes" to this question.

4.2 Question 3: Do you use different water use rates for MDD and/or ADD in newly built/greenfield areas vs. older/more established areas for planning required infrastructure?

Table 4-1 illustrates which municipalities confirmed if they use different water rates for maximum day demand (MDD) and/or average day demand (ADD) in newly built/greenfield areas vs. older/more established areas for infrastructure planning purposes.

Table 4-1 Do You Use Different ADD/MDD Values for Older and Newer Areas

	City of Calgary	A	B	C	D	E	F	G	J	K	L	M	N	O	P
Yes					✓	✓	✓			✓		✓			
No	✓	✓	✓	✓				✓	✓		✓		✓	✓	✓

- The City, along with 9 other municipalities do not use different water use rates for ADD/MDD in newly built areas in comparison to more established areas.

For those who answered "yes", below is a summary of what they do:

- Municipality D: The municipality's design guidelines provide ADD/MDD values for developers for greenfield areas. For greenfield areas with unique requirements, the municipality creates a comprehensive estimate of demands by combining residential and ICI (Industrial, Commercial, Institutional) data from existing areas. This estimate is then applied to undeveloped lands to project future ADD. In cases where more detailed servicing is available, such as inner-city growth projections, the municipality may adjust the ADD/MDD values specified in the design guidelines to develop a more accurate and tailored ADD based on system knowledge.
- Municipality E: Future use in existing areas is based on existing recorded use. Additional future use from densification within existing areas is applied at the same use rate as greenfield areas.

- Municipality F: Water billing data and SCADA (Supervisory Control and Data Acquisition) data are used for existing developed areas and city demand rates for greenfield areas.
- Municipality K: For new/future development areas, theoretical ADD/MDD/PHD (Peak Hour Demand) is used. For existing/established areas, available metered information is used to establish the average consumption for different types of use (single family, townhouse, etc.) with the assumption that the average numbers will stay more or less the same in the future.
- Municipality M: The peaking factor (i.e., ratio of ADD to MDD) is dependent on the characteristics of the zone.

4.3 Question 4: What residential and ICI values do you use for future water use forecasting (e.g. MDD and ADD liters per capita per day)?

Figure 4-1 illustrates the residential and ICI values each municipality uses for future water use forecasting.

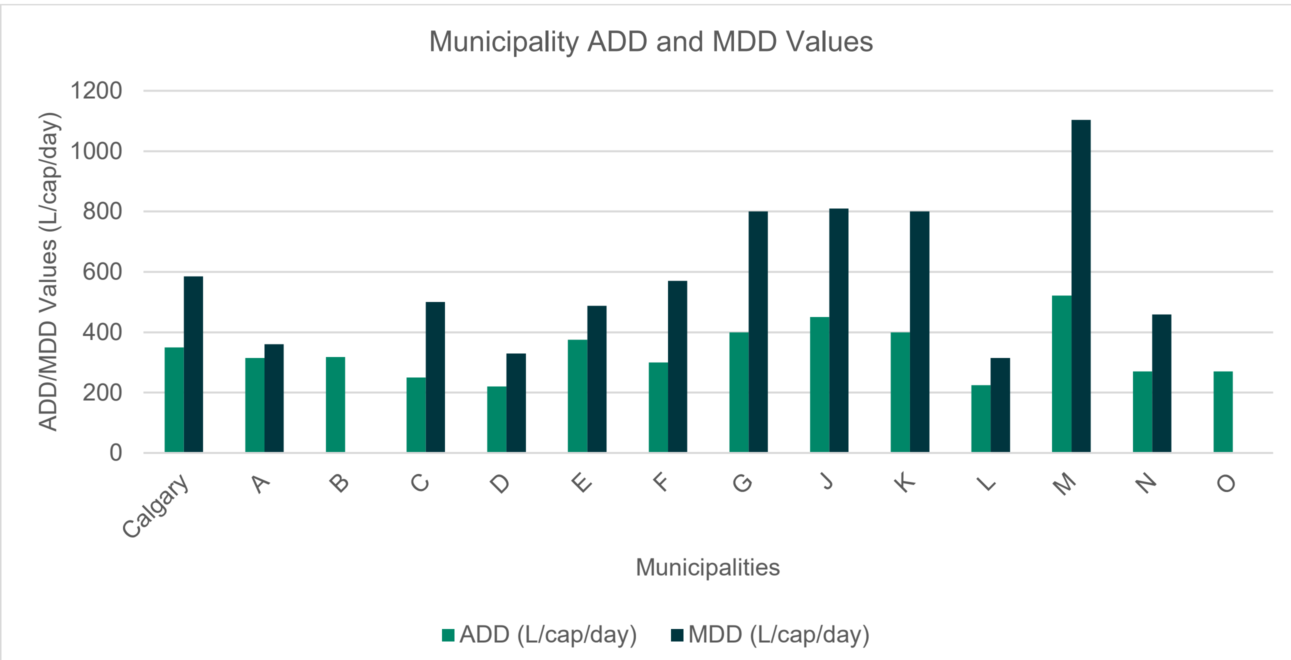

Figure 4-1: Municipality ADD and MDD Values

- The City of Calgary noted an ADD value of 350 L/cap/day and a MDD value of 585 L/cap/day.
- The average ADD value for the group is 333 L/cap/day and the average MDD value for the group is 593L/cap/day.

4.4 Question 5: How were the values of MDD and ADD determined (e.g. based on historical data or anticipated future rates)? How often do you update them and how far into the future do you project your water use?

Table 4-2 illustrates how each of the ADD/MDD values were determined.

Table 4-2 How Were ADD/MDD Values Determined

	City of Calgary	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P
Historical	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	
Anticipated Future Rates									✓			✓				✓

- The City of Calgary uses recent historical data from plant production and census data to determine MDD and ADD values. The values are revisited every 5 years and are forecasted out to 2076.
- Municipality A, B, D, E, F, J, and N update their values every 5-10 years.
- Municipality C updates their values every 2-3 years and projects it out 25 years.
- Municipality L reviews and updates their projection model internally semi-annually and is currently projected out to 2045.
- Municipality D's current projections are to 2060.
- Municipality E projects their water use out 30 years.
- Municipality F's current projections are to 2051.
- Municipality G's projections were updated in 2000 and are currently being updated.
- Municipality J's current projections are to 2055.
- Municipality K projects their water use out at least 50 years.
- Municipality N projects their water use out 25 years.

4.5 Question 6: Do you calculate your water loss?

Table 4-3 summarizes which municipalities calculate their water loss.

Table 4-3: Calculate Water Loss

	City of Calgary	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Yes	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
No			✓									✓					✓

- 82% of participants, including Calgary, calculate water loss.

4.6 Question 7: If you quantified your water loss, which metric(s) do you use (ILI, real losses, unavoidable real loses (UARL)and what is the value(s)?

Figure 4-2 and **Figure 4-3** illustrate the quantified water loss values by ILI and Municipality Real Losses & UARL, respectively.

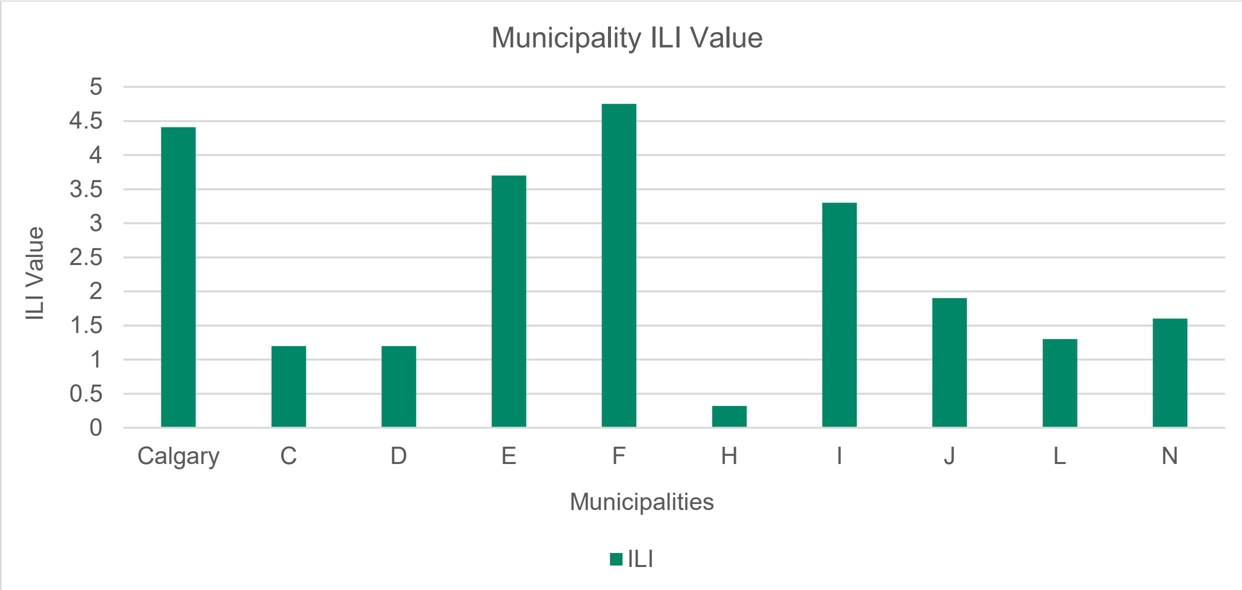

Figure 4-2: Municipality ILI Value

- The City's ILI value is 4.41.
- The median ILI value for the group is 1.75.

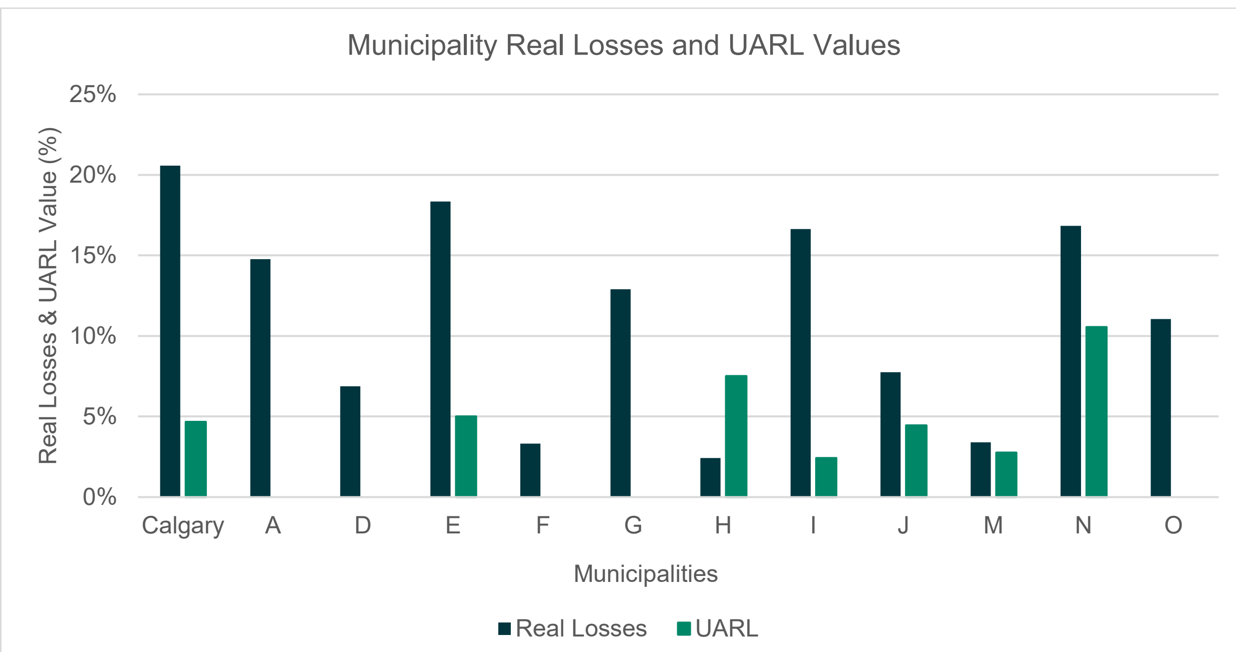

Figure 4-3: Municipality Real Losses & UARL Value

- The City has a Real Loss value of 21% and UARL value of 5% (represented as a percentage of annual water consumption).
- The median real losses value for the group is 12% and the median UARL value is 5%.

4.7 Question 8: How has your water loss changed over the last 10 years? If you have quantified the change in water loss over the last 10 years, please note it below.

Figure 4-4 illustrates how many municipalities have observed changes in water loss over the last 10 years.

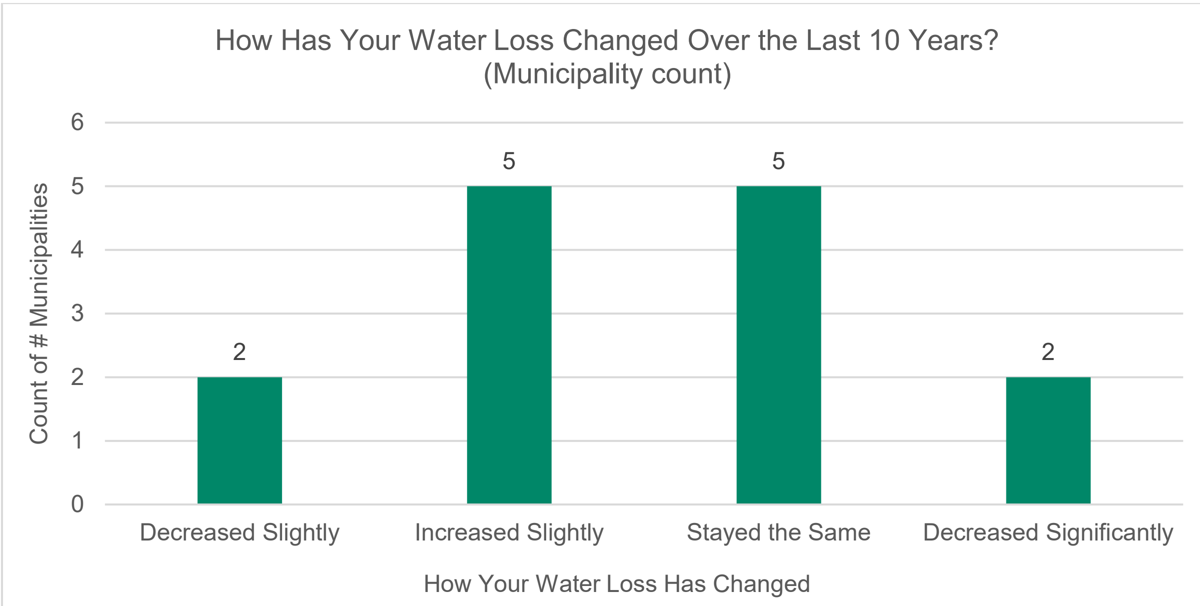

Figure 4-4: How Your Water Loss Has Changed Over 10 Years

- The City of Calgary noted a slight increase with an ILI value of 3 in 2015 and just over 4 in 2023.
- Municipality A, and H's water loss decreased slightly.
- Municipality C, E, I, and L's water loss increased slightly.
- Municipality D, G, J, M, and O's water loss stayed the same.
- Municipality F and N's water loss decreased significantly.
- Municipality F noted an increase in ILI of 3 in 2014 up to 3.7 in 2023/2024.
- Municipality I noted a decrease of 5%.

4.8 Question 9: What is your total length of pipe with corrosion protection (cathodic protection vs. polyethylene encasement)?

Figure 4-5 illustrates the total length of pipe with corrosion protection.

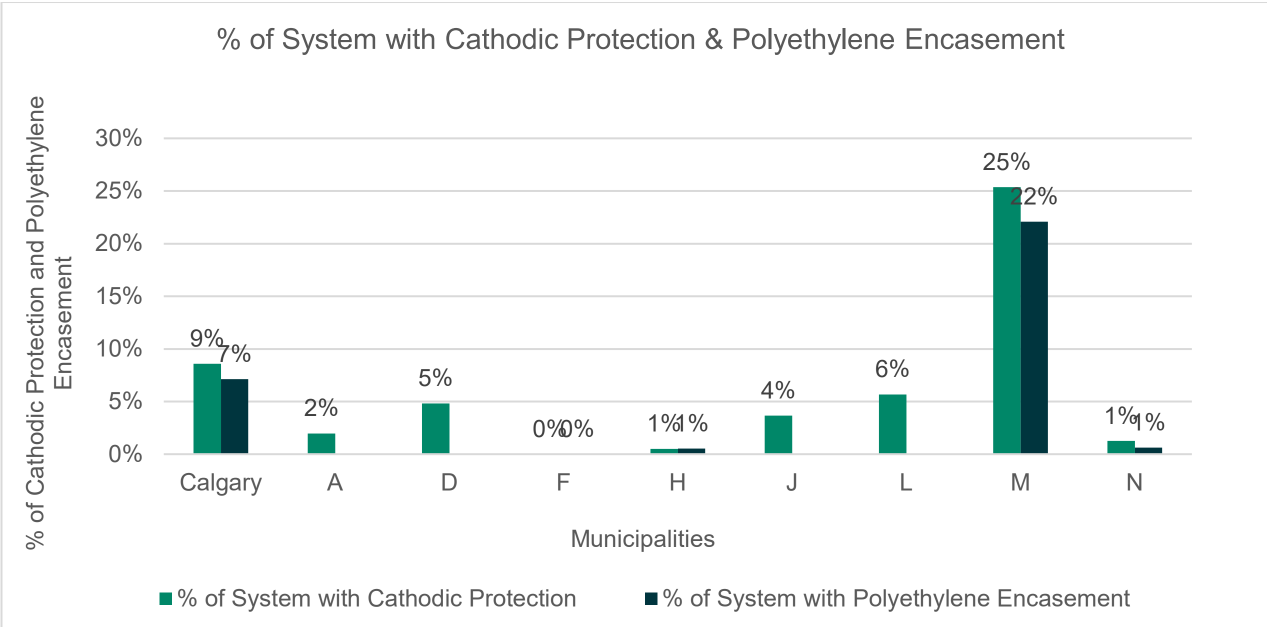

Figure 4-5: Percent of System with Cathodic Protection & Polyethylene Encasement

- The length of system with cathodic protection and polyethylene have been normalized by that municipality's total system length.
- The median value of % of system with cathodic protection is 4%.
- The median value of % of system with polyethylene encasement is 4%.
- The City has 9% of its system with cathodic protection and 7% of its system with polyethylene encasement, both of which are above the group median.

