
# WATER MAIN RENEWAL PLAN

2025

**BY:**
ASI Engineering

**DATE:**
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# Executive Summary

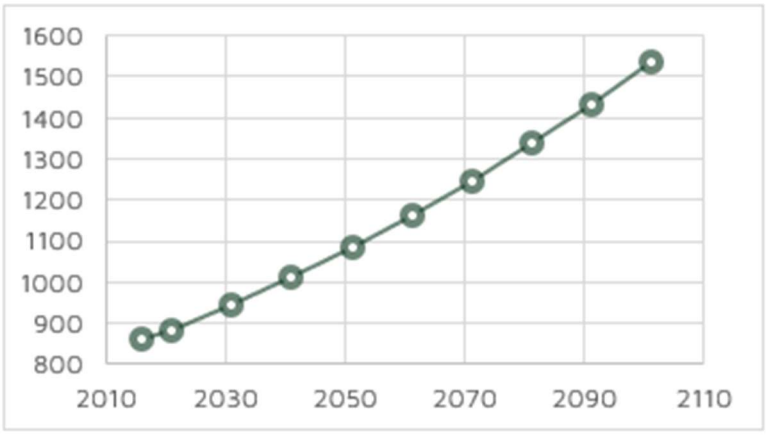
The Town of Leader maintains a municipal water distribution system consisting of **22.4 km** of water mains. The network is predominantly constructed of Asbestos Cement (AC), Polyvinyl Chloride (PVC), and Ductile Iron (DI) pipes, as shown in Table 1 below.

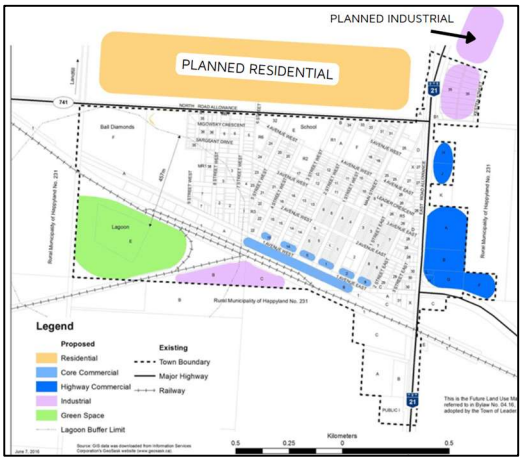
**Table 1 Water System Overview**

| Material | Length (m) | km | Percent | Average Install Year | Average Age | Estimated Useful Life | Remaining Life |
|---|---|---|---|---|---|---|---|
| PVC | 6,548 | 6.55 | 29.3 | 1999 | 26 | 80 | 54 |
| DI | 6,590 | 6.59 | 29.5 | 1960 | 65 | 60 | -5 |
| CI | 23 | 0.02 | 0.1 | 1955 | 70 | 60 | -10 |
| AC | 9,102 | 9.10 | 40.7 | 1970 | 55 | 60 | 5 |
| Copper | 104 | 0.10 | 0.5 | 1965 | 60 | 50 | -10 |
| **TOTAL** | **22,367** | **22.37** | **100** | **1970** | **55** | | |

Leader has experienced steady population growth, projected to reach approximately 1,537 residents by 2101. The Town's Official Community Plan previously identified **28 hectares** of development along Highways 21 and Township Road 224, which have now been fully built. **Future expansion** is planned north of Township Road 224 for residential growth and further industrial development north of the existing industrial area to the Northeast. Figure 1 below highlights this information.

**Figure 1 Predicted Population Growth (left) and 2025 Growth Plans (right)**




A key focus of this plan was to ensure that future growth and intensification are properly accounted for. Current average water demand is 227 $m^3$/day, with projected future demand reaching **396 $m^3$/day**. A detailed engineering design will be required to confirm system capacity issues and ensure infrastructure investments support long-term growth, reliability, and fire protection.

Over the past 7 years, the Town has recorded **76 water main breaks**, almost 11 a year on average. This underscores a key conclusion of this plan: deferring renewal leads to higher long-term costs and more frequent service interruptions.

For the current 2025 year, this plan identifies **7.3 km** of priority mains for replacement based on material vulnerability, system age, and potential service impact. These mains are shown highlighted red in the next figure.

**Figure 2 Water Mains Marked for Renewal**


The **estimated capital cost** to complete the recommended renewals is approximately **$15.8 million**.

**Unpaved** = 427m x $1,516.67/m = **$647,618**
**Partial Paving** (Half Road Width) = 6,868m x $2,204.60/m* = **$15,141,193**

The table below highlights three funding scenarios at 3% inflation per year:

**Table 2 Funding Scenario Overview**

| Scenario | Timeline | Annual Investment Required | Total | Notes |
|---|---|---|---|---|
| **A** | 7 Years | ~$2.47 million/year | ~$17,282,000 | Maximizes short-term grant opportunities; high annual cost; reduces the most risk |
| **B** | 10 Years | ~1.81 million/year | ~$18,099,000 | Balanced pace; manageable costs; aligns with phased funding and risk |
| **C** | 15 Years | ~1.31 million/year | ~$19,576,000 | Lowest yearly cost; higher risk of failure and service disruption. Highest Total Cost |

The final decision rests with Town Council to select the scenario that best fits the available budget while balancing risk and cost. ASI recommends the 10-year option as the most appropriate balance between financial feasibility and service reliability. Key recommendations are listed on the following page.

## Key Recommendations

1. **Adopt a 10-Year Replacement Plan Focused on High-Risk Infrastructure**
   Implement the 10-year phased water main replacement plan outlined in *Section 7.0*, targeting approximately 7.3 km of aging water mains at a total estimated cost of $15.8 million. This strategy focuses on the Town's most failure-prone segments—including Ductile Iron (DI), Cast Iron (CI), Asbestos Cement (AC), and Copper—as detailed in *Section 5.2 Prioritization Strategy* and the system inventory in *Section 2.2*. The plan balances cost, risk, and service reliability while phasing construction to align with the Town's financial capacity.

2. **Secure Council Support, Increase Budget, and Pursue Grant Funding**
   Work with Council to implement the financial pathway recommended in *Section 5.5 Financial Strategy*, including annual capital budget increases. Pursue external grant funding through the CHIF program, combined with other sources such as Municipal Revenue Sharing (MRS) and the Canada Community-Building Fund (CCBF), as outlined in *Section 5.4 Funding Scenario Overview*, to reduce the financial burden on local ratepayers and accelerate implementation.

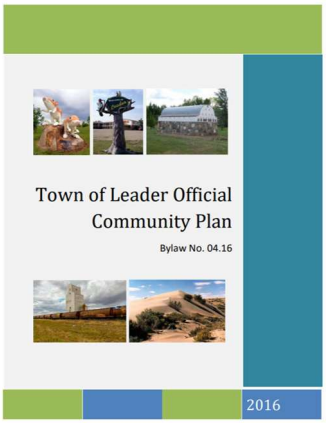
3. **Plan for Replacement of the Raw Water AC Pipeline**
   As recommended in *Section 5.3 Total Cost of Renewal Plan*, defer the replacement of the 8.5 km raw water AC pipeline from the South Saskatchewan River until after the 10-year replacement program concludes. Continue monitoring its condition and include it in the next capital planning cycle if signs of deterioration or failure emerge.

4. **Strengthen Inter-Municipal Coordination**
   Engage neighboring RMs to explore cost-sharing opportunities for infrastructure renewal along shared corridors such as Township Road 224 and Range Road 3264, as discussed in *Section 3.1* on future land use and development areas.

# 1.0 Introduction

This Water Main Renewal Plan has been developed to guide the long-term renewal and investment strategy for the Town's municipal water distribution system. It outlines the current condition of the network, identifies high-priority segments through a risk-based assessment, and proposes a phased replacement strategy that balances technical need with financial feasibility. The plan is specifically tailored to the Town of Leader, emphasizing practicality, data-informed decision-making, and alignment with available local resources.

## 1.1 Alignment with Municipal Priorities




This Renewal Plan supports several key policy directions identified in the Town of Leader's Official Community Plan[1] (Bylaw 04.16). Specifically, it responds to Council's commitment to:

1. **Enhancing infrastructure systems** in a timely and efficient manner to meet updated standards (OCP Sec. 2.3, 3.10);
2. **Maintaining a long-term asset management plan** to guide fiscally responsible infrastructure investment (3.10.5);
3. **Protecting water quality and source water** through proactive planning and risk mitigation (3.9);
4. **Pursuing intergovernmental partnerships** and funding opportunities to support infrastructure renewal (3.10, 3.12).

The Water Main Renewal Plan aligns with the Official Community Plan by directly addressing growth pressures, housing availability challenges, and known deficiencies in the water system. Aging infrastructure and recurring service disruptions have already limited development potential, including the ability to attract new residents and essential professionals. Proactive renewal of the water network is therefore essential to support both existing service demands and future residential growth.

## 1.2 Methodological Framework


This plan integrates elements from recognized best-practice frameworks to ensure technical robustness, policy alignment, and community relevance:

- **InfraGuide (2003)** – Provides a foundational structure for water distribution system renewal, including condition assessment and capital planning processes.
- **NRC Water Distribution Network Renewal Guide (2001)** – Supports integrated asset planning, scenario analysis, and long-term infrastructure management.
- **Risk Assessment Model for Water Main Renewal (2023)** – Introduces a simplified and scalable risk scoring system that incorporates material risk, system age, and public health considerations.
- **International Infrastructure Management Manual (IIMM, 2020)** – Informs asset inspection frequencies, condition grading models, and criticality-weighted risk matrices that guide defensible investment decisions.

[1] Town of Leader Official Community Plan, Bylaw No. 04.16, adopted June 7, 2016.

## 1.3 Benchmarking and Research

As part of this Water Main Renewal Plan, ASI conducted a targeted benchmarking review of municipal water renewal strategies across Saskatchewan. The findings informed the plan structure, prioritization matrix, and communication approach. The following tables summarize the findings.

**Table 3 Municipal Benchmark Summary**

| Municipality | Key Practices |
|---|---|
| North Battleford, SK | Multi-utility integration (UPAR); public updates via website and community engagement tools. |
| Moose Jaw, SK | Cast iron main replacement guided by break history; LIP used for resident cost-sharing. |
| Wynyard, SK | Practical, locally driven renewals; direct input from CAO; limited formal documentation. |
| Regina, SK | Long-range planning; ICIP funding; detailed cost bands; strong communications. |
| Saskatoon, SK | LOS framework; renewal triggered by break thresholds; risk-based capital planning. |

**Table 4 Water Main Replacement Cost Benchmarking**

| Municipality | Repair Category | Notes | Unit Cost* |
|---|---|---|---|
| Wynyard | Intermediate (avg. 2021–2024) | Includes water main replacement and road repaving | $2,241/m |
| Moose Jaw | Intermediate (2km a year) | Basic replacement + milling & paving of roads, and minor sidewalk repairs | $2,200/m |
| Regina | Basic | Trenching and fill/compaction with gravel, Temporary water, disinfection, testing only | $2,900/m |
| | Intermediate | Adds road repaving | $3,400/m |
| | Advanced | Full utility/street replacement; highly variable (e.g. 11th Ave & Dewdney) | Not provided. Estimated $4500-$10,000+/m |
| Saskatoon | Intermediate (estimated) | Based on $3.18B over 1,192,000 m | $2,667/m |
| Synergy Construction | 5 – Basic Main Replace (per m) | Class D estimate based on an expected max cost using proper construction techniques, with assumptions made for fluctuating prices and site-specific details. Minor differences between material type and size. Includes demolition, disposal, material, labour. Assumes an average soil type. | $1200-1344/m |
| | 4 – Partial Paving (sq m) | | additional $150/sq m |
| | 3 – Intermediate (sq m) | | additional $300/ sq m |
| | 2 – Expanded Scope (sq m) | | additional $223/sq m |
| | 1 – Advanced | | Not provided. |

*Note: Unit costs rates above reflect full replacement, including construction, engineering, traffic control, and limited paving, assuming average soil conditions. Inflation and contingency allowances are included to align with typical Saskatchewan municipal projects.

On average, the unit cost for replacing a water main is estimated at

- $1,516.67/m for unpaved segments and
- $2,204.60/m for paved segments (half road width).

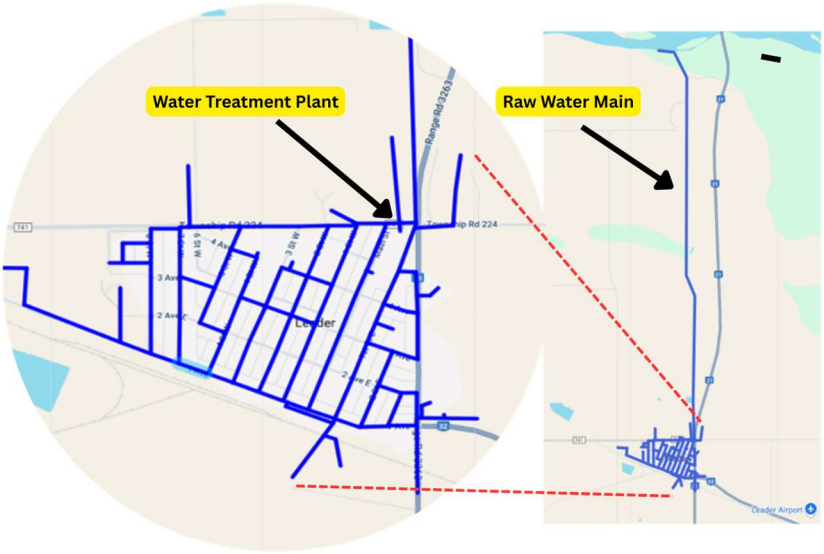
These benchmarks reflect industry best practices while remaining appropriate for Leader's local context, available resources, and current infrastructure maturity. The following section provides an overview of Leader's water main system.

# 2.0 System Overview

## 2.1 Water Distribution Profile

The Town of Leader manages a water distribution network totaling **22.4 km**. The network includes a range of pipe materials, with a notable portion dating back many decades. The figure below is a split overview of the Towns' water main system from the SilverSmith software.

**Figure 3 Location of Water Mains in Leader**




Notable segments include the core distribution network within the main body of the Town, the long northern main supplying raw water from the South Saskatchewan River, and a small diameter line extending west through baseball diamonds.

## 2.2 Pipe Diameter and Material

The Town's water distribution network consists of a mix of legacy and modern materials. Install years were estimated for most segments due to data inconsistencies in SilverSmith and confirmation from Town staff. Older DI and AC mains pose higher risk due to age and deterioration, while PVC make up the newer, more reliable portions. Pipe diameter and material data from SilverSmith informs the risk-based prioritization in this plan. The current breakdown by material is shown below:

**Table 5 Water Main System Summary**

| Material | Length (m) | km | Percent | Average Install Year | Average Age | Estimated Useful Life | Remaining Life |
|---|---|---|---|---|---|---|---|
| PVC | 6,548 | 6.55 | 29.3 | 1999 | 26 | 80 | 54 |
| DI | 6,590 | 6.59 | 29.5 | 1960 | 65 | 60 | -5 |
| CI | 23 | 0.02 | 0.1 | 1955 | 70 | 60 | -10 |
| AC | 9,102 | 9.10 | 40.7 | 1970 | 55 | 60 | 5 |
| Copper | 104 | 0.10 | 0.5 | 1965 | 60 | 50 | -10 |
| **TOTAL** | **22,367** | **22.37** | **100** | **1970** | **55** | | |

As shown above, CI and Copper lines are the oldest in the system, averaging 10 years beyond their expected service life. However, due to their limited total length, this plan focuses on **Ductile Iron (DI)** mains (averaging 5 years past service life) and **Asbestos Cement (AC)** mains (with approximately 5 years

remaining). The AC raw water line from the South Saskatchewan River to the Town has been excluded from the financial analysis within Section 5.0 due to its significant length and historically low break rate.