4.9 Question 10: How many total watermain breaks did you have in 2023?

Figure 4-6 illustrates the total number of watermain breaks reported in 2023 and number of breaks per km of system.

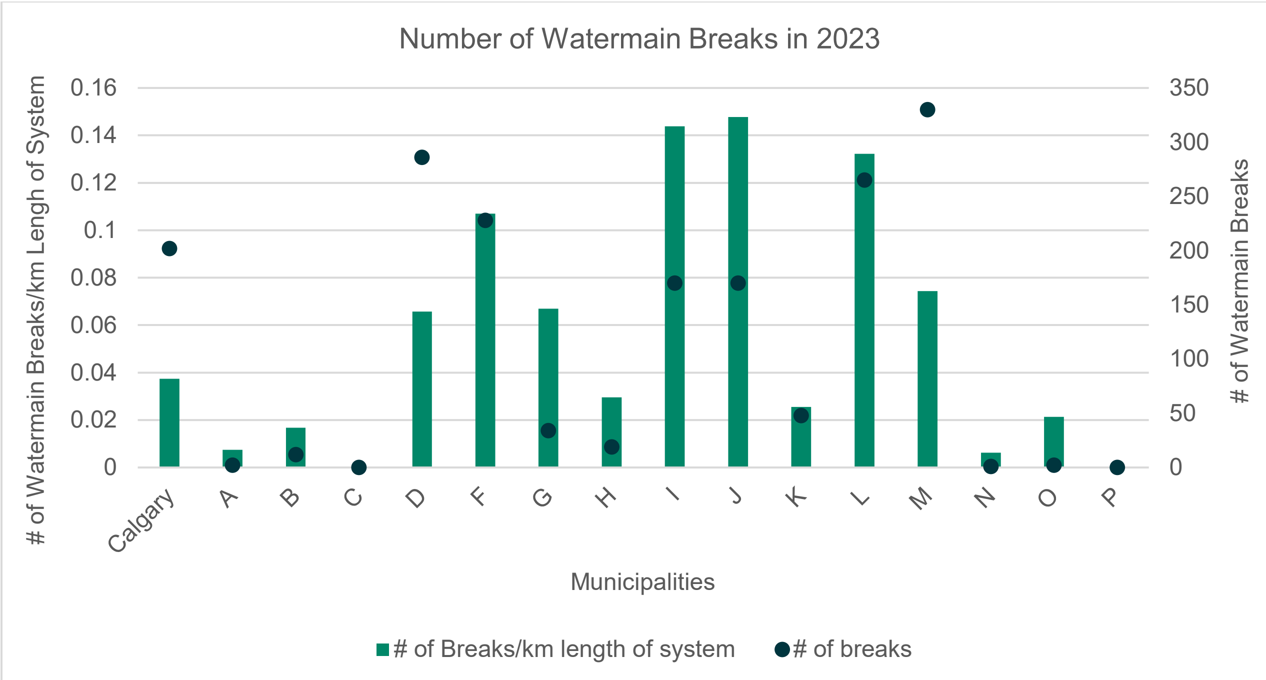

Figure 4-6: Number of Watermain Breaks in 2023

- The City recorded 202 watermain breaks in 2023.
- The number of watermain breaks have been normalized by that municipality's total system length.
- Each municipality's # of breaks is shown on the secondary (right) y-axis and represented by the dot on the graph.
- The median value of number of breaks per km length of system is 0.033. The City's value for number of breaks per km length of system is 0.037.

4.10 Question 11: What length of your system have you relined and please note the main driver(s) for your watermain relining.

Figure 4-7 illustrates the total length of each system that has been relined.

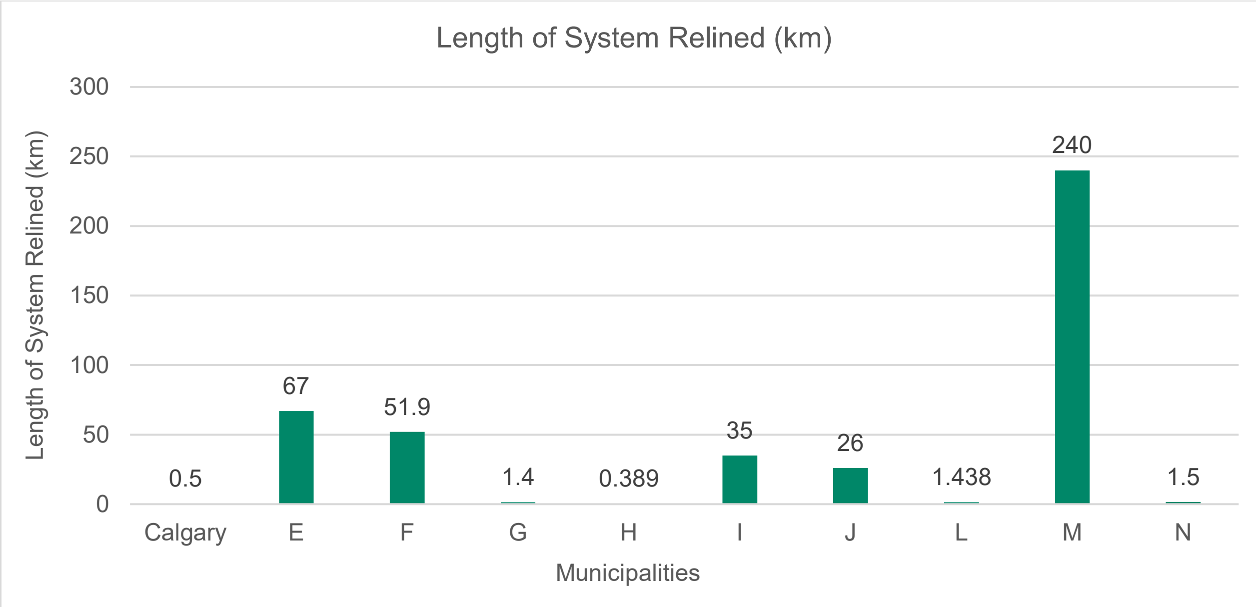

Figure 4-7: Length of System Relined

- Municipality A, B, C, D, O, and P have not relined any of their system.
- The City's main drivers for relining is for restoring structural integrity.
- Municipality E noted their drivers for relining include hydraulic performance and structural integrity.
- Municipality H relined their system if the lines run through residential property, or they cross a busy intersection.
- Municipality J noted their lining is done in locations where open trench replacement is not an option.
- Municipality L relined cast iron pipe to restore structural integrity.
- Municipality M relined pipe due to hydraulic reasons and water quality.

4.11 Question 12: What length of the system do you flush by uni-directional flushing (UDF) each year?

Figure 4-8 illustrates the percentage of each system that is flushed by UDF each year.

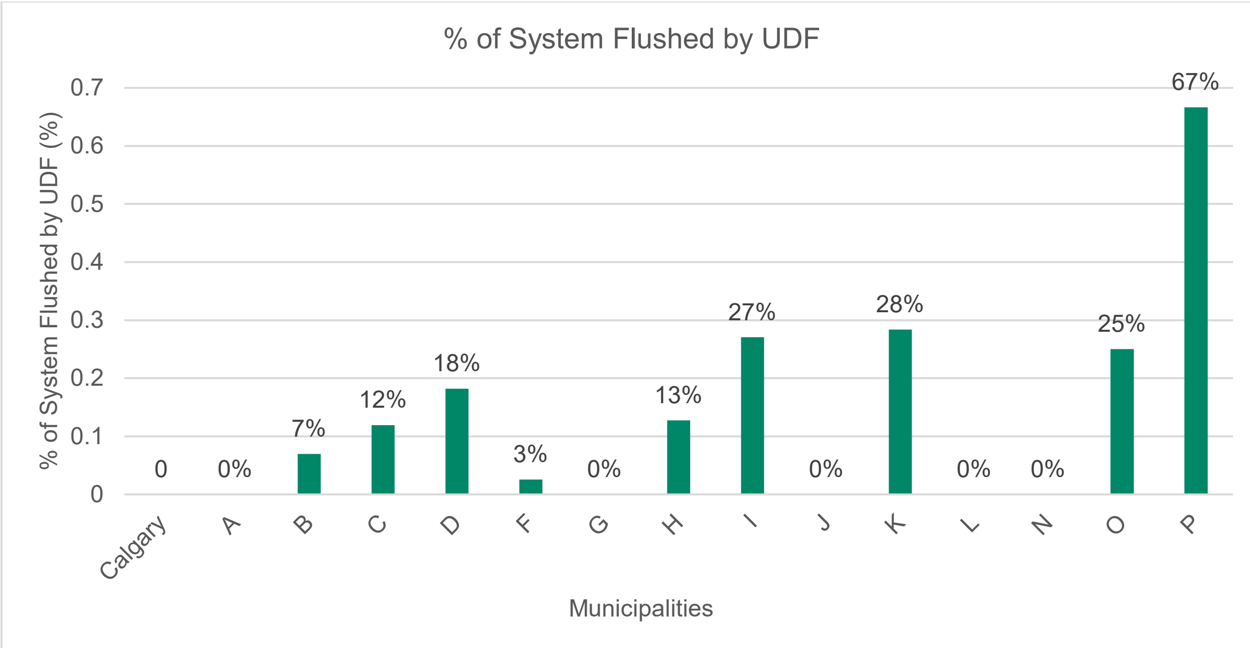

Figure 4-8: % of System Flushed by UDF

- The median value of the group for percent of system flushed by UDF is 9%.
- The City of Calgary reported no flushing.

4.12 Question 13: Do you use any of the following forms of permanent monitoring (zone metering, district metering, other)?

Figure 4-9 illustrates the number of municipalities that use each type of permanent metering.

District Metering monitors a discrete area of a distribution system usually created by the closure of valves or complete disconnection of pipe work in which the quantities of water entering and leaving the area are monitored. This area is based on geography. This differs from zone metering which is typically based the pressure zones of a municipality.

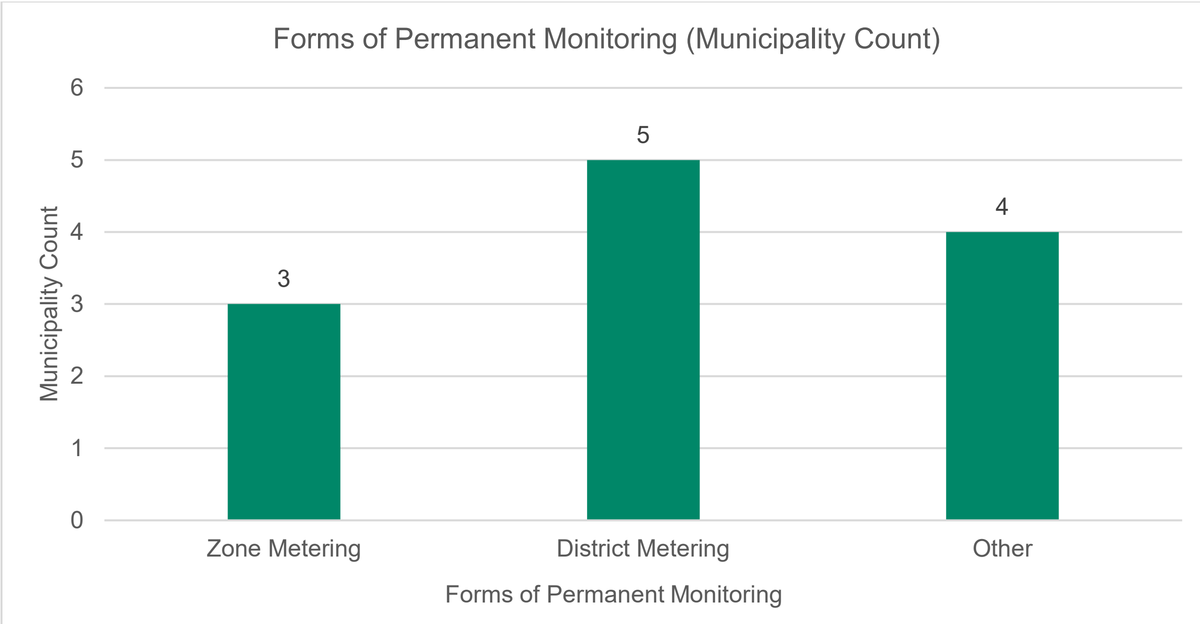

Figure 4-9: Forms of Permanent Monitoring

- The City of Calgary utilizes District Metering.
- Municipality B, E, H, and N utilize District Metering.
- Municipality C, D, and K utilize Zone Metering.
- Municipality A and O (like most municipalities) utilizes individual service metering.
- Municipality F utilizes lift and shift leak detection technology.
- Municipality L is a single interconnected pressure zone. They measure water entering the distribution system at their pump stations and exiting at customer meters.

4.13 Question 14: Do you meter the water used by contractors for: flushing, commissioning, construction, other?

Figure 4-10 illustrates the number of municipalities who meter the water used by contractors for the listed activities.

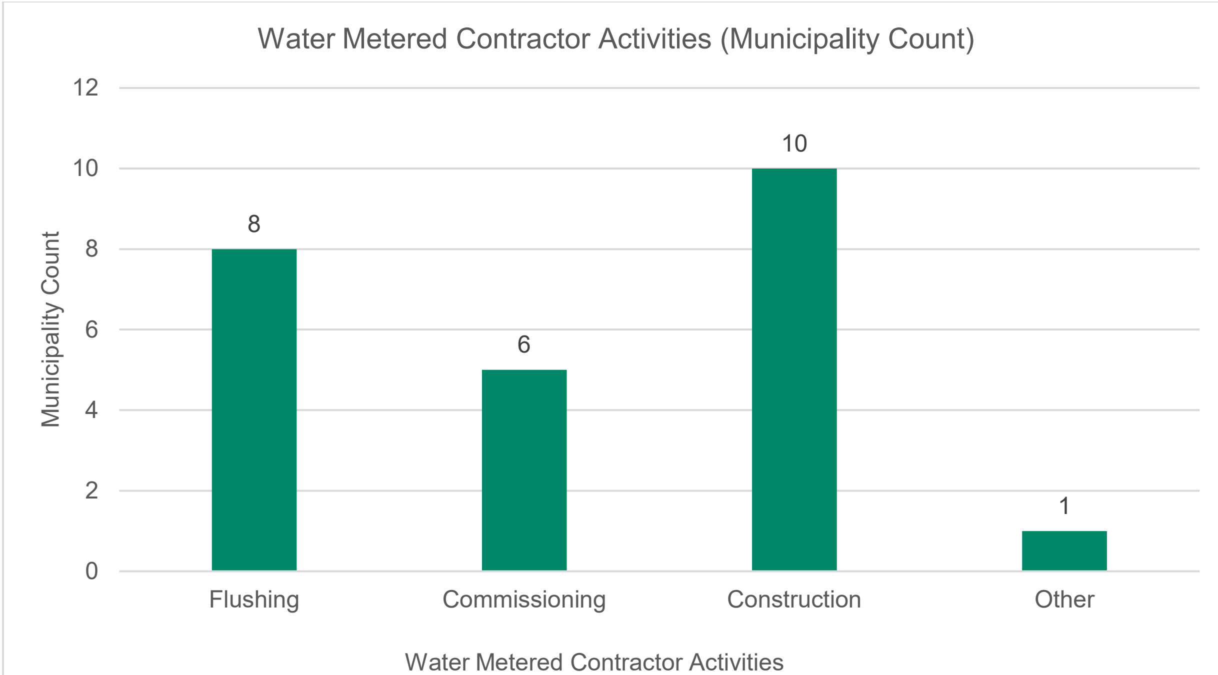

Figure 4-10: Water Metered Contractor Activities

- The City of Calgary meters contractor work for construction through a rental hydrant connection unit program. They are in the process of implementing metering for flushing and commissioning.
- Municipality A, C, D, F, G, N, O, and P meter water used by contactors for flushing.
- Municipality A, C, F, G, N, and P meter water used by contractors for commissioning.
- Municipality A, C, G, H, K, M, N, O, and P meter water used by contractors for construction.
- Other external water use activities metered include the selling of bulk water.

4.14 Question 15: What percentage of valves do you cycle each year?

Figure 4-11 illustrates the percentage of valves that each municipality cycles each year.