The figures below are an overview of pipe material and diameter from the SilverSmith software.

**Figure 4 SilverSmith Pipe Material (left) and Pipe Diameter (right) Summary Map**


Excluding the AC raw water line from the river, key observations from the figure above include:

- Ductile Iron (DI/DIP) constitutes the largest portion of the network and is associated with aging infrastructure, brittle failure risks, and potential water quality concerns.
- PVC also represents a significant share but is considered a low-risk material due to being a newer type of material that resists corrosion. Typically found in newer subdivisions and the others confined to isolated segments.
- The remaining materials (AC, Copper, CI) make up a small share.

*• **DI and AC mains (excluding the raw water line) make up 32%** of the system and are at or beyond service life.*
*• **PVC (29%)** has ~54 years of remaining life and low renewal priority.*

It also highlights that the majority of water mains are 6 inches in diameter, with notable exceptions including a 1 & 2-inch line extending west, south, and to local farms. Pipe diameter must be considered when planning for future growth to ensure adequate capacity over the 80-year horizon of this plan, the EUL of PVC.

*New **PVC** mains have an 80-year estimated useful life*

Overall, the system's material composition, pipe sizing, and installation history provide the foundation for understanding current limitations and planning for future capacity needs, as explored further in Section 3.0.

# 3.0 Growth and Capacity Assessment

This section highlights the importance of designing water mains that not only meet current needs but also support future growth. It aligns with the Town's land use and housing objectives, enhancing eligibility for infrastructure funding. The analysis identifies areas of projected development, assesses current system capacity, and outlines estimated upgrades over an 80-year horizon. Recent input from Council and the CAO reinforces the urgency of this planning, especially given missed healthcare recruitment opportunities tied to a shortage of available housing, and through multiple Planning and Development Meetings.

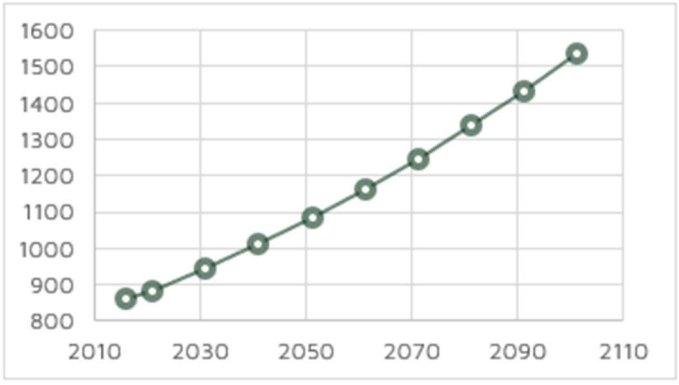
## 3.1 Population & Land Use Growth

Leader has experienced modest but consistent population growth over the past decade. According to 2021 census data from Statistics Canada, the population increased by 5.1% between 2011 and 2016, followed by a further 2.1% increase from 2016 to 2021, rising from 863 to 881. This positive trend indicates a gradual but steady increase in population, supporting the need for long-term infrastructure planning.

Using this historical data, long-range population projections have been developed for an 80-year planning horizon. These projections assume an average 5-year growth rate of approximately 3.6%, or **7.2%** over a 10-year period, reflecting a continuation of recent trends.

**Table 6 Estimated Population Growth**

| Year | Population | % Change |
|---|---|---|
| **2016** | 863 | +5.1 |
| **2021** | 881 | +2.1 |
| **2031** | Estimated 944 | Estimated +7.2 |
| **2041** | 1012 | ... |
| **2051** | 1085 | ... |
| **2061** | 1163 | ... |
| **2071** | 1247 | ... |
| **2081** | 1337 | ... |
| **2091** | 1433 | ... |
| **2101** | 1537 | +7.2 |




*The Town's projected population growth of **75% by the year 2101** supports strong justification for infrastructure investments that enable housing growth.*

The Town of Leader's Official Community Plan (OCP) shown below identifies up to 28 hectares of future development, primarily concentrated in the northwest quadrant. In addition, the OCP designates commercial and industrial corridors along Highways 21 and Township Road 224. As of 2025, these areas have already been developed, with future plans for a large portion of residential zoning north of Township Road 224, and the current industrial area expanded further north.

**Figure 5 Future Land Use Concept from OCP (Left) & Current 2025 Additions (Right)**


Coordinating land development with water infrastructure investment will be essential to support continued growth and ensure long-term service reliability.

*There is **28 ha** of planned expansion that has already taken place since the OCP was created. With current 2025 plans looking for **large residential expansion** north of Township Road 224*

## 3.2 Water Demand & System Capacity

Future water demand in the Town of Leader must account for both domestic usage and fire protection requirements, especially as the community grows and land use intensifies. The next table highlights the important components of the water system, including current and future demand.

**Table 7 Water System Demand Summary**

| Metric | Value |
|---|---|
| Current Avg Daily Demand (2017-2024) – 881 people | 227.2 $m^3$/day |
| Current Demand per Person | 257.9 L/person/day or 0.258 $m^3$/person/day |
| Projected Demand (2101) – 1537 people | 396 $m^3$/day |
| Current Fire Flow Requirement (Max allowable) – estimated | 28.3 L/s (based on zoning/use) |
| Current Fire Volume Needed - estimated | 500 $m^3$ |
| Total Storage (raw reservoir + two treated water tanks) | 24,605 $m^3$ + 3,400 $m^3$ |
| In-Pipe Storage (13.8km*6inch average diameter) | 251.7 $m^3$ |

Current information from the Town indicates a demand of 227 cubic meters per day. Based on a projected 2101 population of 1,537 and an average daily consumption of 257.9 Litres per person per day, the anticipated future daily system demand will be approximately 396 cubic meters per day.

*Future water system demand is expected to exceed **390 $m^3$/day**, requiring upgraded capacity and fire flow reliability to support residential intensification and institutional growth.*

A portion of this demand can include non-revenue water, such as leakage and unmetered system losses. In systems with aging AC and DI mains, leakage can account for 20–30%[2] of total water use. For the Town of Leader, this could represent 45–68 $m^3$/day, highlighting the importance of targeted pipe replacement not only for capacity but also for operational efficiency and water conservation.

*According to the Canadian Water and Wastewater Association, communities with aging infrastructure lose **20–30% of total water demand** to leakage and unmetered system use.*

*This could equate to **45–68 $m^3$/day** of wasted water in the Town of Leader each day*

In addition to domestic consumption, fire flow capacity must be maintained across all residential, institutional, and commercial zones. Fire flow requirements from similar sized communities are estimated around 28 litres per second, depending on zoning and building type. Larger-use facilities—such as schools, care homes, or industrial buildings—require higher flows and redundant system capacity.

Current limitations in the water distribution network may impact the ability to meet these combined demand requirements. Specific segments could present capacity issues, particularly in growth and

[2] Canadian Water and Wastewater Association (CWWA). *Municipal Water and Wastewater Survey.* 2009.
American Water Works Association (AWWA). *Manual M36 – Water Audits and Loss Control Programs*, 4th ed., 2016.

redevelopment zones. A detailed **engineering design** will need to be conducted at the time of construction to confirm issues with individual pipe segments. This design process can highlight the following priorities:

- Upsizing existing mains in growth areas, for example from 100 mm to 200 mm, to improve fire protection and maintain pressure stability.
- Installing new trunk mains to support planned subdivisions and future residential expansion.
- Maintaining system looping to eliminate dead ends and enhance overall reliability.
- Coordinating water main upgrades with land releases, subdivision approvals, and roadway work to reduce costs and minimize disruption.
- Upgrading pumps where necessary to meet future system demands.

Any confirmed limitations present both a risk and an opportunity. Proactive investment in upsizing trunk mains and improving network connectivity will ensure that the system can support higher densities, increased fire protection standards, and future residential, commercial or institutional development. This, along with other contributing factors, highlights the need for a professional engineering design to accommodate future system demands.

*An **engineering design** is required to confirm and capacity issues, and proper sizing of mains within the Town, beyond population-based water demand calculations.*

# 4.0 Condition and Reliability

Section 4.0 highlights the deteriorating reliability of Leader's water distribution system, emphasizing the frequency and cost of pipe failures and service disruptions. Historical records and visual evidence point to recurring issues, underscoring the need for targeted renewal planning.

## 4.1 Break History and Leak Events

Available records from Town staff and historical observations identify several high-risk areas in the distribution system. While not all events are formally tracked, anecdotal and visual evidence confirms recurring problems. The following table summarizes water main break data in Leader from 2019 to 2025, including the number of breaks, actual repair costs, and inflation-adjusted totals projected to 2025 dollars.

**Table 8 Break History 2019-2025**

| Year | # of Breaks | Inflated Cost 2025 | Location |
|---|---|---|---|
| 2019 | 20 | $186,984.54 | 1st & 2nd St W, 3rd St E. Many records lack precise location but trend toward east-central grid |
| 2020 | 13 | $107,000.17 | 4th St W, 1st St E/W, 1st Ave W, ERA, Miller St |
| 2021 | 8 | $32,372.89 | 2nd St W, 1st St W, 3rd Ave E, 3rd St W, ERA zone |
| 2022 | 14 | $91,226.76 | 1st St E/W, 2nd Ave E, 3rd St E, 7th St W, 3rd Ave W, East Road Allowance, 4th & 5th St W, Arena & Post Office Migowsky & Leader Crescent zones |
| 2023 | 8 | $43,435.74 | 1st St W, Main St, 3rd St W, 3rd Ave W, 2nd St E, 1st Ave E, 500 Block Main |
| 2024 | 8 | $96,068.07 | 2nd Ave E, 2nd St E, 1st St W, 3rd St E. Industrial Park |
| 2025 | 5 | $47,069.55 | Main Street (multiple blocks), 1st Ave E, 1st St E, 4th St W, 7th St W, 3rd Ave W, 2nd St E |
| **Total** | **76** | **$604,158** | |

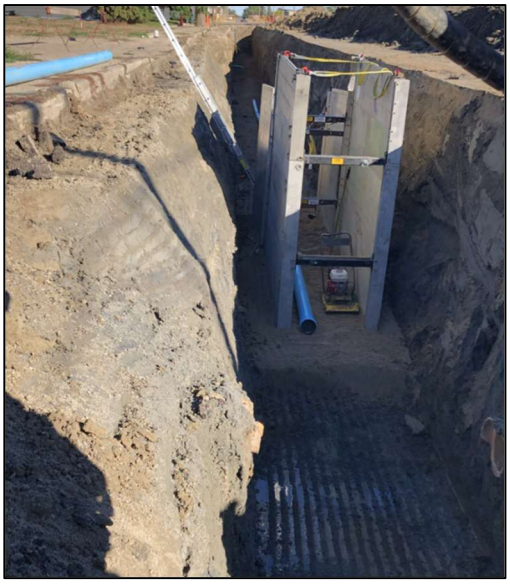
*Note: Data was supplemented through interviews with the CAO and Public Works, as well as Google Street View observations. Cost data provided to ASI reflected preferential rates and was not used in the final estimates shown.*

Between 2019 and 2025, the Town experienced **76 water main breaks**, with estimated inflation-adjusted costs totaling over $600,000. While actual repair expenses were lower due to preferential rates, the true cost burden is significantly higher. This highlights the financial impact of deferring renewal and supports the need for proactive replacement planning.

- *__76 water main breaks__ recorded over 7 years, with inflation-adjusted costs exceeding __$600,000__*
- *Actual repair costs were lower due to preferential rates, but the __true financial burden is significantly higher__*
- *Data confirms that __deferring renewal increases long-term costs and service disruptions__*

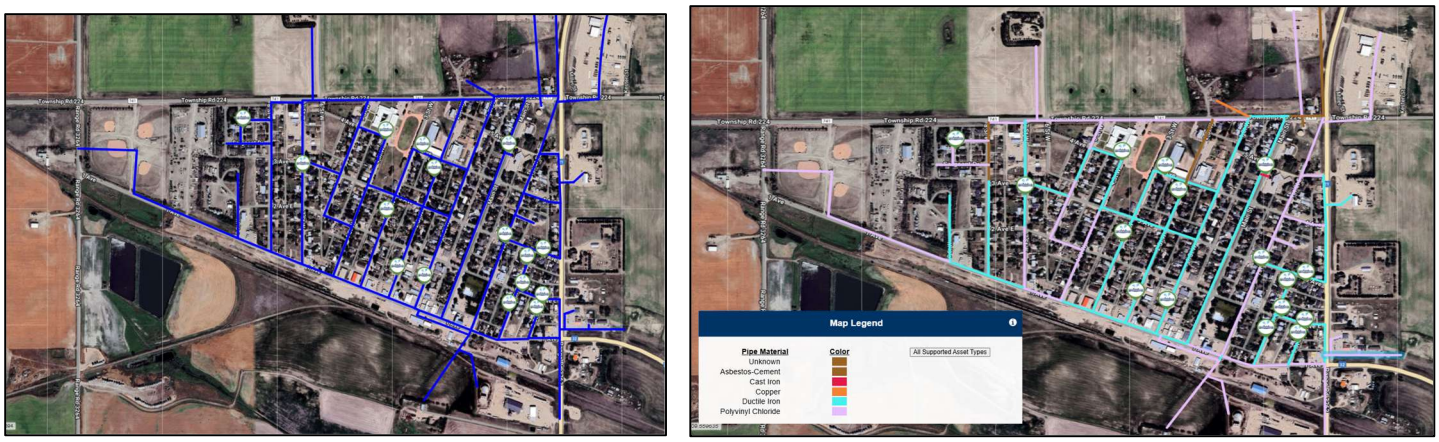
The following figures are photographs from previous water main renewal projects on 1st Avenue and 7th Street. They provide visual evidence of the deteriorating condition of the existing infrastructure.

**Figure 6 Break Evidence on 1st Avenue & 7th Street**

A summary of the water main breaks within Silversmith at the time of this report is shown in the following figures.