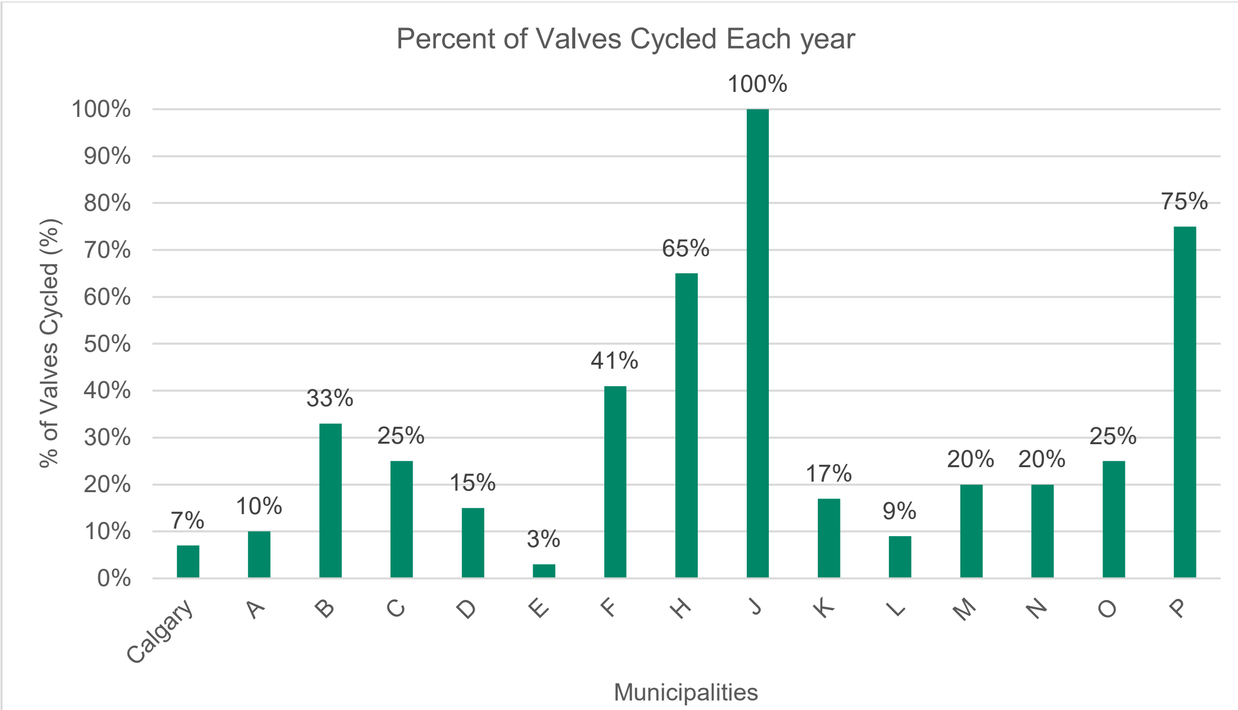

Figure 4-11: Percent of Valves Cycled Each Year

- The median value for percent of valves cycled each year is 20%. Valve cycling helps identify valves that are not functioning and/or leaking. Properly functioning valves also help isolate watermain breaks when they occur.
- Calgary cycles 7% of their valves per year.

4.15 Question 16: What percentage of hydrants do you inspect each year?

Figure 4-12 illustrates the percentage of hydrants that each municipality inspects each year.

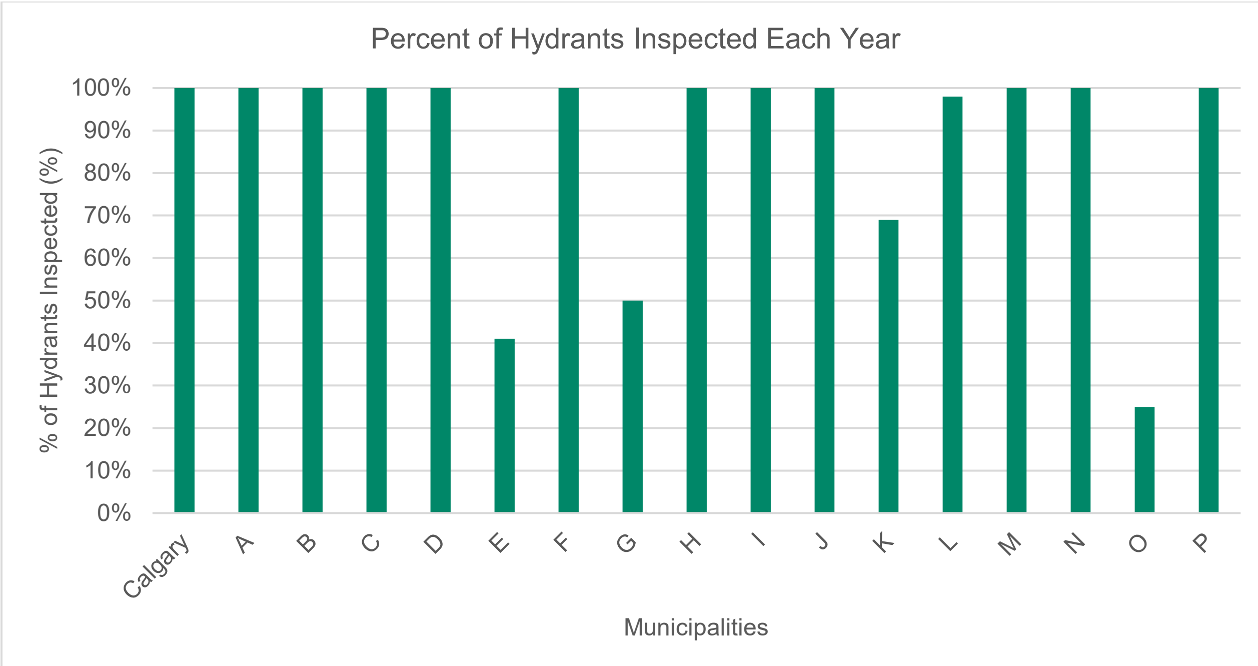

Figure 4-12: Percent of Hydrants Inspected

- The median value for percent of hydrants inspected each year is 100% which matches The City of Calgary's value.

4.16 Question 17: How many service connection breaks did you identify in 2023?

Figure 4-13 illustrates the number of service connection breaks normalized by that municipality's total number of service connections

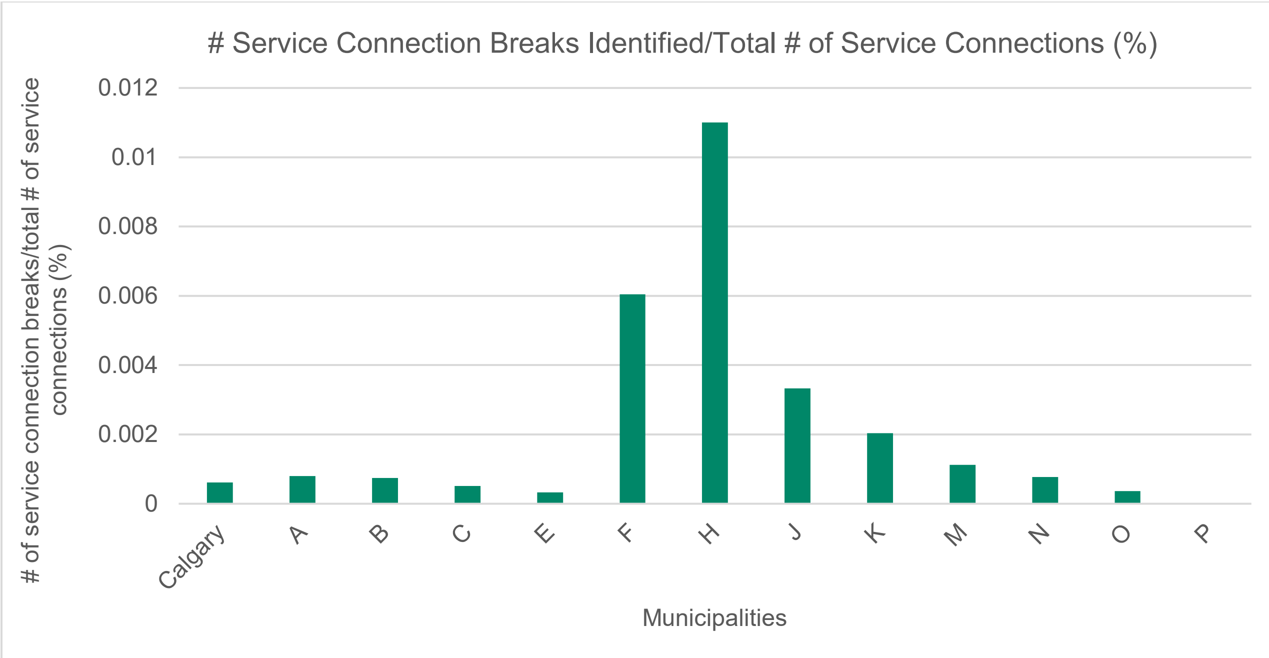

Figure 4-13: # of Service Connection Breaks

- The City identified 253 service connection breaks in 2023.
- The median value for number of service connection breaks per total number of connections is 0.0007 %. The City's value is 0.0006 %.

4.17 Question 18: Do you think any of the following (pipes, hydrants, services, meters, other) are significant sources of water loss?

Table 4-4 illustrates the number of municipalities who noted that the listed assets were sources of water loss.

Table 4-4 Sources of Water Loss

	City of Calgary	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	TOTAL
Services	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓			13
Pipes					✓	✓	✓			✓		✓		✓	✓	✓		8
Joints			✓			✓		✓			✓	✓		✓		✓	✓	8
Meters							✓					✓	✓					3
Hydrants											✓	✓						3
Valves											✓						✓	2
Other							✓											1

- The City noted services as a source of water loss. They surveyed over 1,000 km of their distribution mains and not as many breaks were found as expected. This has caused an increased interest in breaks on service connections.
- Municipality F noted water theft as a source of water loss (other).

4.18 Question 19: Do you understand the differences in your water loss by geographic area?

Table 4-5 shows whether or not a municipality understands the differences in their water loss by geographic area.

Table 4-5: Water Loss by Geographic Area

	City of Calgary	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Yes	✓	✓		✓	✓	✓		✓	✓		✓	✓					
No			✓				✓			✓			✓	✓	✓	✓	✓

- The City understands their water loss by geographic area at a high level. They have areas that they are aware of that are prone to non-surfacing breaks as well as data on areas with more corrosive soils.
- Municipality A noted that areas with copper services with no cathodic protection are susceptible to leaks.
- Municipality C understands their leaks by pipe materials, location, and age.
- Municipality D assumes areas with older cast iron pipes leak more.
- Municipality E utilizes their district metered areas (DMAs) to determine and understand leakage in each DMA. They know of certain pipe materials/age that are more prone to breaks and leaks. They are also aware of areas that have soil which results in leaks.
- Municipality G notes areas with cast iron pipe have an increase in leaks.
- Municipality H notes that the era of pipe is the main difference in water loss, as well as soil type.
- Municipality J knows that the majority of their breaks occur on 1940-1970 cast iron pipe. Pre-1940 cast iron has fewer breaks. They have very few breaks on AC and PVC pipe. Lead service lines have a higher failure rate than other materials.
- Municipality K utilizes zone metering data to understand, to a degree, water loss by area.

4.19 Question 20: Do you have a proactive leak detection program?

Table 4-6 shows whether a municipality has a proactive leak detection program.

Table 4-6: Leak Detection Program

	City of Calgary	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Yes	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	
No			✓					✓		✓							✓

- 13/17 municipalities, including Calgary, have a proactive leak detection program.
- Municipality A noted that they have an aggressive leak detection program that focuses on service leaks.
- Municipality C noted the use of hydrophones at copper services.
- Municipality O utilizes meter monitoring.

4.20 Question 21: What was the total length of watermain tested for leakage in 2023?

Figure 4-14 illustrates the total length of watermain that was tested for leakage in 2023 for each municipality.

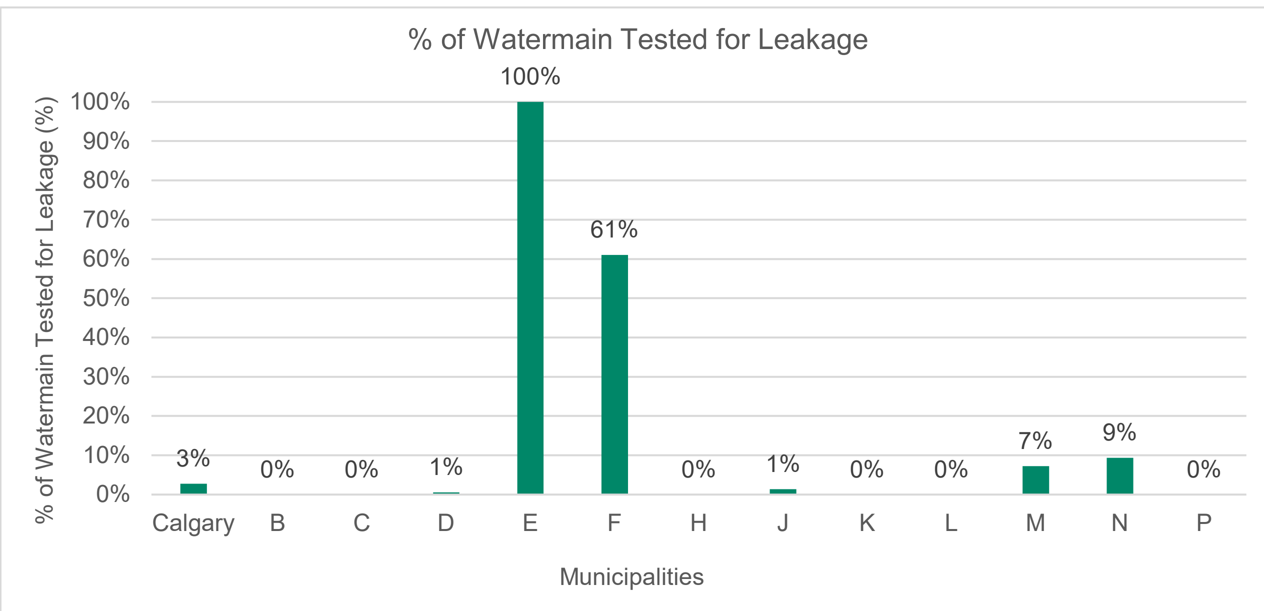

Figure 4-14: % of Watermain Tested for Leakage

- The City tested 3% of its system for leakage in 2023, which is above the group median of 1%.

4.21 Question 22: Please describe any water loss reduction initiatives, noting what has worked and what hasn't.

- The City of Calgary has utilized different leak detection methods such as satellite leak detection, Gutermann lift-and-shift loggers, and Echlogics Leak Finder ST.

- Municipality A, C, and D utilize cathodic protection programs.
- Municipality B, D, J utilize watermain replacement programs.
- Municipality E, F utilize district metering.
- Municipality E, F, and L utilize AMI (Advanced Metering Infrastructure).
- Municipality D, E, F, M utilize Proactive Leak Detection programs.
- Municipality I utilize relining and unmetered water investigations
- Municipality N and O utilize public education programs.
- Municipality D also utilizes transmission main inspection programs, optimization of UDF flushing, education of contractors, hydrant permit program, hydrant flow/pressure monitoring, reservoir leak testing, water loss auditing, neighbourhood leak detection programs, reactive leak detection, and meter QAQC annual reporting.
- Municipality J mentioned that proactive leak detection did not detect background leakage as when they have watermain breaks they surface quickly.

4.22 Question 23: What was your total water consumption in 2023?

Figure 4-15 shows each municipality's 2023 water consumption.

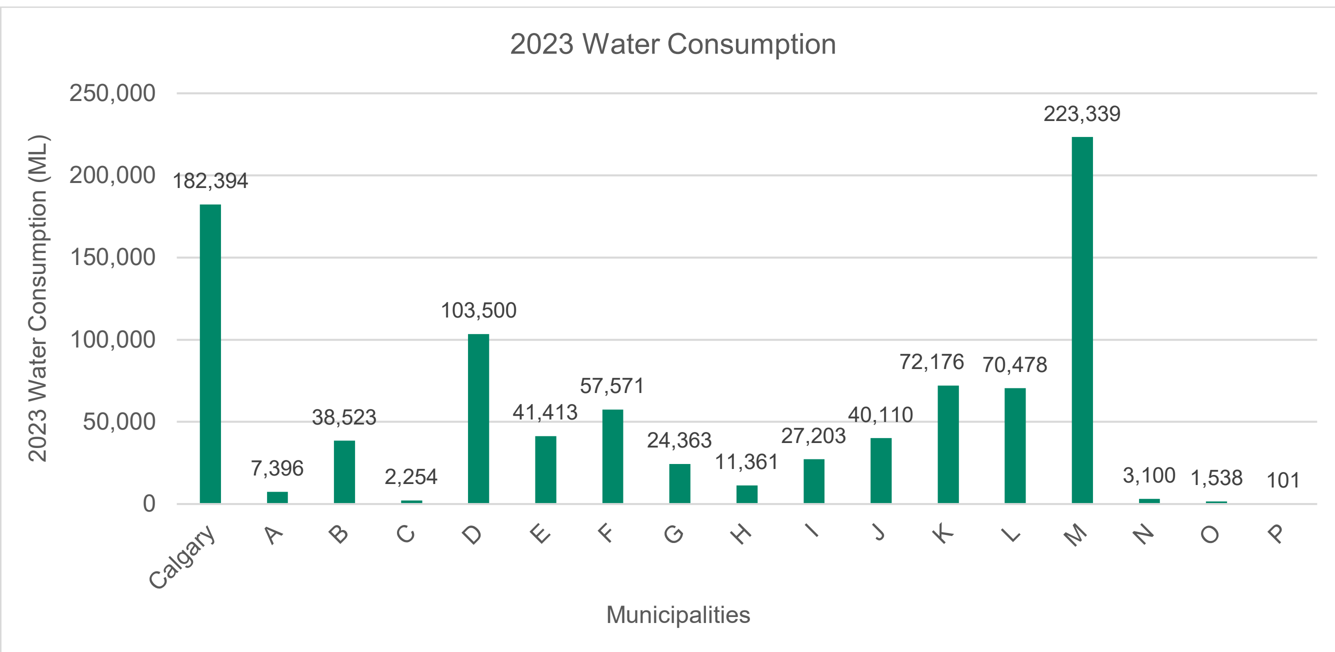

Figure 4-15 2023 Water Consumption

4.23 Question 24: What was your average residential water consumption in 2023 (e.g. total metered residential customer/metered population)?

Figure 4-16 illustrates the average residential water consumption rate.