**Figure 7 Water Breaks Overlayed on the Water Main Layer in SilverSmith (left) and on the Material Layer (right)**



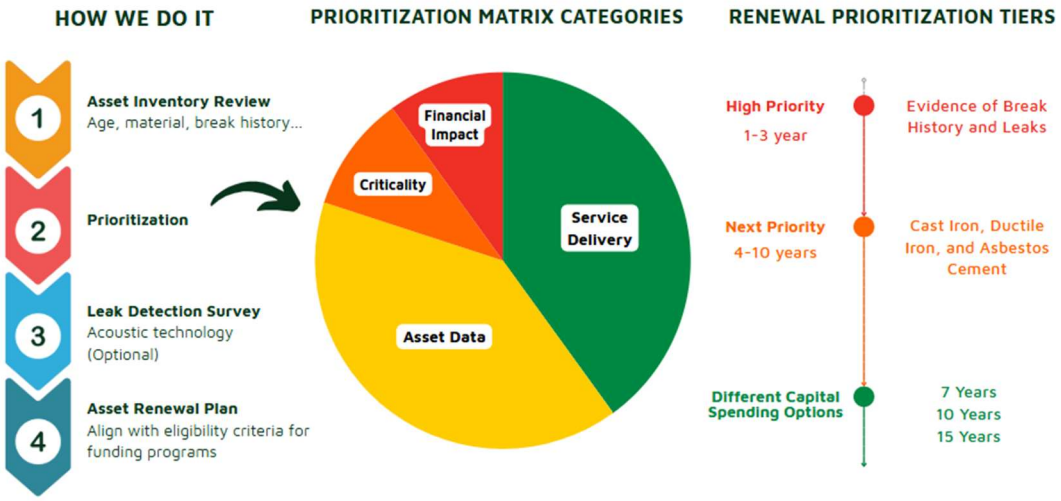

As shown above, 16 water breaks are confirmed within SilverSmith, in which a majority occurred on DI pipe.

# 5.0 Renewal Strategy

## 5.1 Risk Assessment Framework

ASI has applied a simplified, risk-based scoring system to prioritize water main segments for renewal. This framework is tailored to suit the Town's smaller population and limited historical data, while still aligning with best practices in municipal infrastructure planning.

**Figure 8 Assessment Framework**




The first step of the prioritization process involves creating the criteria on which to score each water main segment. Based on estimates for importance of each category, a weight (shown as a percentage) is assigned. Each of these four categories is broken down further into measurable criteria and rated on a 1-5 scale.

**Figure 9 Risk Scoring Criteria**

| Category | Purpose | How 1–5 is Calculated |
|---|---|---|
| **Asset Data** | Evaluates physical condition and material of the pipe | Score 1 = oldest, high-risk materials; Score 5 = new PVC/HDPE |
| **Service Delivery** | Assesses history of failure and road surface condition | Score 1 = repeated breaks or poor roads; Score 5 = no breaks, good road |
| **Criticality** | Measures impact based on number and type of users | Score 1 = critical users or >100 people; Score 5 = 1–10 low-impact users |
| **Financial Impact** | Estimates renewal cost and constructability constraints | Score 1 = complex corridor or highway crossings; Score 5 = rural, low-cost work |

The analysis weighting primarily focused (90%) on the Asset Data and Service Delivery categories, identifying older pipes made of outdated materials, with the most breaks. The remaining 10% considered criticality and potential financial impacts.

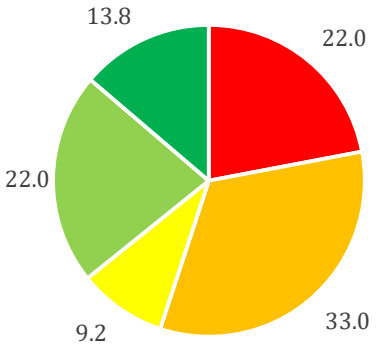
## 5.2 Prioritization Strategy

Once criteria were determined, weighting was given to each criterion and category. The weights applied to each risk factor is shown in the full matrix within **Appendix A**. This strategy used a 100-point health scoring, with the higher the score the healthier the segment, and vice versa. After all segments were scored, a summary for all water main segments was created.

The following tables and figures highlight the results:

**Table 9 Score Criteria Summary**

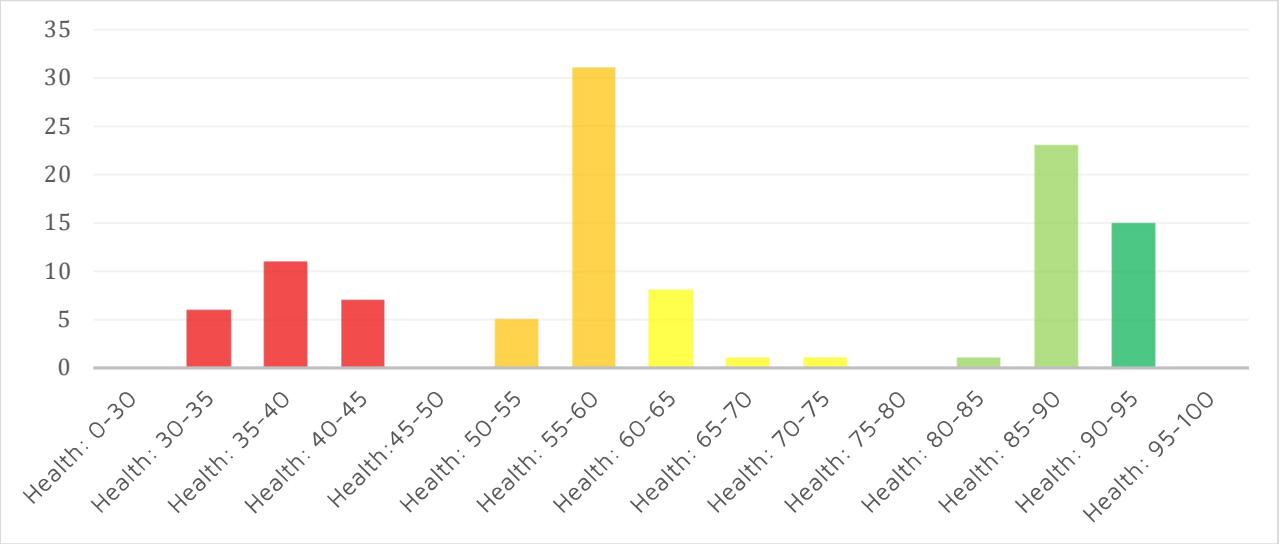
| Colour | Health Score Range | Priority Description | Replacement Urgency | Percent of Segments |
|---|---|---|---|---|
| | 0 - 50 | Very Poor Health | Immediate Replacement | 22.0 |
| | 50.01 – 60 | Poor Health | Replace in Near Term | 33.0 |
| | 60.01 – 75 | Fair Health | Monitor & Replace if Needed | 9.2 |
| | 75.01 – 90 | Good Health | Defer Replacement | 22 |
| | 90.01 – 100 | Excellent Health | No Replacement Required | 13.8 |




See **Appendix A** for the full list of segments and ranking.

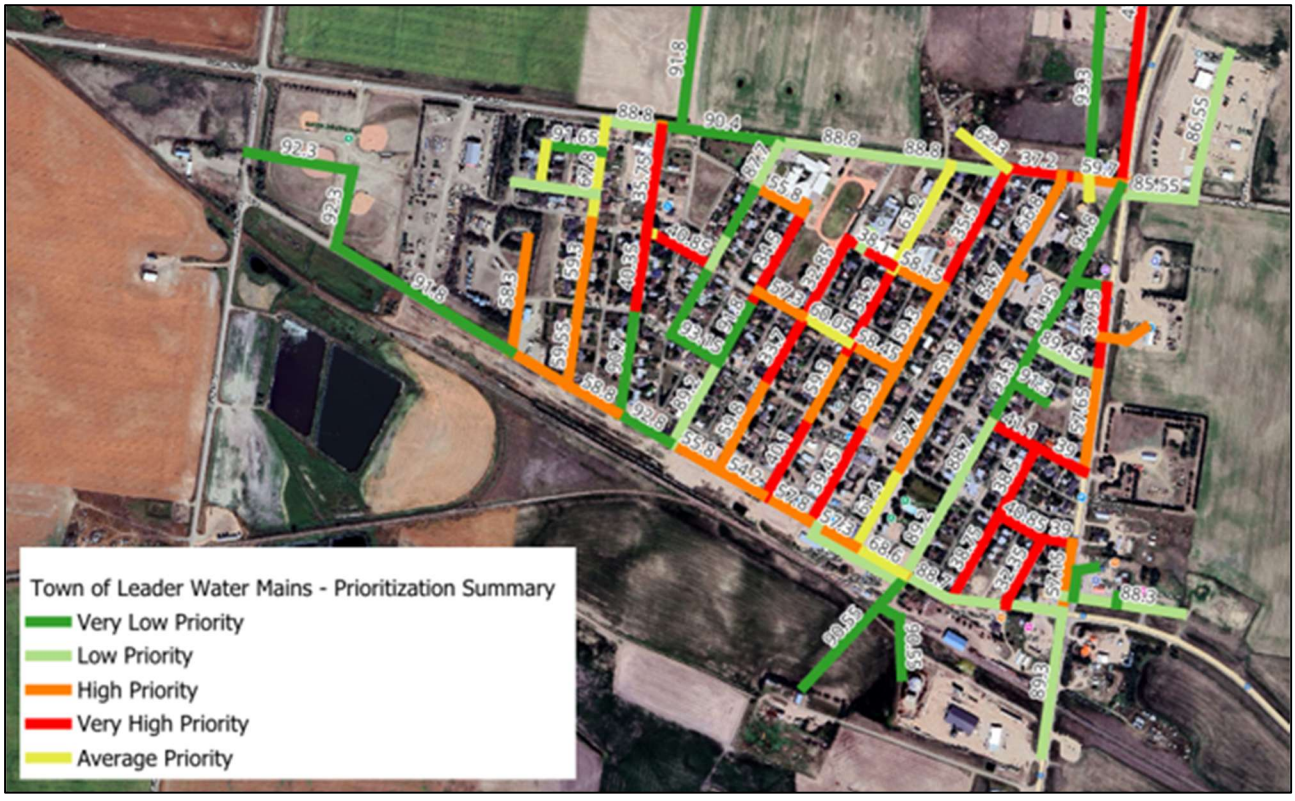
Approximately **55%** of the water system is rated as **Poor or Very Poor**. These segments will be the focus of the renewal program, excluding the AC raw water line from the river to the Town. After all segments were prioritized, the number of water main segments that fell within each health range (5-point increments), is summarized below:

**Figure 10 Water Main Health Summary by Number of Segments (114 total segments)**




The next figure describes where each of the segments are located. Score labels are shown adjacent to each segment.

**Figure 11 Prioritization Map**




After each segment was scored, a financial analysis was performed to address priority mains. Approximately **7,300m** total length was selected.

## 5.3 Total Cost of Renewal Plan

The total replacement cost for the water main renewal plan of 7.3km is estimated at **$15,800,000** (in 2025 dollars). This Class D estimate was developed using benchmark data from four municipalities and pricing input from Synergy Construction to ensure accuracy. It accounts for all major components necessary to deliver the program successfully, including:

- **Construction costs** for water main replacement, including excavation, bedding, and backfilling
- **Labour and equipment** for installation and field execution
- **Engineering and project management**, including design, tendering, contract administration, and quality control
- **Traffic accommodation and safety measures** required during construction
- **Disposal and decommissioning** of removed pipe materials
- **Surface restoration, where applicable** limited to road paving in areas where replacement occurs beneath paved surfaces
- **Assumed average soil conditions** across the project area for excavation and compaction
- **Contingencies** for unforeseen conditions and cost variability

To control costs, ASI focused on Repair Category 4 **(unpaved)** and 5 **(half width road repaving)** renewals, which avoid pricey full road or corridor reconstructions while still improving system reliability. Unit rates were then applied based on repair category and surface condition, using $/meter and $/square meter assumptions. All replacements are assumed to be *like-for-like*, with unpaved segments remaining unpaved, similar diameters, but using modern PVC. The following figure identifies all water mains included in this plan

**Figure 12 Priority Mains to Replace**


ASI reviewed cost estimates from Synergy Construction for relining existing mains instead of full replacement. However, the projected savings were only around 30%, and the advanced age and condition of the existing pipes presented too high a risk for effective relining without future breakage.

**Cost Calculations:**

Unpaved (Repair Score 5) = 427m x $1,516.67/m = **$647,618**
Partial Paving (Repair Score 4) = 6,868m x $2,204.60/m* = **$15,141,193**

**Note*: An average road width of 13.0m (6.5m half width) was used for paving calculations per discussions with the Town Foreman and measurements from the SilverSmith software.

Prioritizing which mains to replace is only the first step. The next subsection outlines three funding scenarios, each based on a different implementation timeline: 7, 10, and 15 years.

## 5.4 Funding Scenario Overview

Based on this total cost of 15.8M, An inflation rate of 3% was compounded for all years past 2025 to demonstrate true costs. The table below summarizes three recommended scenarios to choose from, while sections 6.0, 7.0, and 8.0 of the plan will go into specifics for each scenario.

**Table 10 Funding Scenarios**

| Scenario | Timeline | Annual Investment Required | Total | Notes |
|---|---|---|---|---|
| **A** | 7 Years | ~$2.47 million/year | ~$17,282,000 | Maximizes short-term grant opportunities; high annual cost; reduces the most risk |
| **B** | 10 Years | ~1.81 million/year | ~$18,099,000 | Balanced pace; manageable costs; aligns with phased funding and risk |
| **C** | 15 Years | ~1.31 million/year | ~$19,576,000 | Lowest yearly cost; higher risk of failure and service disruption. Highest Total Cost |

The Town of Leader should adopt one of the staged implementation strategies above. To choose between each strategy, the Town should consider which plan fits within their internal budget, needs, and Council direction. The strategies are designed to offer differing balances in terms of risk and cost.

Each strategy follows three main phases:

- **Phase 1: High-Risk Replacements – Break-Prone & Lowest-Scoring Segments**
  Focuses on clustered segments with the highest break history and lowest condition scores. These are the most vulnerable areas requiring immediate intervention to reduce service disruptions and repair costs.
- **Phase 2: Moderate-Risk Segments – Low Scores with Limited Break Data**
  Targets areas with poor condition scores but limited or unknown break history. These sections present emerging risk and will be proactively renewed to prevent future failures.
- **Phase 3: Remaining Segments – System Completion**
  Final phase addresses all remaining ductile iron (DI) and asbestos cement (AC) segments.

This phased approach ensures that renewal efforts are risk-informed, budget-aligned, and strategically bundled with other infrastructure projects to deliver long-term value to the community. The next section highlights current and planned funds that can be dedicated to the program.

## 5.5 Financial Strategy

To deliver the recommended renewal program, the Town will require a combination of internal reserves, external grants, and optional local contributions. Special consideration has been given to structuring the plan for a successful CHIF application, with an emphasis on combining grants to reduce the financial burden on local taxpayers wherever possible. This information is summarized below.

1. **Town Reserves**

   The Town of Leader has $68,800 in utility reserves, reduced in 2024 due to a new water tank. An additional $106,560 in infrastructure fees is budgeted to rebuild reserves this year.

2. **CHIF Funding**

   If approved, CHIF could fund up to 73% of the $15.8M project, about $11.5M—leaving the Town responsible for the remaining 4.3M. Other programs like CCBF and MRS can be stacked to reduce local costs further.

3. **Canada Community Building Fund (CCBF) & Municipal Revenue Sharing (MRS)**

   Together, CCBF and MRS can provide approximately $318,000 in additional funding per year. These programs can be stacked with CHIF to reduce the Town's out-of-pocket share and are well-suited for supporting phased implementation. Availability depends on annual allocations and Council direction.

4. **Local Contribution (optional)**

   To support the Town's share of project costs, a tax levy or utility rate increase could be used. This approach distributes the cost equitably among users while supporting long-term infrastructure renewal.

5. **Infrastructure Loan (optional)**

   Another option may be covered through a long-term infrastructure loan. This approach spreads the financial impact over time, with repayment aligned to water utility revenues and future capital planning cycles.