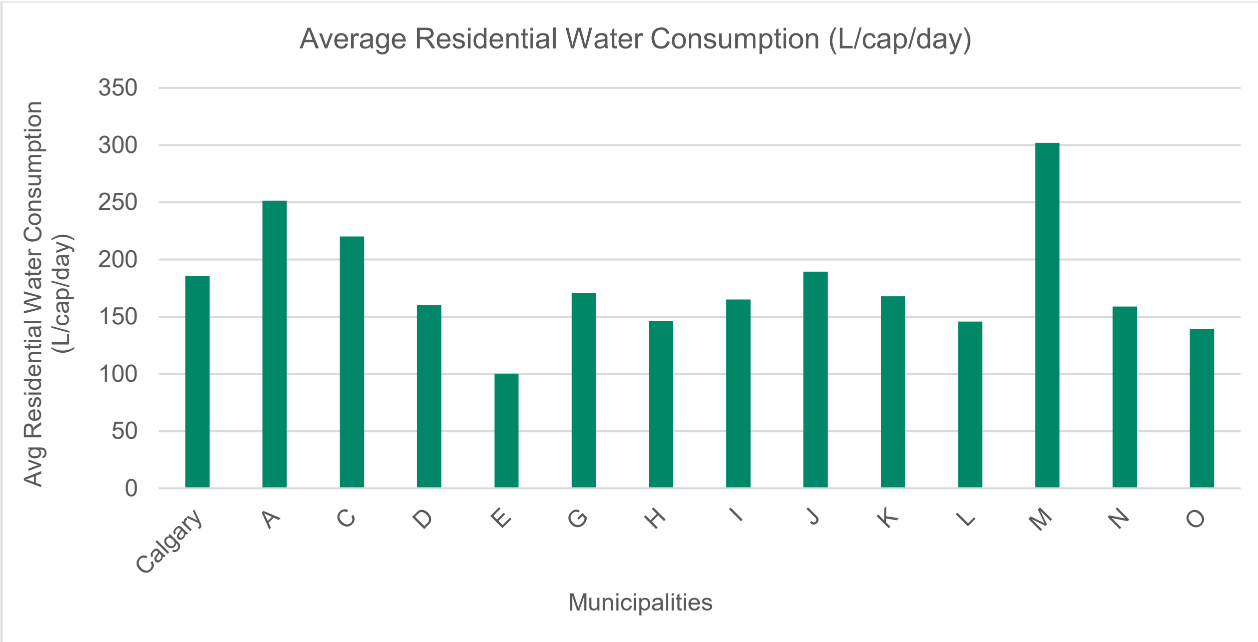

Figure 4-16: Average Residential Water Consumption

- The City's residential water consumption was 185.7 L/cap/day in 2023.
- The median value of residential water consumption of the group is 165 L/cap/day.

4.24 Question 25: What is your total length of watermain?

Figure 4-17 shows each municipality's total length of watermain.

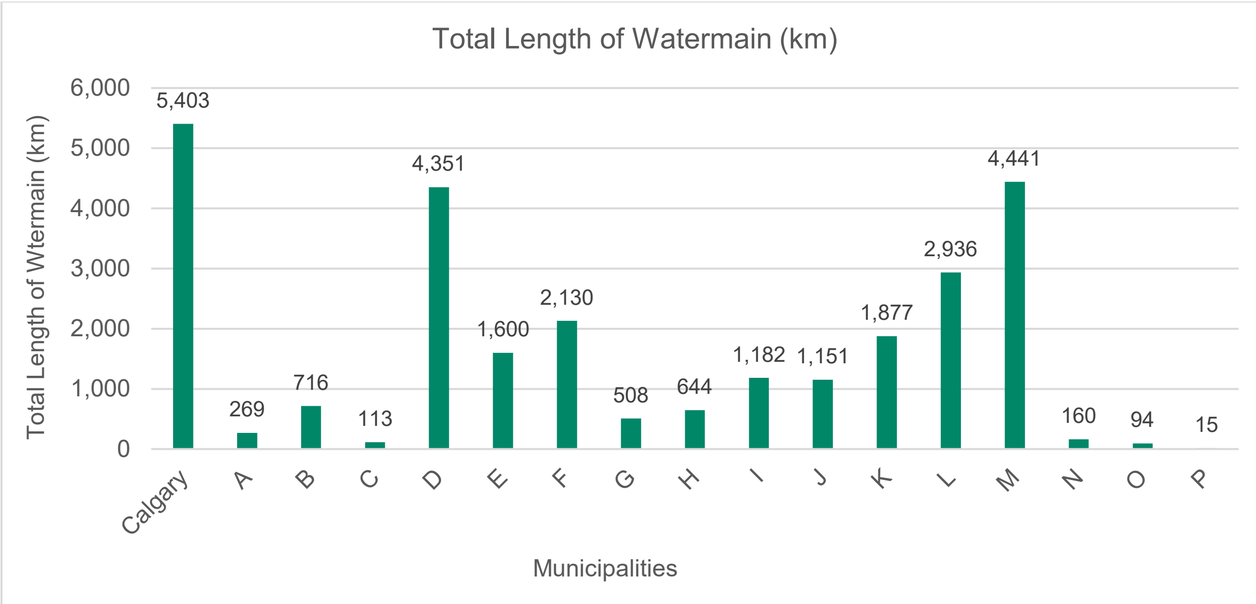

Figure 4-17 Total Length of Watermain

4.25 Question 26: What length of cast iron watermain from pre-1950 do you have?

Figure 4-18 illustrates each municipality's length of cast iron watermain pre-1950 normalized by that municipality's total length of watermain.

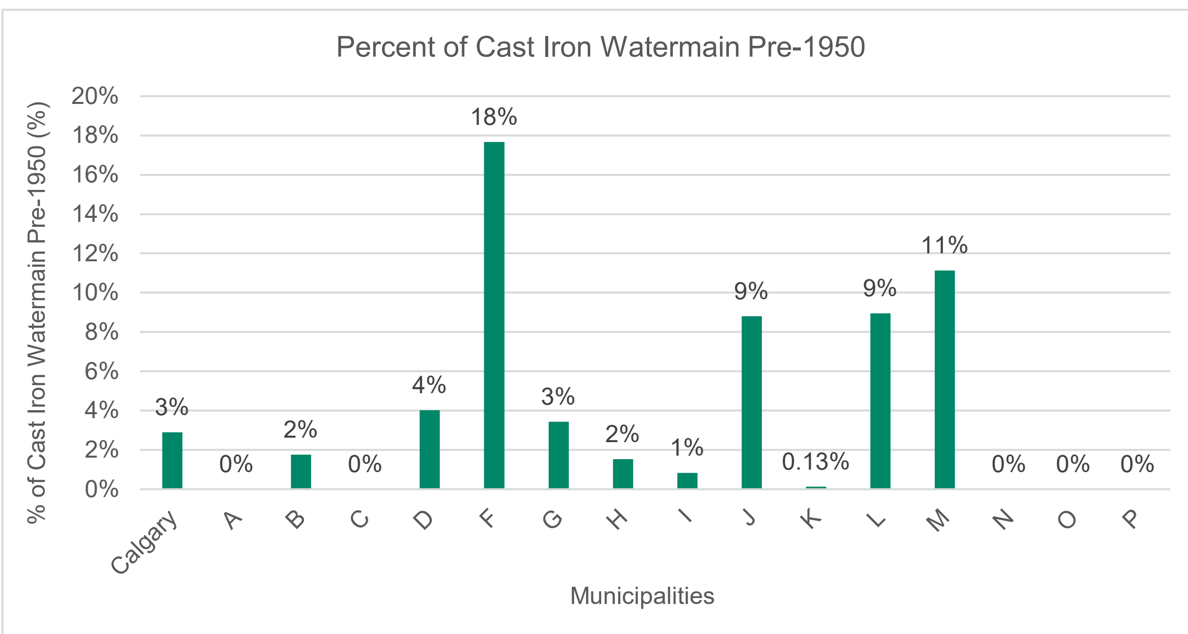

Figure 4-18: Percent of Cast Iron Watermain Installed Pre-1950

- The median value of % of cast-iron watermain installed pre-1950 is 2%.

- The City's % of cast-iron watermain in their system installed pre-1950 is 3%.

4.26 Question 27: What length of cast iron from post-1950 do you have?

Figure 4-19 illustrates each municipality's length of cast iron watermain post-1950 normalized by that municipality's total length of watermain.

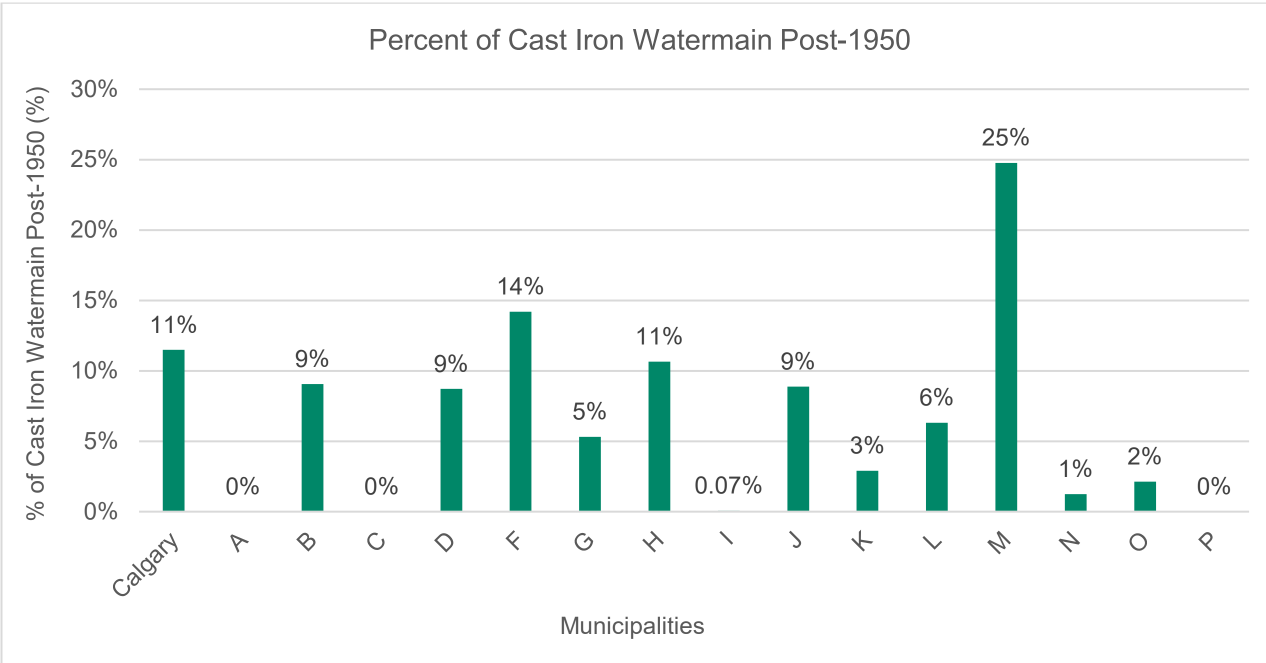

Figure 4-19: Percent of Cast Iron Watermain Installed Post-1950

- The median value of % of cast iron watermain installed post-1950 is 6%.
- The City's % of cast iron watermain installed post-1950 is 11%.

4.27 Question 28: What length of ductile iron watermain do you have?

Figure 4-20 illustrates each municipality's length of ductile iron watermain normalized by that municipality's total length of watermain.

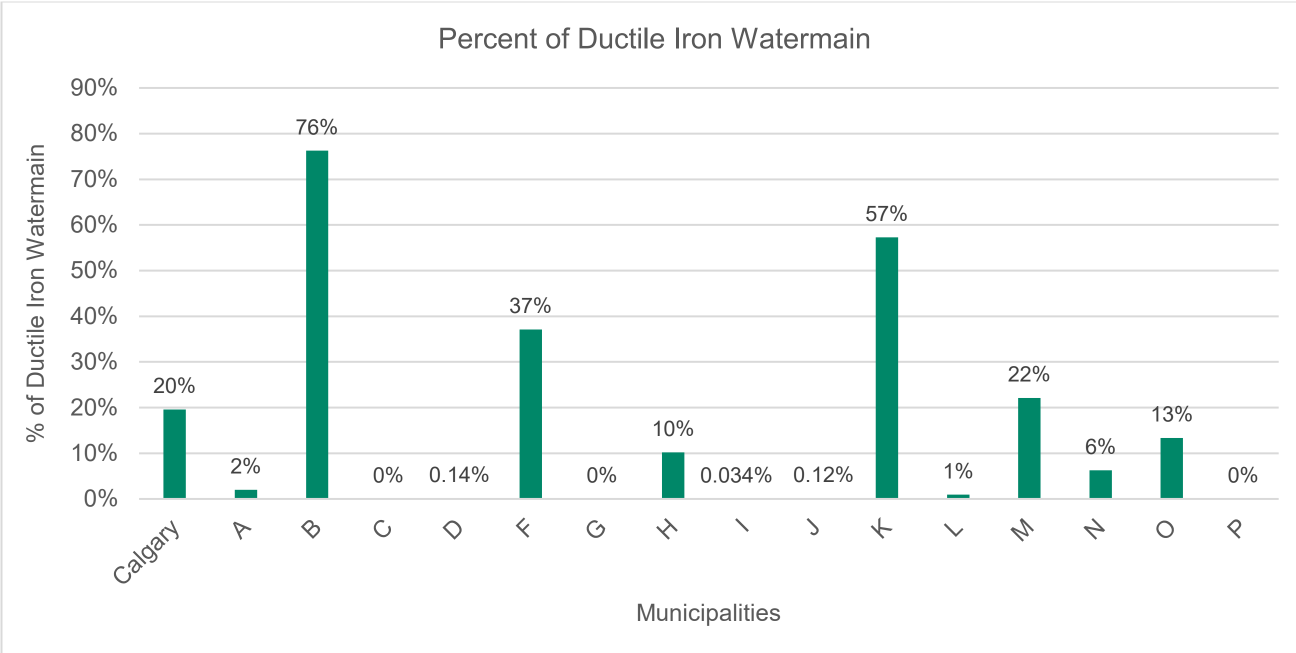

Figure 4-20: Percent of Ductile Iron Watermain

- The median value of % of ductile iron is 4%.
- The City's percent of ductile iron watermain is 20%.

4.28 Question 29: What length of Asbestos cement watermain do you have?

Figure 4-21 illustrates each municipality's length of asbestos cement (AC) watermain normalized by that municipality's total length of watermain.

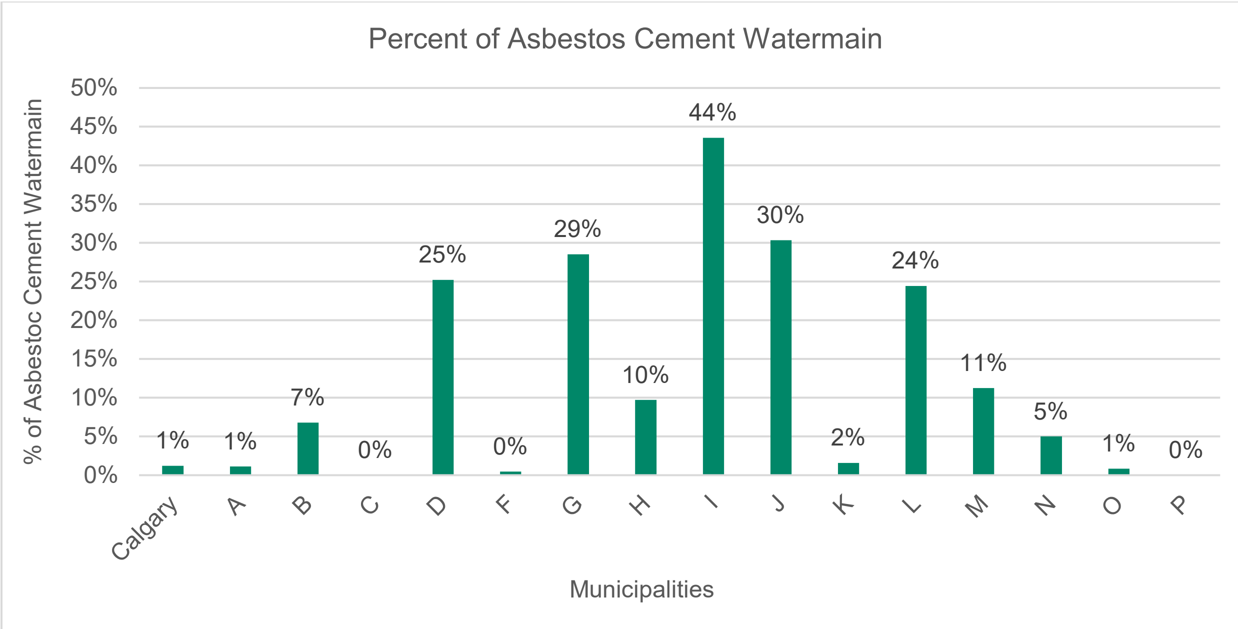

Figure 4-21: Percent of Asbestos Cement Watermain

- The median value of % of asbestos cement watermain is 6%.
- The City's percent of AC watermain is 1%.

4.29 Question 30: What length of watermain was constructed in the period from 1950-1975?

Figure 4-22 illustrates each municipality's length of watermain constructed between 1950-1975 normalized by that municipality's total length of watermain.