The following table gives a plan to fund the $15,800,000 using the previous information, for **Scenario B**.

**Table 11 Funding Options: Scenario B (10-Years)**

| Funding Source | Estimated Amount (2025 $) | Contribution % | Details |
|---|---|---|---|
| Canada Housing Infrastructure Fund (CHIF) | 11,534,000 | 73.0 | 40% Federal + 33% Provincial. Requires application and may have timing constraints. Not guaranteed. |
| Municipal Revenue Sharing (MRS) | 2,617,280 | 16.5 | May be used as stacking or match funding, dependent on annual budget and Council priorities. $261,728*10 years= $2,617,280 |
| Canada Community Building Fund (CCBF) (Optional) | 0 | 0 | Eligible for water infrastructure; annual allocation can be committed to phased projects. If the town dedicates this fund each year for 10 years = $560,320. |
| Reserves | 1,753,600 | 11 | Current $68,800 + $106,560 going forward. Over 10 years = $1,753,600 |
| Local Contribution (Optional) | 0 | 0 | Example: A $52.50/yr tax levy for 450 households over 5 years could raise $118,125. |
| Infrastructure Loan (Optional) | 0 | 0 | Long-term financing may be needed for the balance for any changes to these funding options. Can be repaid over 10–20 years. |
| **Combined** | **~15,800,000** | **~100** | **Total** |

This funding breakdown illustrates how the Town can realistically cover the estimated $15.8 million cost of the renewal program. While CHIF remains the cornerstone of the strategy, additional sources such as CCBF, MRS, and Local Contribution provide flexibility for phased implementation.

The following sections detail the three implementation scenarios—7-year, 10-year, and 15-year plans.

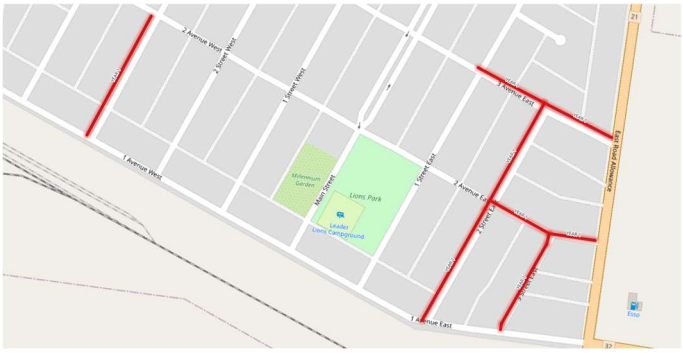
# 6.0 Scenario A: 7-year

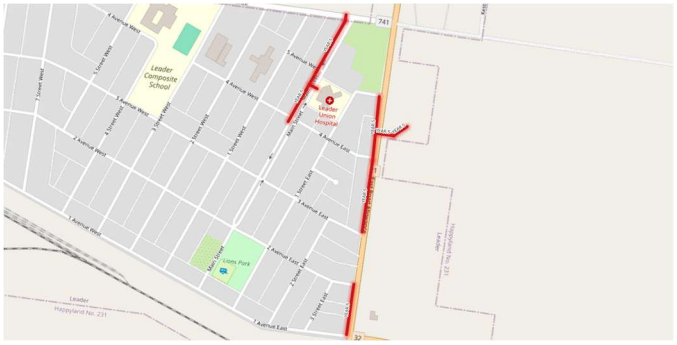
This scenario outlines an accelerated 7-year replacement plan targeting the Town of Leader's highest-risk water mains. Compared to the 10-year base scenario, this approach emphasizes quicker risk reduction and front-loading of investment to mitigate emergency repairs. The 7-year timeline may be more attractive to funding agencies seeking measurable near-term impact but will require greater annual expenditures and construction coordination.

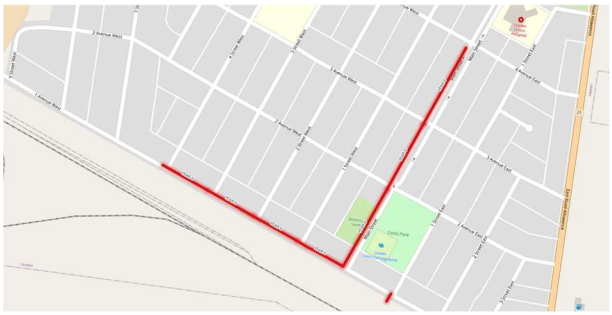
## 6.1 Replacement Strategies

Segments have been grouped into logical annual packages, each targeting **1000m** of water main per year on average. These groupings were built to suit available construction windows, maximize staging efficiency. The proposed phasing is visualized on the following pages.

**Table 12 Program Annual Breakdown**

| Plan Year | Length (m) | Cost ($) | Total Cost ($) | Figure |
|---|---|---|---|---|
| **1:** *2nd Ave East, 3rd Street East, 2nd Street East, 3rd Ave, 3rd St West.* **Approx. 980 m** | 118.21 | 260,605 | **$2,150,000** |  |
| | 59.98 | 132,232 | | |
| | 87.8 | 193,564 | | |
| | 164.75 | 363,207 | | |
| | 98.66 | 217,506 | | |
| | 157.73 | 347,731 | | |
| | 14.23 | 31,371 | | |
| | 7.52 | 16,579 | | |
| | 95.66 | 210,892 | | |
| | 174.76 | 385,275 | | |
| **2:** *Remainder of 3rd St West, 2nd St West, 4th Ave West, 3rd Ave West* **Approx. 990 m** | 136.03 | 299,891 | **$2,200,000** |  |
| | 178.91 | 394,424 | | |
| | 93.89 | 206,990 | | |
| | 172.59 | 380,491 | | |

| | | | | |
|---|---|---|---|---|
| | 100.24 | 220,989 | | |
| | 142.09 | 313,251 | | |
| | 168.85 | 372,246 | | |
| **3:**<br>*1st St West, 3rd Ave West, remainder of 4th Ave West, Township Road 224*<br><br>**Approx. 1070 m** | 189.93 | 418,719 | **$2,400,000** |  |
| | 120.71 | 266,117 | | |
| | 101.54 | 223,855 | | |
| | 192.21 | 423,746 | | |
| | 101.82 | 224,472 | | |
| | 234.75 | 517,529 | | |
| | 115.61 | 254,873 | | |
| | 14.26 | 31,438 | | |
| **4:**<br>*Remainder of Township Road 224, WTP, remainder of 3 Ave West, 4th Street West, 4th Ave West, 5th Street West, 7th Street West,*<br><br>**Approx. 1030 m** | 99.81 | 220,041 | **$2,500,000** |  |
| | 33.61 | 50,975 | | |
| | 33.51 | 50,823 | | |
| | 92.32 | 203,528 | | |
| | 182.26 | 401,810 | | |
| | 99.7 | 219,798 | | |
| | 10.28 | 22,663 | | |
| | 6.47 | 14,264 | | |
| | 16.69 | 36,795 | | |
| | 124.85 | 275,244 | | |
| | 142.39 | 313,913 | | |
| | 189.66 | 418,124 | | |
| | 108.97 | 240,235 | | |
| **5:**<br>*Highway 21, Main Street*<br><br>**Approx. 1080 m** | 129.04 | 284,481 | **$2,300,000** |  |
| | 183.16 | 403,794 | | |
| | 162.89 | 359,107 | | |
| | 46.54 | 102,602 | | |
| | 41.29 | 62,623 | | |
| | 215.76 | 475,664 | | |
| | 5.29 | 11,662 | | |
| | 150.06 | 330,822 | | |
| | 143.29 | 315,897 | | |