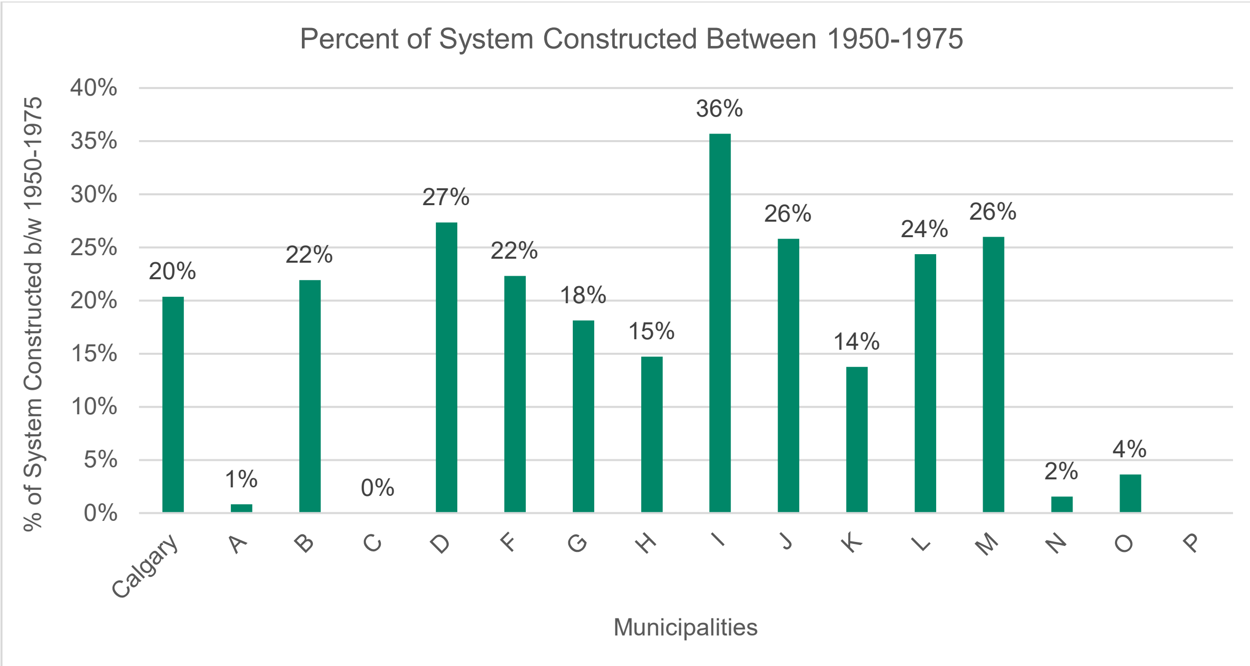

Figure 4-22: Percent of System Constructed Between 1950-1975

- The median value of % of system constructed between 1950-1975 is 20%.
- The City's percent of system constructed between 1950-1975 is 20%.

4.30 Question 31: How many service connections do you have?

Figure 4-23 shows the total number of services connections for each municipality.

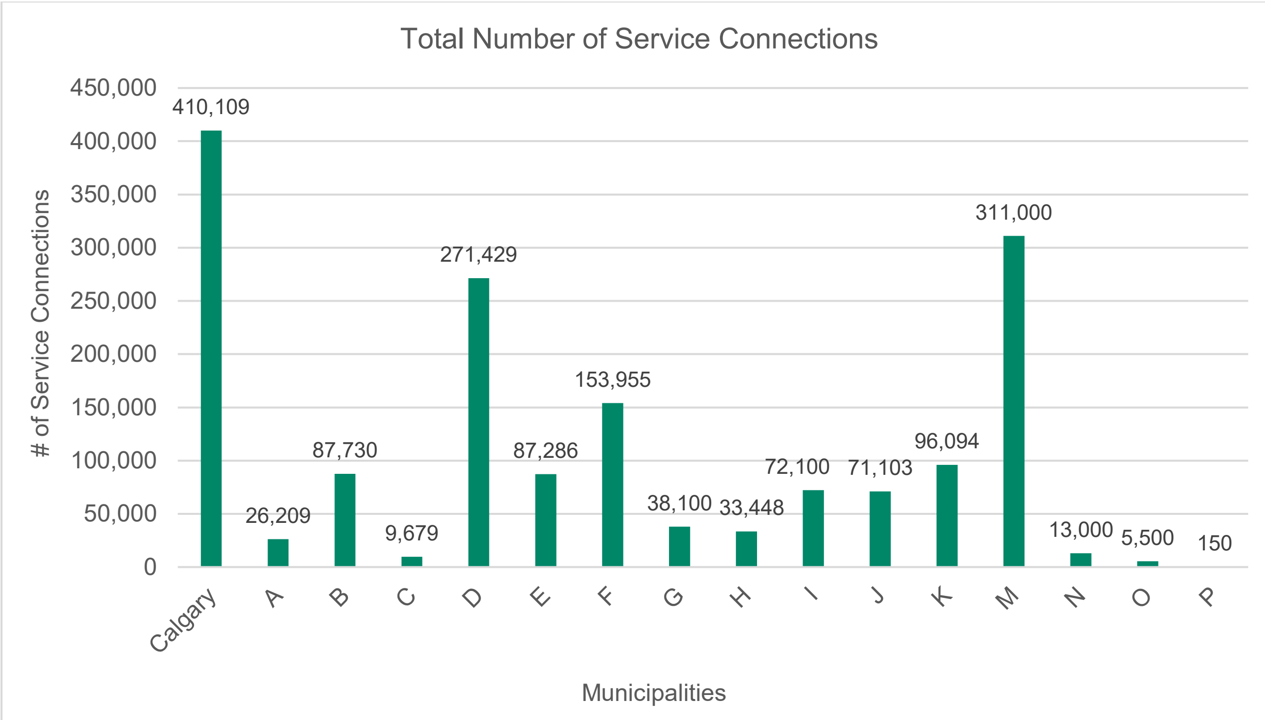

Figure 4-23 Total Number of Service Connections

4.31 Question 32: What percentage of your service connections are metered?

Figure 4-24 illustrates the percent of service connections that are metered for each municipality

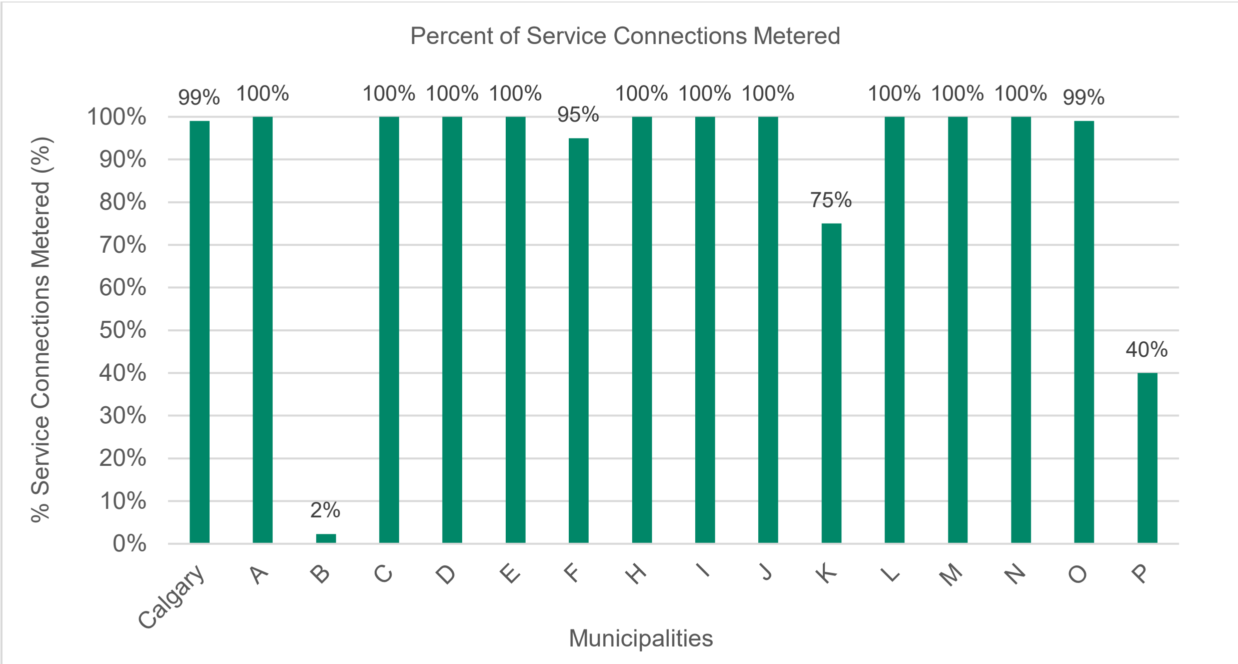

Figure 4-24: Percent of Service Connections Metered

- The City's service connections are 99% metered.
- The median value of percent of service connections metered for the group is 100%.

4.32 Question 33: What is your average operating pressure?

Figure 4-25 illustrates the average water distribution system operating pressure for each municipality.

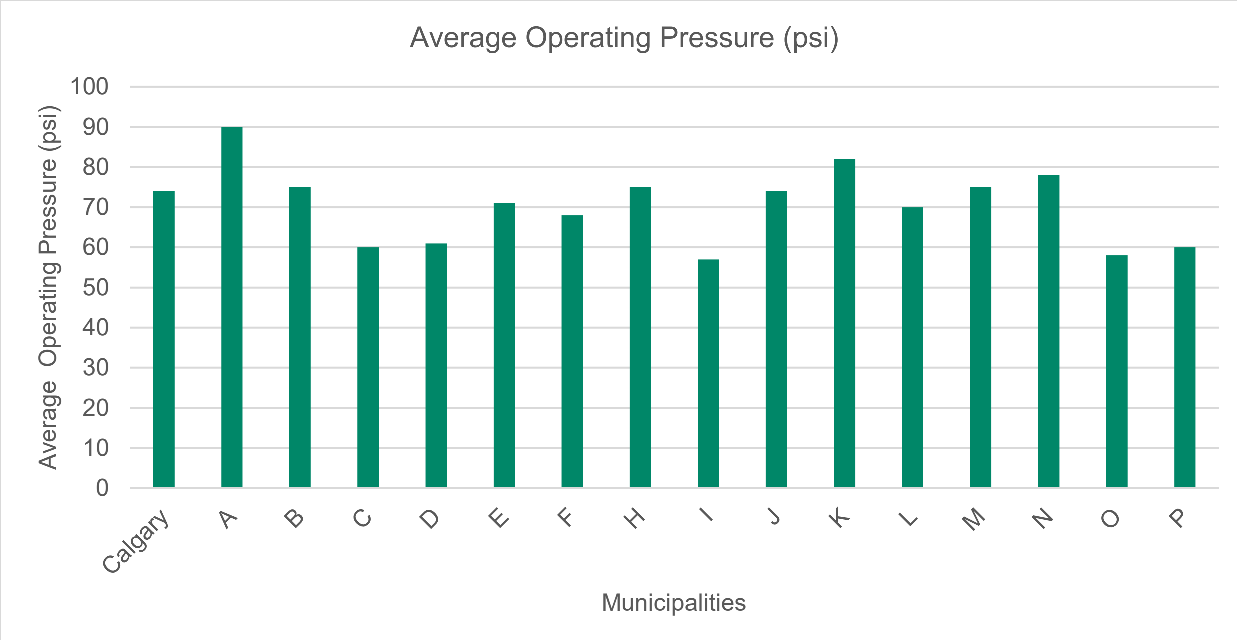

Figure 4-25: Average Operating Pressure

- The City's average operating pressure is 74 psi (52 m of head).

4.33 Question 34: Which of the following describe your water rate structure for charging customers?

Table 4-7 summarizes each municipality's water rate structure that is used for charging customers.

Table 4-7: Water Rate Structure

Municipality	Flat Rate	Fixed Charge	Uniform Rate	Declining Block Rate	Inclining Block Rate
City of Calgary		✓	✓		
A	✓	✓			
B	✓				
C					✓
D		✓		✓	✓
E		✓	✓		
F		✓	✓		

Municipality	Flat Rate	Fixed Charge	Uniform Rate	Declining Block Rate	Inclining Block Rate
G		✓	✓		
H		✓	✓		
I		✓	✓		
J		✓	✓		
K	✓	✓	✓		
L		✓	✓		
M					✓
N					✓
O	✓		✓		
P			✓		

- The City utilizes a fixed charge and uniform rate structure, along with 7 other municipalities.

4.34 Question 35: What is your volumetric rate (e.g. $/m^3)?

Table 4-8 summarizes each municipality's volumetric rate used for charging customers.

Table 4-8 Volumetric Rate

Municipality	Volumetric Rate
City of Calgary	Residential: $1.4247/m^3 Multi-Family: $1.3189/m^3 ICI: <75mm service: $1.4018/m^3 ICI: ≥ 75mm service: $1.3512/m^3
A	$1.5876/m^3
B	$1.737/m^3
C	Residential: 0-18m^3: $1.22/m^3 Residential: >18m^3: $2.47/m^3

Municipality	Volumetric Rate
	Non-residential: 0-100m^3: \$1.67/m^3 Non-residential: >100m^3: \$2.68/m^3
D	Residential Inclining Block rate for the year 2024: 0-10m3: \$2.3173/m^3 10.1m^3-35m^3: \$2.5316/m^3 Over 35m^3: \$3.1996/m^3
E	\$1.128/m^3
F	Residential 0-10m^3: \$0.98/m^3 Residential >10m^3: \$1.96/m^3 ICI: \$1.96/m^3
G	Residential: \$2.00/m^3 ICI 0-750m^3: \$1.146/m^3 ICI 751-25,000m^3: \$0.799/m^3 ICI 25,001-50,000m^3: \$0.688/m^3 ICI >50,000m^3: \$0.522/m^3
H	\$1.69/m^3
I	\$2.40m^3
J	0-17m^3/month: \$1.79/m^3 17-34m^3/month: \$2.018/m^3 >34m^3: \$2.656/m^3
K	\$1.2239/m^3
L	\$2.00/m^3
M	Tier 1: \$1.06/m^3 average winter consumption Tier 2: \$1.91/m^3 next 57m^3 Tier 3: \$2.54/m^3 next 57m^3
N	0-15m^3: \$1.30/m^3 15-30m^3: \$1.85/m^3 >30m^3: \$2.80m^3

Municipality	Volumetric Rate
O	$2.80/m^3
P	N/A

Figure 4-26 below illustrates a residential customer's monthly water charge. This was based on the following:

- Residential Consumption (185.7 L/cap day – City of Calgary's 2023 average residential consumption)
- 2.6 capita per dwelling unit
- 30 days in a month

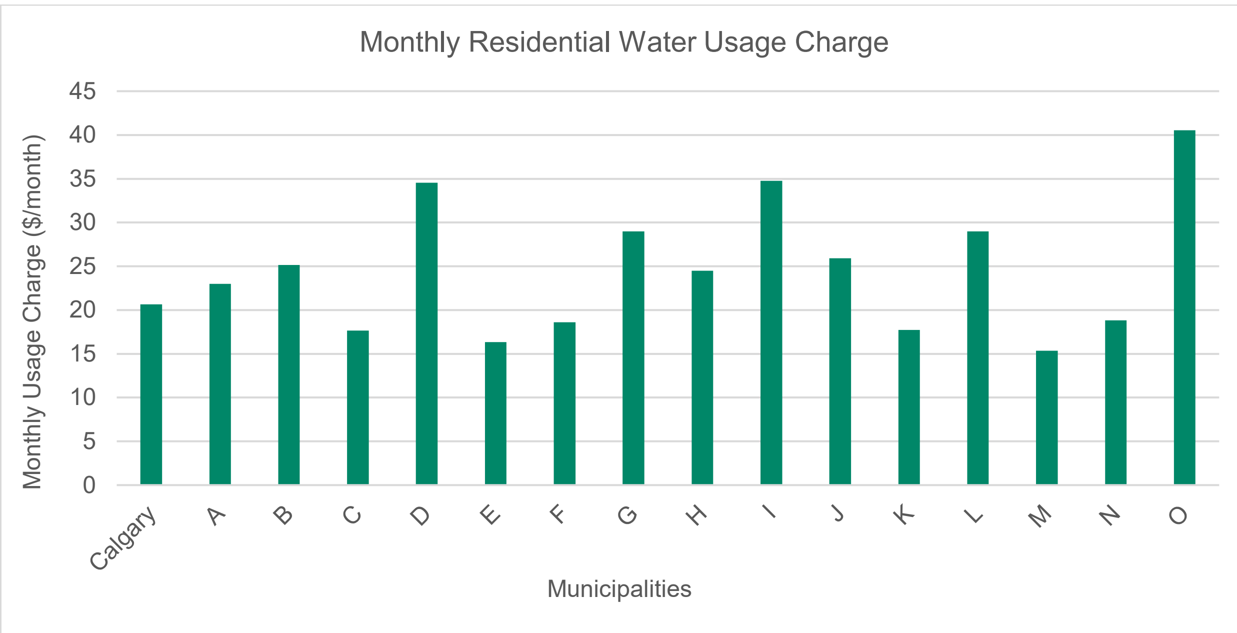

Figure 4-26 Monthly Residential Water Usage Charge

- The City's residential customer charge is $20.63 per month.
- The median residential customer charge of the group is $23.74 per month.

4.35 Question 36: Please record the approximate percentages of meters that are read using the methods listed below (this should add to 100%).

Figure 4-27 summarizes the percent of municipalities who utilize each type of meter reading. Municipalities may use more than one meter reading method. "Other" methods were not described.

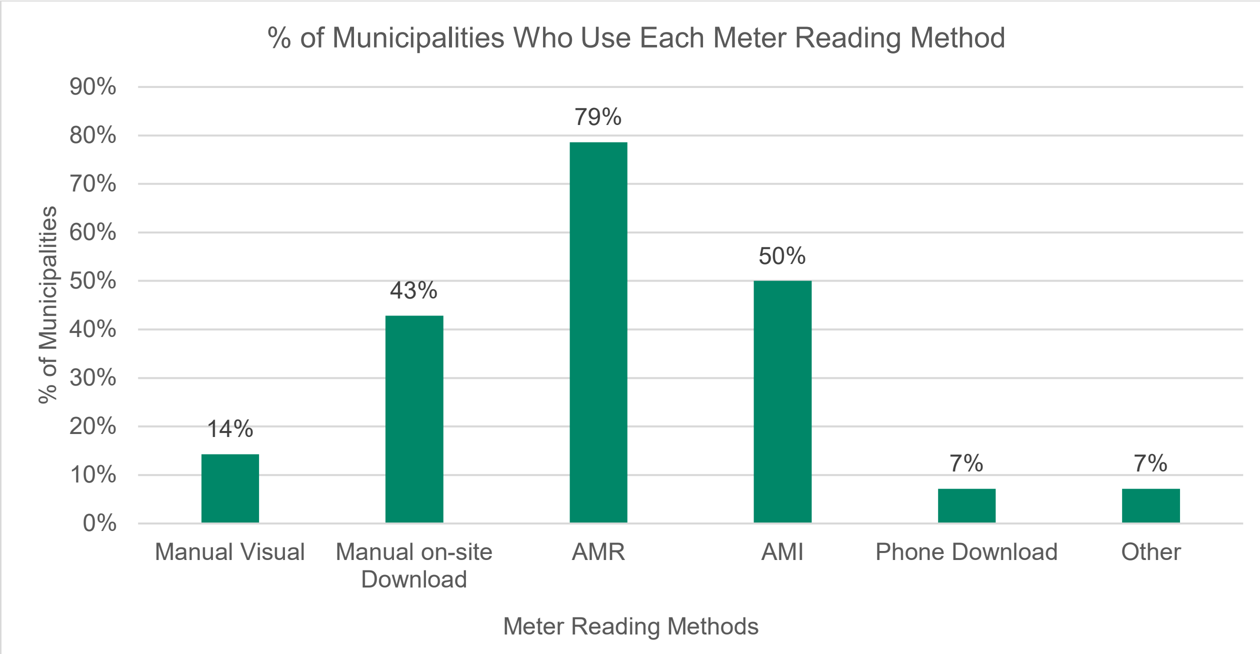

Figure 4-27 Percent of Municipalities Who Use Each Meter Reading Method

- The City did not provide data for this question.
- AMR: Automatic Meter Reading
- AMI: Advanced Metering Infrastructure

4.36 Question 37: Do you have geotechnical conditions that may impact the amount of leakage and/or ability to detect leakage?

Table 4-9 summarizes whether a municipality has geotechnical conditions that may impact the amount of leakage and/or ability to detect leakage in their system.

Table 4-9: Geotechnical Conditions

Municipality	Corrosive Soils	Clay-based soils	Primarily Gravel	Other
City of Calgary	✓		✓	
A	✓		✓	
B	✓	✓	✓	
C	✓			

Municipality	Corrosive Soils	Clay-based soils	Primarily Gravel	Other
D	✓	✓		
E	✓			
F				✓
G	✓			
H	✓			
I		✓		
J	✓	✓		
K	Data not available			
L		✓		
M	✓	✓	✓	
N		✓	✓	
O		✓		
P	Data not available			

- Ten municipalities, including the City of Calgary, have corrosive soils that can deteriorate watermains and cause leakage.
- Five municipalities, including the City of Calgary, have primarily gravely soils that can make leak detection challenging (i.e., leaks dissipate quickly).
- Other geotechnical conditions noted in Municipality F include rocky/porous escarpment and mountain brow.

4.37 Question 38: Do you find seasonal use/conditions affect system leakage (e.g. increase in breaks during cold weather events or summer peaks)?

Table 4-10 summarizes whether a municipality has seasonal conditions that affect system leakage.

Table 4-10: Seasonal Conditions Affect on System Leakage

	City of Calgary	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Yes	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	-	✓	✓		✓	
No				✓											✓		✓

- Municipality A and J noted a slight increase in breaks during thaw periods.
- Municipality B, E, F, G, H, I, J, L, O, and P noted an increase in breaks during colder months.
- Municipality D noted an increase in breaks during the summer when clay soils defrost.
- Municipality L sees an increase in breaks during hot and dry weather.

5. Survey Result Observations

Using the data from the survey results in Section 4, observations were made regarding how The City determines values for water use forecasting compared to other municipalities, the effects of different factors on water loss, and if other municipalities are experiencing similar situations. Figure 5-1 illustrates each municipality's ADD and MDD and how that compares to the collective averages.

5.1 Water Use Forecasting

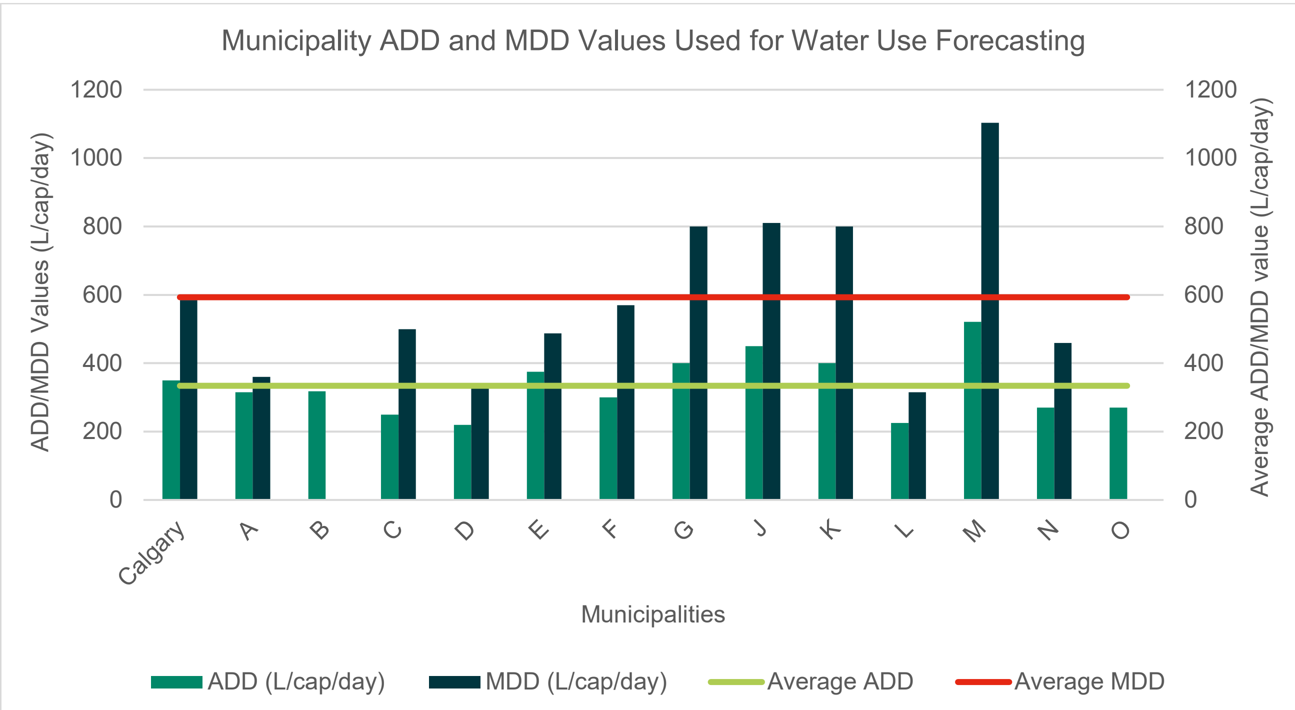

Figure 5-1: Municipality ADD and MDD Values

When comparing the City of Calgary's ADD and MDD values used for future water use forecasting, The City's values are in line with the group averages for both ADD (333 L/cap/day) and MDD (593 L/cap/day). The City values are based on historical data which is the same method used by 81% of survey participants. The City updates their values every 5 years and is in line with the group which updates their values every 5-10 years.

Five municipalities (D, E, F, K, and M) utilize different future ADD/MDD values in newly built/greenfield areas versus older/more established areas. The ADD/MDD values shown in Figure 5-1 are the municipality's greenfield values. These municipalities utilize historical data (SCADA, water metering, etc.) to estimate the ADD/MDD values for the area in question. Municipality D has an additional step where if a greenfield development has unique requirements, they will create an estimate of demands by combining residential and ICI data from existing areas that are similar to the area in question and apply those estimates to the greenfield area. Municipality H utilizes the same ADD/MDD values for densification within existing areas as they do for greenfield areas.

5.2 Water Loss Management

The following graphs show that water loss is a complex issue and is typically not a result of one single factor (e.g., the presence of cast iron pipe built in the 1950's and 1960's or the lack of a leak detection program). Although many municipalities share common factors (e.g., corrosive soils) that impact their water loss, the combination of contributing factors (e.g., pipe types, soils, metering, leak detection, corrosion protection, valve maintenance, service renewal etc.) are often unique to a municipality and must be considered holistically to address water loss.

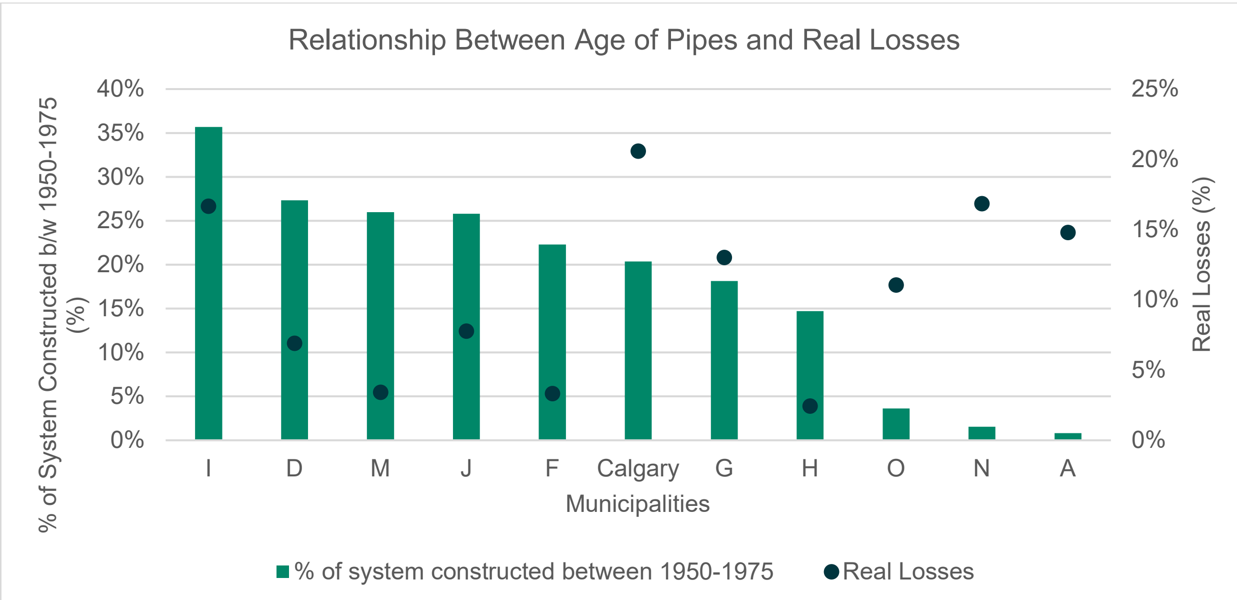

Figure 5-2: Relationship Between Age of Pipes and Water Loss

When reviewing The City's water loss, it was noted that there is not a clear singular relationship between the age of the pipes, in this case, between 1950-1975, and the municipality's real losses. It is shown in **Figure 5-2** that municipalities with more pipe installed between 1950-1975 do not necessarily have higher real losses. Municipalities A and N have less than 2.5% of their system installed between 1950-1975 and are experiencing real losses higher than the group median, 12%.

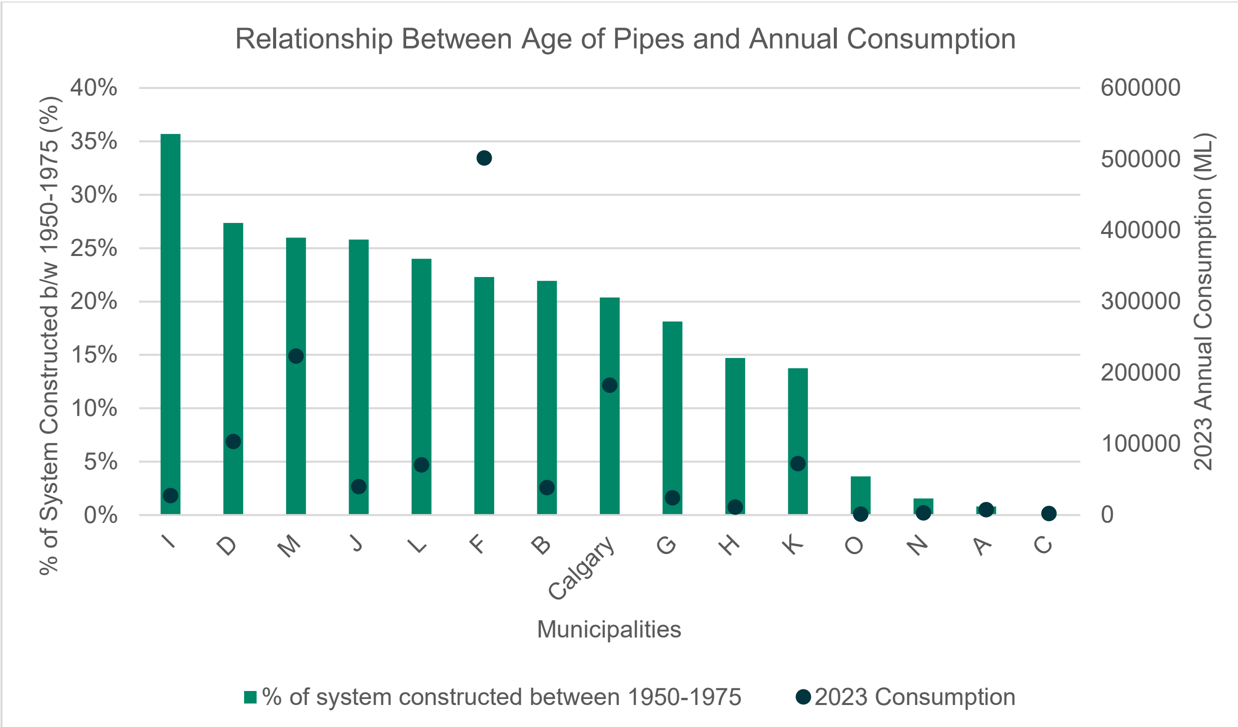

Figure 5-3: Relationship Between Age of Pipes and Annual Consumption

When reviewing The City's annual consumption, it was noted that there is not a clear singular relationship between the age of the pipe, installed between 1950-1975, and the municipality's annual consumption. It is shown in **Figure 5-3** that municipalities with more pipe installed between 1950-1975 do not necessarily have higher consumption rates. Municipality **I** has 15% more of its system installed between 1950-1975 than the City of Calgary and has less than half the consumption.

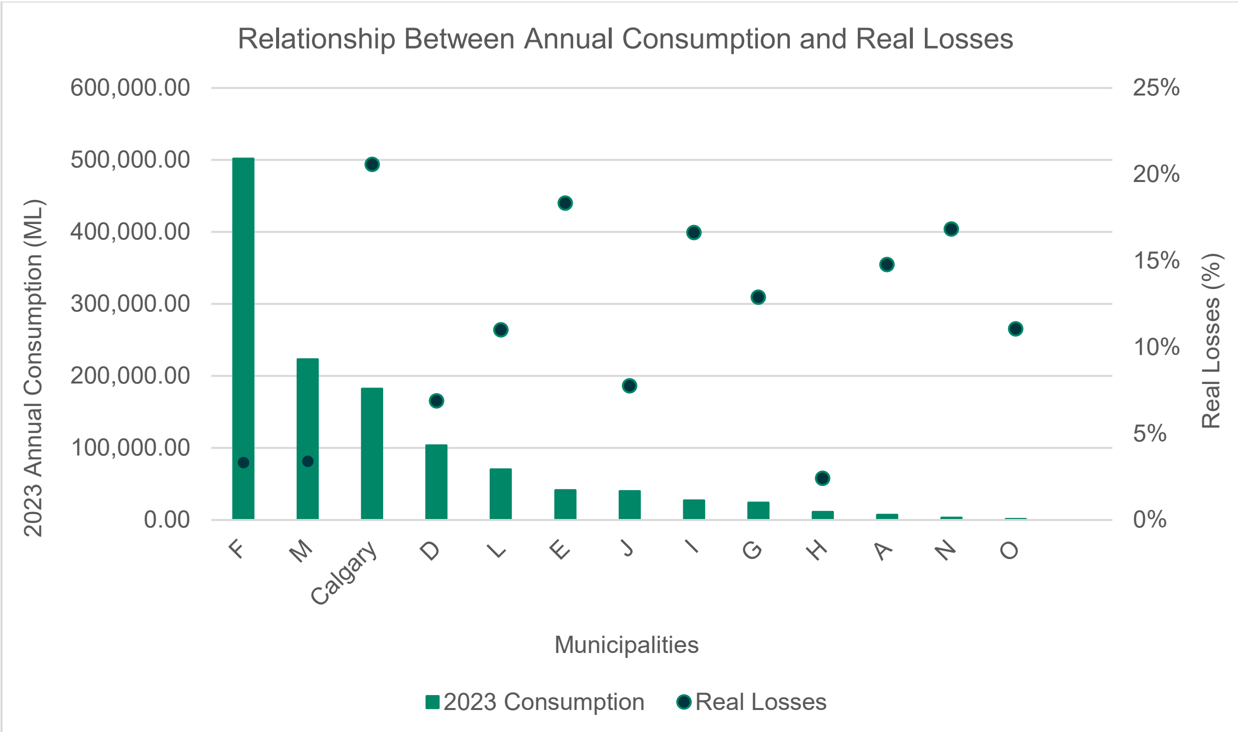

Figure 5-4: Relationship Between Annual Consumption and Real Losses

Figure 5-4 above shows that a municipality with higher annual consumption does not necessarily have higher losses.

The following three figures, **Figure 5-5**, **Figure 5-6**, **Figure 5-7** and **Figure 5-8** illustrate that there is not a clear singular relationship between pipe material and age of pipe with real losses.

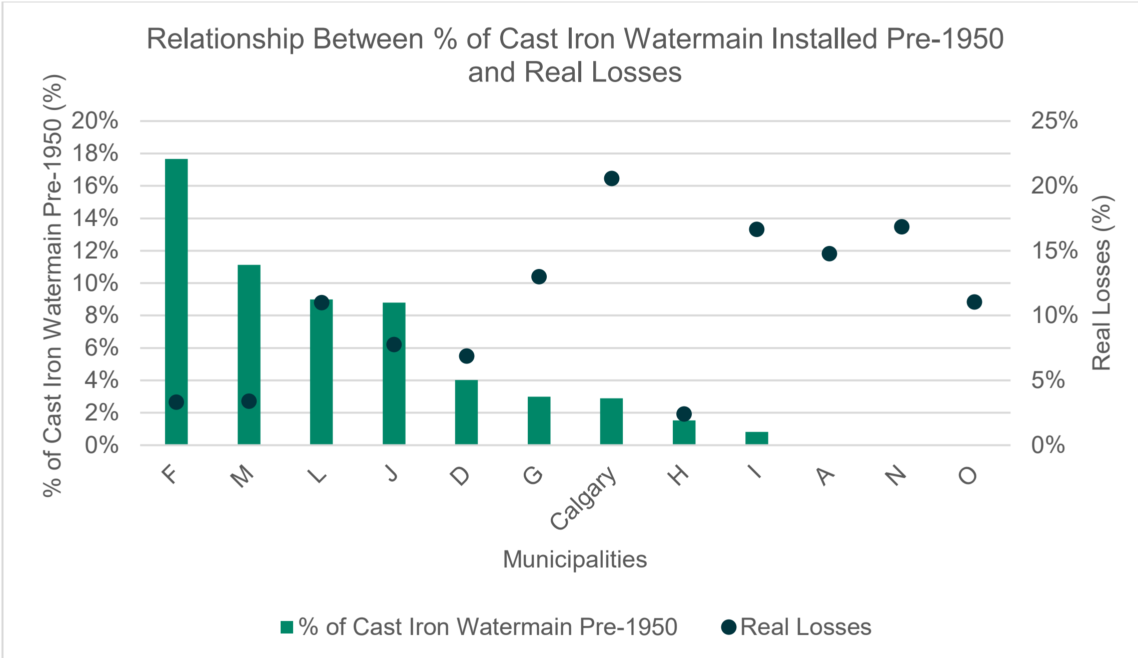

Figure 5-5: Relationship Between % of Cast Iron Watermain Installed Pre-1950 and Real Losses

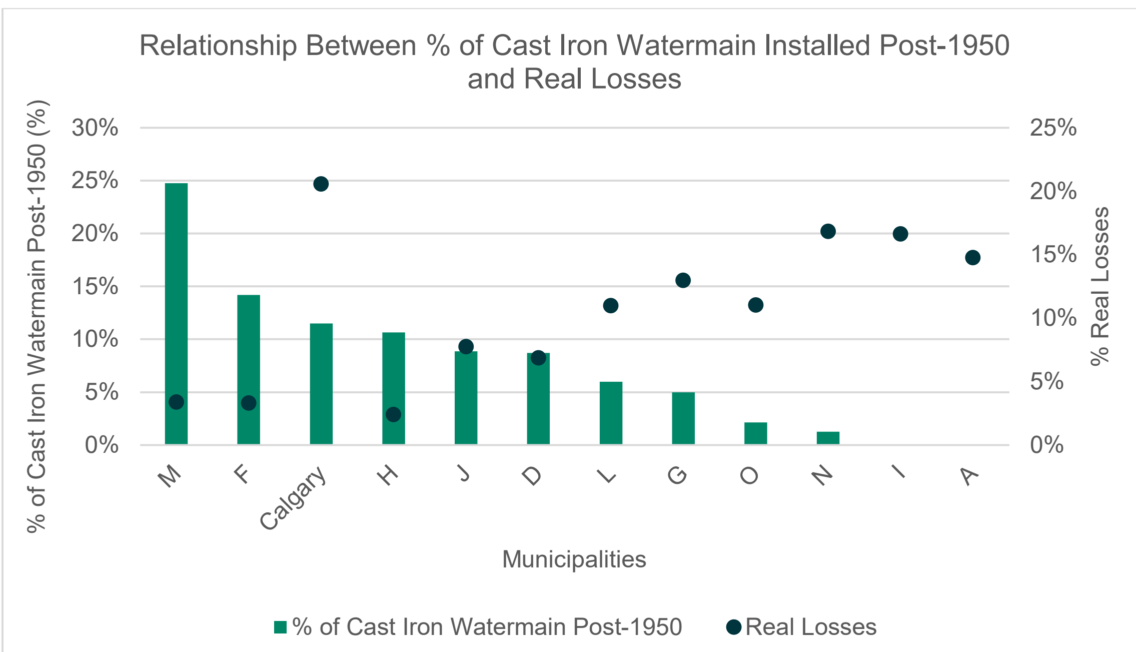

Figure 5-6 Relationship Between % of Cast Iron Watermain Installed Post-1950 and Real Losses

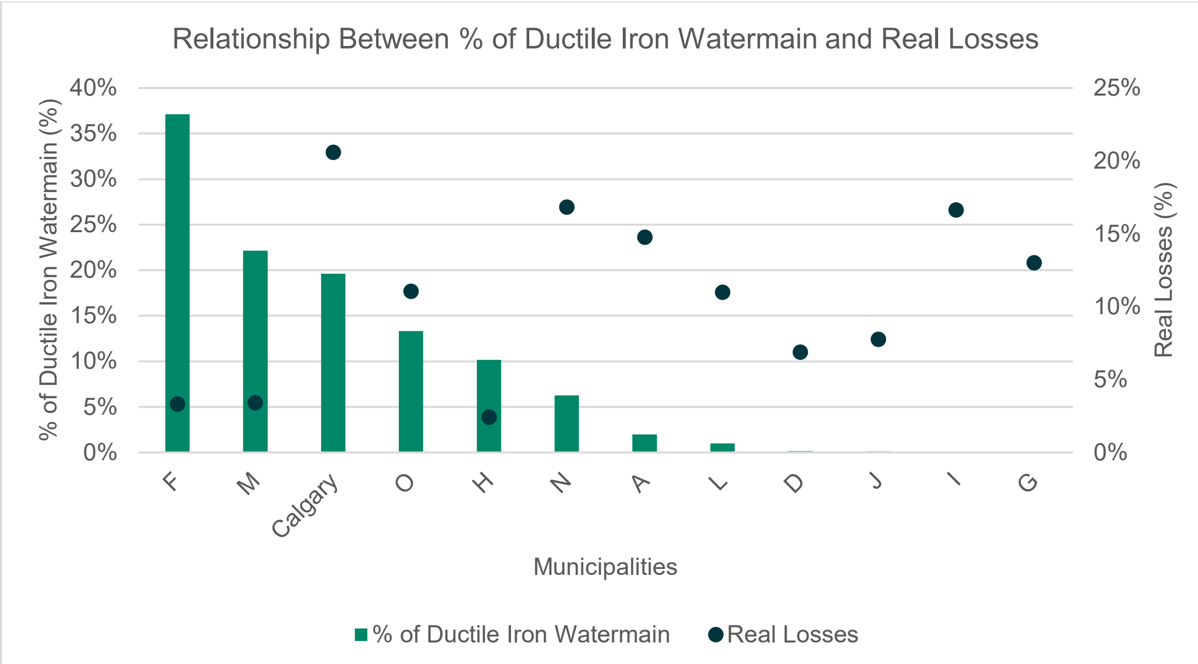

Figure 5-7: Relationship Between % of Ductile Iron Watermain and Real Losses

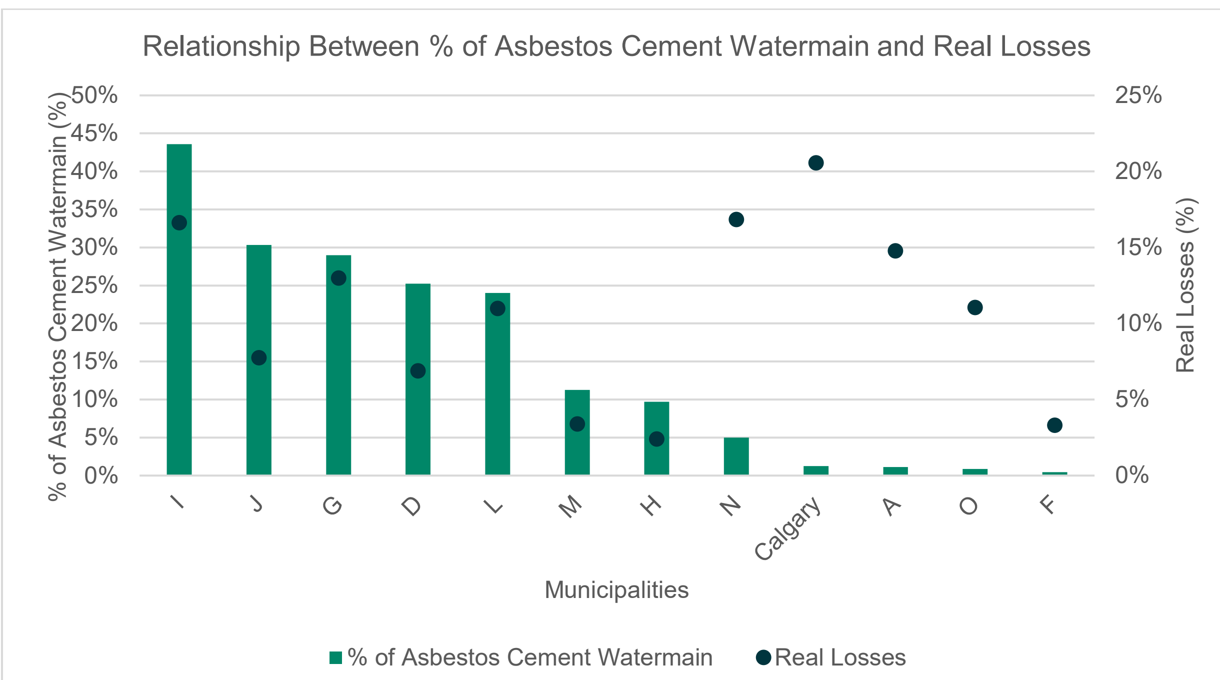

Figure 5-8: Relationship Between % of Asbestos Cement Watermain and Real Losses

The City of Calgary, along with Municipality C, E, I, and L have seen their water loss increase slightly over the last 10 years. The City noted an increase from an ILI of 3 in 2015 to an ILI of just over 4 in 2023. Municipality E noted an ILI of 3 in 2014 which increased to an ILI of 3.7 in fiscal year 2023/2024.

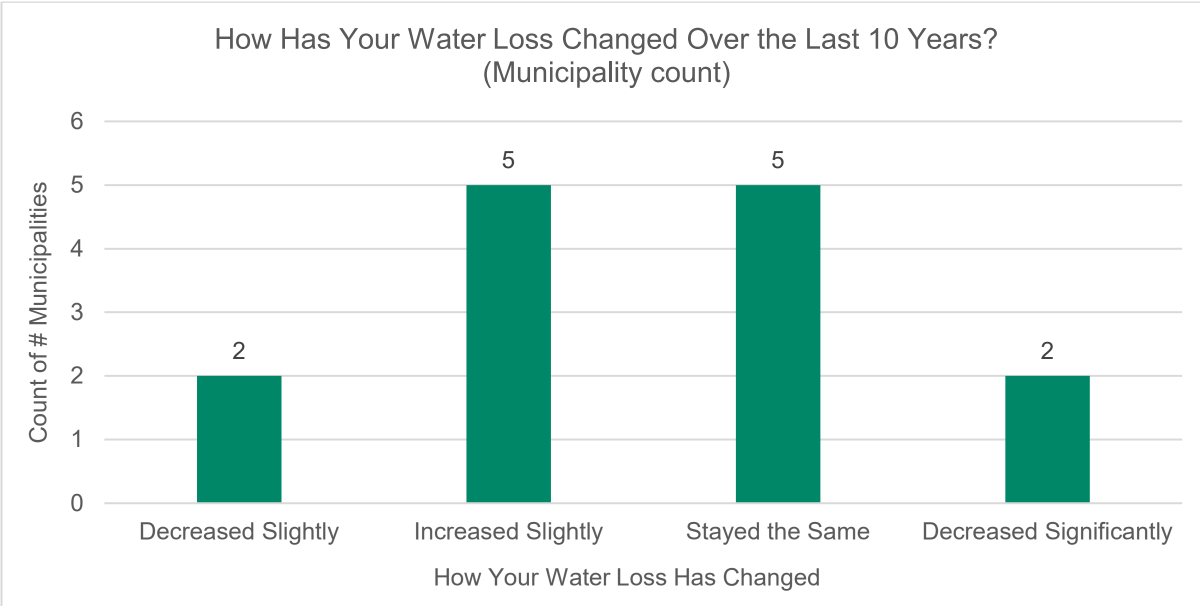

Figure 5-9: How Water Loss Changed Over 10 Years

The City, along with 12 other survey participants noted that services were a significant source of water loss as shown in **Table 5-1**.

Table 5-1: Sources of Water Loss

	City of Calgary	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Services	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓		
Pipes					✓	✓	✓			✓		✓		✓	✓	✓	
Joints			✓			✓		✓			✓	✓		✓		✓	✓
Meters							✓					✓	✓				
Hydrants											✓	✓					
Valves											✓						✓
Other							✓										

With approximately 50% of a service connection being privately owned, it is difficult for a municipality to properly manage water loss at these sources. It is also worth noting that service connections have a shorter service life than, for example, a watermain, and therefore as a system ages it is often the service connections which start to fail first.

As shown in **Figure 5-10**, it is clear that having a proactive leak detection program alone does not equate to minimal real losses. The two municipalities without a leak detection program have similar losses to those with a leak detection program

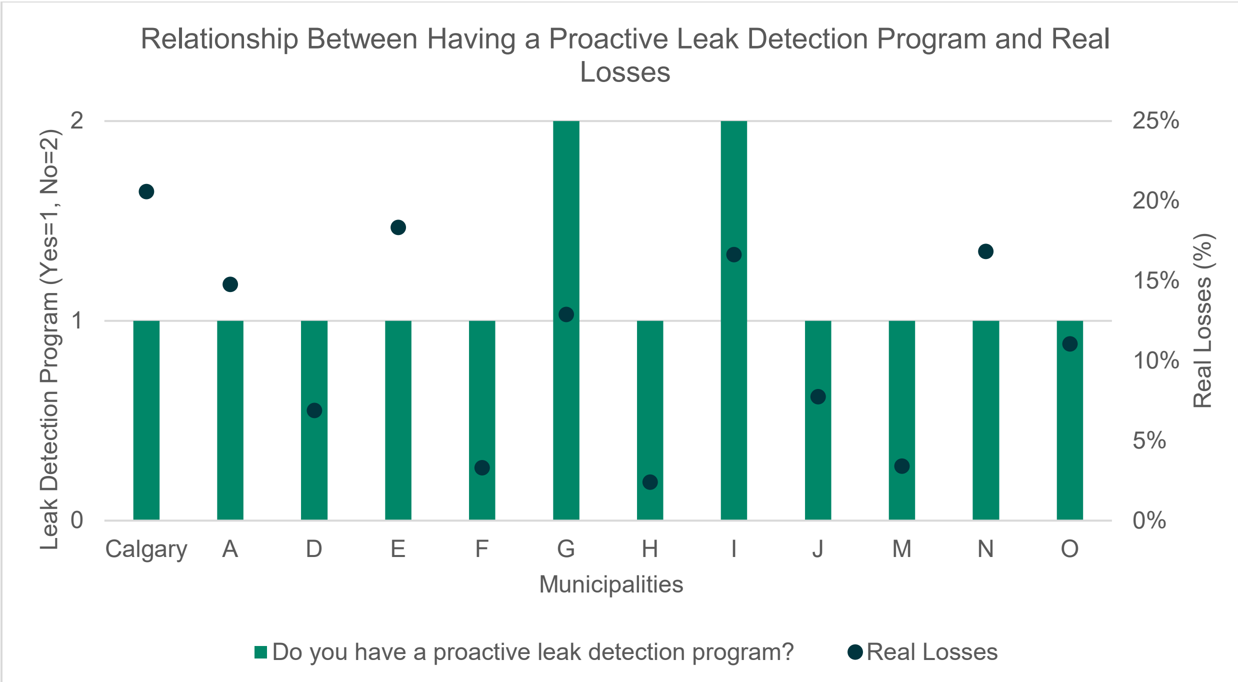

Figure 5-10: Relationship Between Having Proactive a Leak Detection Program and Real Losses

As shown in **Figure 5-11**, The City has more cathodic protection and polyethylene encasement in their system than the group median (4% for both cathodic protection and polyethylene encasement).

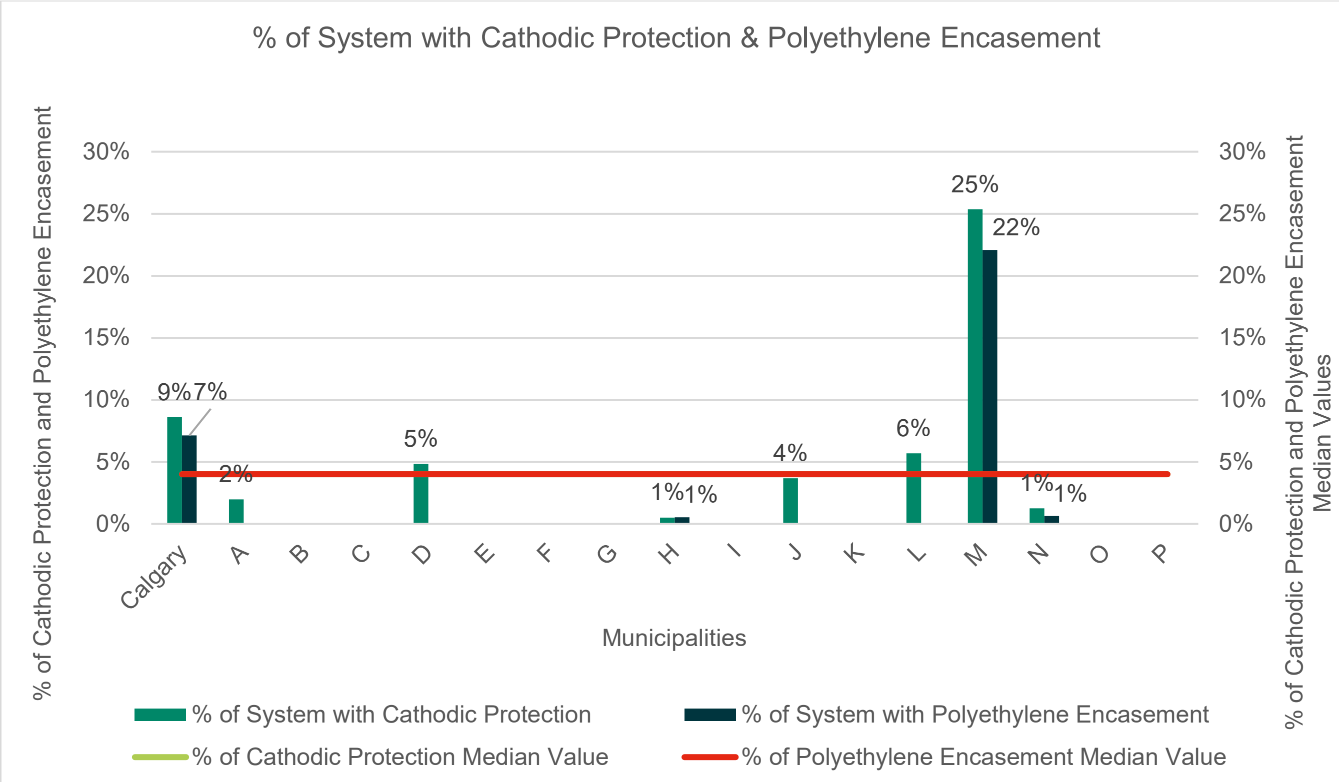

Figure 5-11: % of System with Cathodic Protection & Polyethylene Encasement Group Median

Figure 5-12 and **Figure 5-13** both show that there is no clear singular relationship between a municipality's size of their system, shown by its number of service connections and total length of watermain, and their real losses.

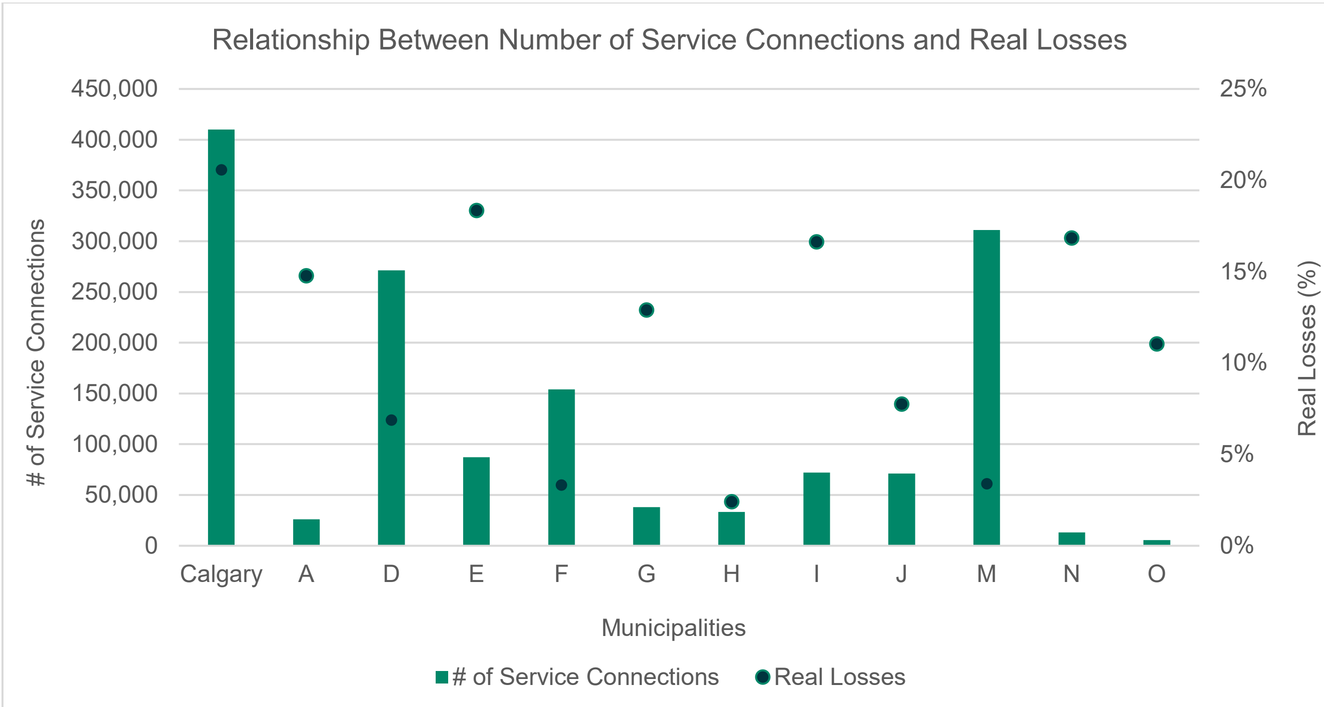

Figure 5-12 Relationship Between Number of Service Connections and Real Losses

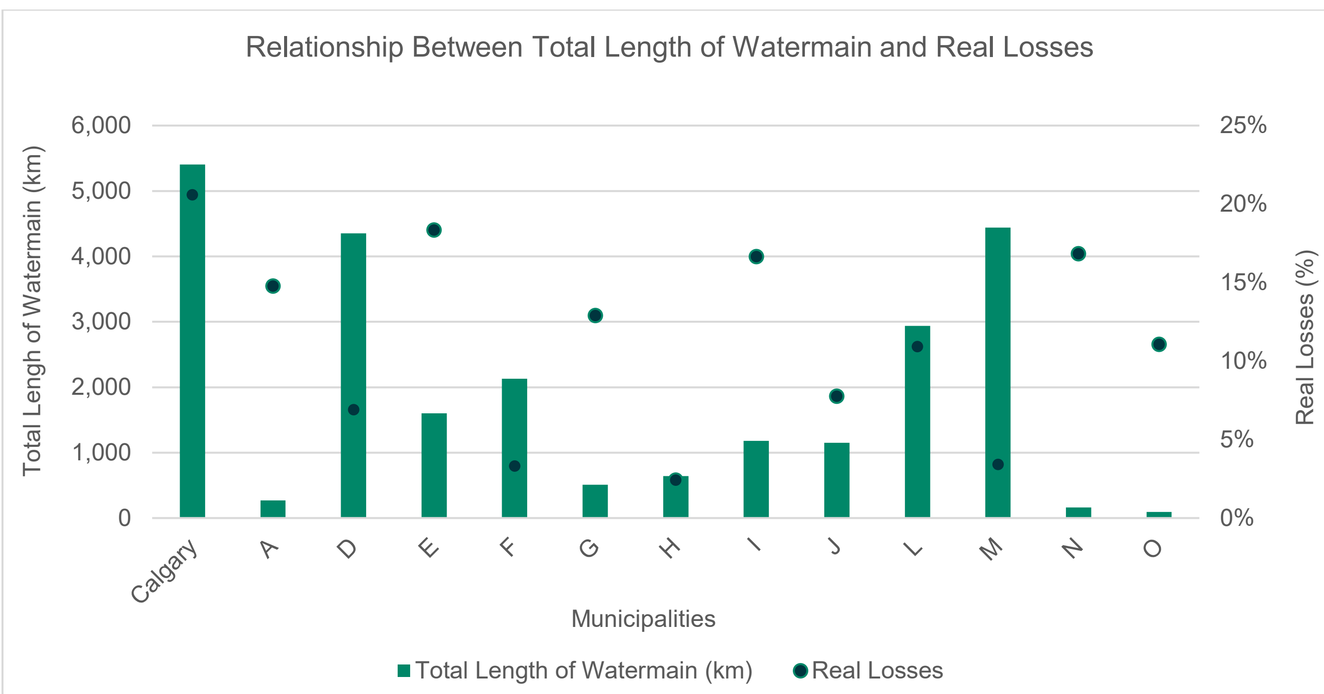

Figure 5-13 Relationship Between Total Length of Watermain and Real Losses

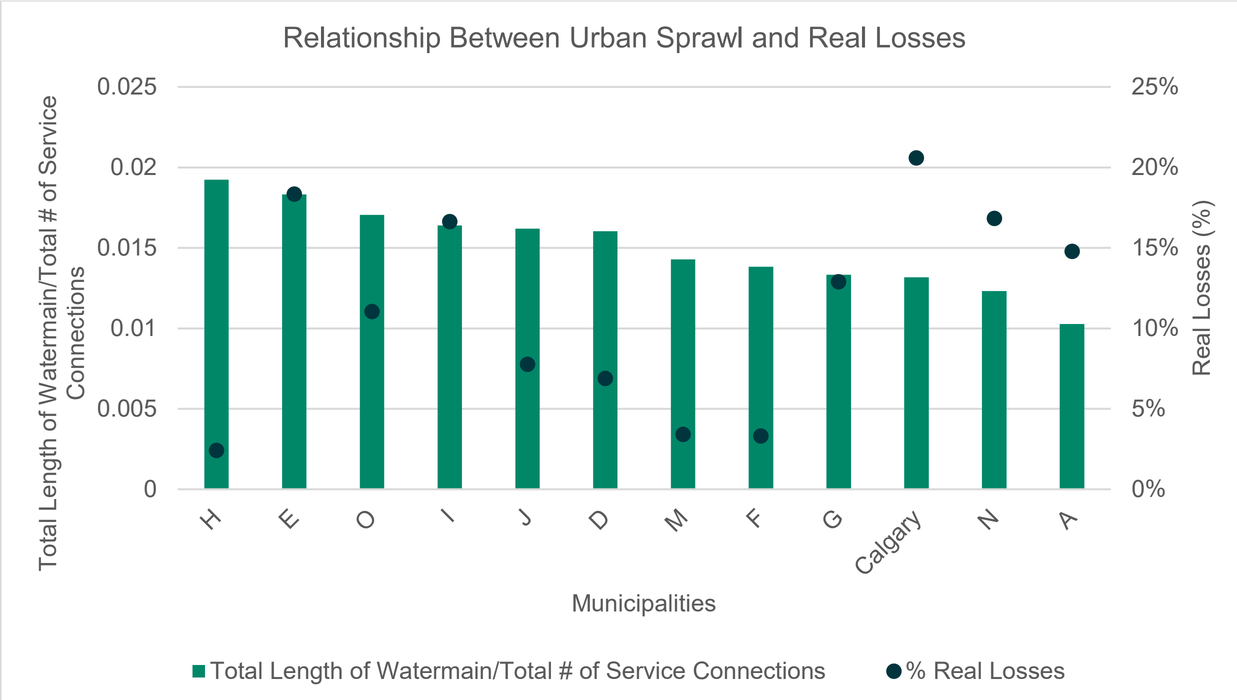

Figure 5-14 Relationship Between Urban Sprawl and Real Losses

Further to **Figure 5-12** and **Figure 5-13**, **Figure 5-14** explores the relationship between urban sprawl and real losses. For this graph, the municipality's total length of watermain is normalized by its total number of service connections. A higher ratio would indicate a municipality which is more spread out (i.e. greater length of watermain between service connections), and a lower ratio would indicate a more densified municipality (i.e. lower length of watermain to service connections). As seen in the graph, there isn't a clear relationship between a densified municipality, a municipality with urban sprawl, and real losses.

Appendix A. Final Survey

Water Survey Questions

Confidentiality Agreement
Detailed results of this survey will be shared with the City of Calgary, AECOM and, if requested, the other municipalities who choose to participate. If you would like to participate but do not want your results shared with the other municipalities, please let AECOM know by November 22, 2024; in this case your results will remain confidential within the City of Calgary and AECOM's project team. Only anonymized results will be included in the final public report to show comparisons to the City of Calgary. If requested, the final report can be shared with survey participants.

Question		Response Type
1.	Please Provide Your Contact Information: Name Municipality Email	Text Input
Water Use Forecasting		
2.	Have you forecasted your future water use for the purpose of large infrastructure planning?	Yes/No
3.	Do you use different future water use rates for MDD and/or ADD in newly built/greenfield areas vs older/more established areas for planning required infrastructure?	Yes/No > Text Input
4.	What residential and ICI values do you use for future water use forecasting (e.g., MDD and ADD litres per capita per day)? Please specify unit of measure.	Text Input
5.	How were the values for MDD and ADD determined (e.g., based on historical data or anticipated future rates)? How often do you update them and how far into the future do you project your water use?	Text Input
Water Loss Management		
6.	Do you calculate your water loss?	Yes/No
7.	If you have quantified your water loss, which metric(s) do you use and what is the value(s)? - ILI: ______ - Real losses: ______ - UARL: ______ - Other: _____	Check boxes & Comment Fields
8.	How has your water loss changed over the last 10 years? If you have quantified the change in water loss over the last 10 years, please note it in the comment box. - decreased significantly - decreased slightly - stayed the same - increased slightly	Check boxes & Comment Field

	- increased significantly If you have quantified the change in water loss over the last 10 years, please note it below:_____	
9.	What is your total length of pipe with corrosion protection (cathodic protection vs polyethylene encasement)? Please specify unit of measure. Cathodic Protection: ____ Polyethylene Encasement: ____	Text Input, separate inputs for cathodic protection vs polyethylene encasement
10.	How many watermain breaks (total) did you have in 2023?	Text Input
11.	What length of your system have you relined and please note the main driver(s) for your watermain relining (e.g., structural, water loss, etc.)? Please specify unit of measure for the length of system relined.	Text Input
12.	What length of the system do you flush by (uni-directional flushing) each year? Please specify unit of measure.	Text Input
13.	Do you use any of the following forms of permanent monitoring? (Select all that apply) Zone metering District metering, Other (please specify)	Check boxes
14.	Do you meter the water used by contractors for: - Flushing: ______ - Commissioning: ______ - Construction: ______ - Other (please specify): _________________	Check boxes & Comment Fields
15.	What percentage of valves do you cycle each year?	Text Input
16.	What percentage of hydrants do you inspect each year?	
17.	How many service connection breaks did you identify in 2023?	Text Input
18.	Do you think the any of the following are significant sources of water loss: - Pipes - Joints - Hydrants - Valves - Services - Meters - Other (please specify): _____	Select all that apply & Text Input
19.	Do you understand the differences in your water loss by geographic area (e.g. different soils/pipe era etc)?	Text Input
20.	Do you have a proactive leak detection program?	Yes/No > Text Input

21.	What was the total length of watermains tested for leakage in 2023? Please specify unit of measure and techniques used.	Text Input
22.	Please describe any water loss reduction initiatives, noting what has worked and what hasn't.	Text Input
Basic Water Distribution System Information		
23.	What was your total water consumption in 2023 (water entering your distribution system minus water sold to regional customers)? Please specify unit of measure.	Text Input
24.	What was your average residential water consumption in 2023 (e.g. total metered residential customer /metered population)? Please specify unit of measure.	Text Input
25.	What is your total length of watermain? Please specify unit of measure.	Text Input
26.	What length of cast iron watermain from pre-1950 do you have? Please specify unit of measure.	Text Input
27.	What length of cast iron watermain from post-1950 do you have? Please specify unit of measure.	Text Input
28.	What length of ductile iron watermain do you have? Please specify unit of measure.	Text Input
29.	What length of Asbestos cement watermain do you have? Please specify unit of measure.	Text Input
30.	What length of water pipe was constructed in the period from 1950-1975? Please specify unit of measure.	Text Input
31.	How many service connections do you have?	Text Input
32.	What percentage of your service connections are metered?	Text Input
33.	What is your average operating pressure? Please specify unit of measure.	Text Input
Customer Billing		
34.	Which of the following describe your water rate structure for charging customers? Select all that apply. - Flat rate - Uniform rate - Fixed charge - Declining block rate - Inclining block rate - Fire protection charge - Other (please specify)	Check boxes
35.	What is your water volumetric rate (e.g., $ per m^3)? Please specify unit of measure.	Text Input
36.	Please record the approximate percentage of meters that are read using the methods listed below (this should add to 100%): - Manual: visual reading or electronic or onsite download - Download by radio: drive by AMR, electronic - Download by radio: fixed AMI, electronic - Download by phone	Text input for each

	- Other	
Environmental Considerations		
37.	Do you have geotechnical conditions that may impact the amount of leakage and/or the ability to detect leakage? Corrosive soils Clay-based soils Primarily gravel Other (please specify):	Select all that apply & Text Input
38.	Do you find seasonal use/conditions affect system leakage (e.g., increase in breaks during cold weather events or summer peaks)?	Yes/No > Comment Field