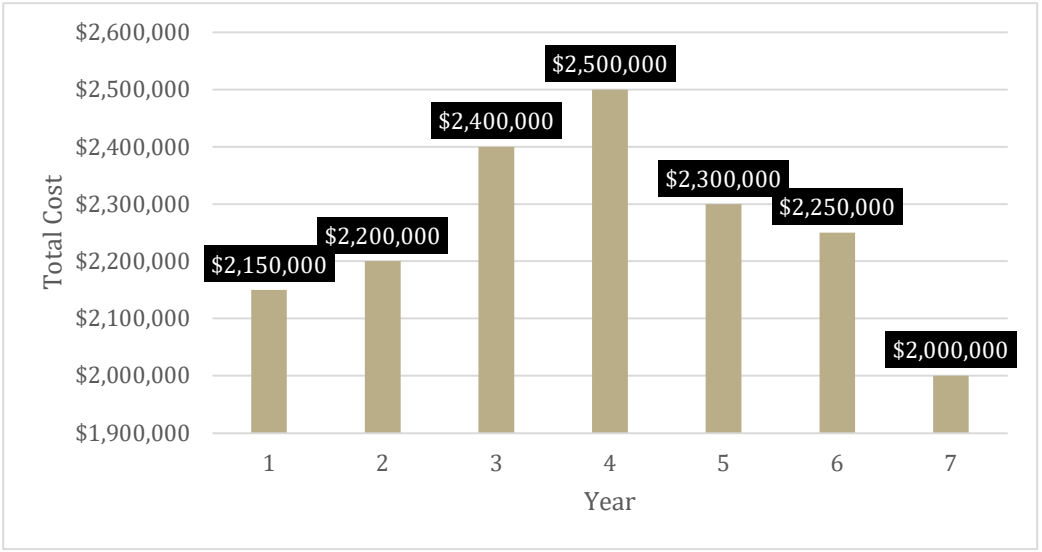
| | | | | |
|---|---|---|---|---|
| **6:** *Remainder of Main Street, 1st Ave East* **Approx. 1035 m** | 169.67 | 374,054 | **$2,250,000** |  |
| | 142.24 | 313,582 | | |
| | 15.44 | 34,039 | | |
| | 22.57 | 49,758 | | |
| | 169.39 | 373,437 | | |
| | 102.12 | 225,133 | | |
| | 16.86 | 37,170 | | |
| | 100.59 | 221,760 | | |
| | 96.8 | 213,405 | | |
| | 99.13 | 218,542 | | |
| | 99.14 | 218,564 | | |
| **7:** *Remainder of 1st Ave West, 8th Street West, 9th Street West* **Approx. 1030 m** | 162.92 | 359,173 | **$2,000,000** |  |
| | 161.92 | 356,968 | | |
| | 189.16 | 417,022 | | |
| | 125.11 | 275,817 | | |
| | 213.91 | 324,430 | | |
| | 174.18 | 229,675 | | |
| | 104.18 | 359,173 | | |

**Note:** All replacement segments will include the replacement or addition of hydrants and isolation valves.

## 6.2 Budget and Lifecycle Costing

As shown in the figure below, annual costs for the 7-year replacement plan range approximately $2.0M to $2.5M per year.

**Figure 13 7-Year Annual Cost**



# 7.0 Scenario B: 10-year

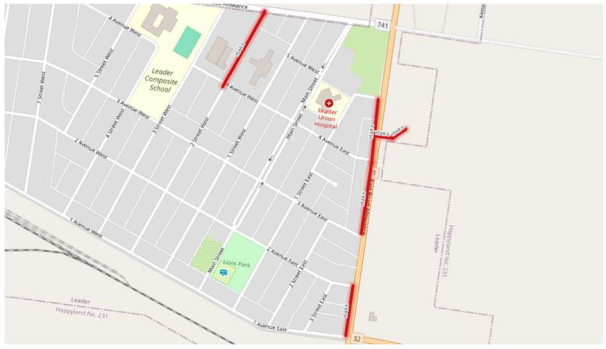
This scenario represents the recommended base case: a 10-year phased water main replacement program that balances urgency, annual affordability, and long-term reliability. It provides meaningful risk reduction through proactive renewal, while maintaining alignment with the Town's existing budget structure and anticipated grant timelines.

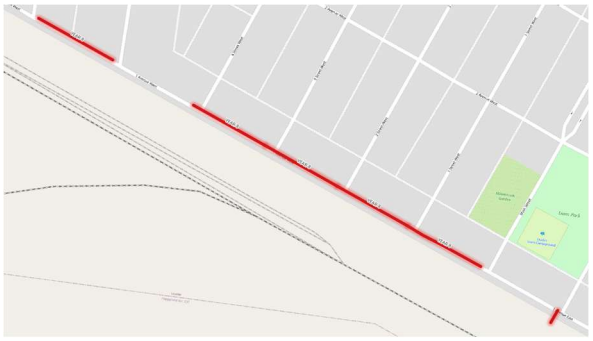
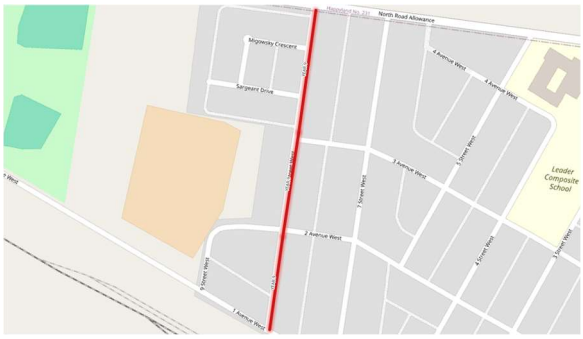
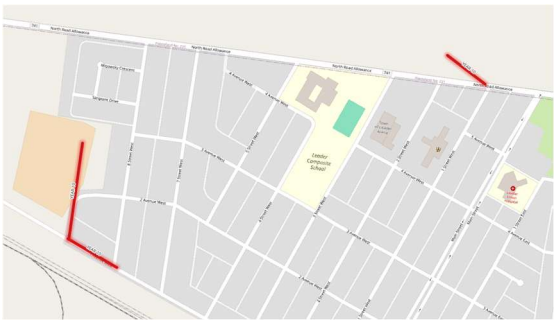
## 7.1 Replacement Strategy

Segments have been grouped into logical annual packages, each targeting **720m** of water main per year on average. The proposed phasing is visualized on the following pages.

**Table 13 Program Annual Breakdown**

| Plan Year | Length (m) | Cost ($) | Total Cost ($) | Figure |
|---|---|---|---|---|
| **1:** *2nd Ave East, 3rd Street E, 2nd Street E, 3rd Ave.* **Approx. 805 m** | 118.21 | 260,605 | **1,800,000** |  |
| | 59.98 | 132,232 | | |
| | 87.8 | 193564 | | |
| | 164.75 | 363,207 | | |
| | 98.66 | 217,506 | | |
| | 157.73 | 347,731 | | |
| | 14.23 | 31,371 | | |
| | 7.52 | 16,579 | | |
| | 95.66 | 210,892 | | |
| **2:** *3rd Street West, 4 Ave 2 St West, 3 Ave* **Approx. 855 m** | 136.03 | 299,891 | **1,900,000** |  |
| | 174.76 | 385,275 | | |
| | 178.91 | 394,424 | | |
| | 93.89 | 206,990 | | |
| | 172.59 | 380,491 | | |
| | 100.24 | 220,989 | | |
| **3:** *Remainder of 2nd St W, 1st St W, 3rd Ave* **Approx. 720 m** | 142.09 | 313,251 | **1,600,000** |  |
| | 168.85 | 372,246 | | |
| | 189.93 | 418,719 | | |
| | 120.71 | 266,117 | | |

| | | | | |
|---|---|---|---|---|
| | 101.54 | 223,855 | | |
| **4:** *Remainder of 3rd St, remainder of 4th St, Township Rd 224, WTP*<br><br>**Approx. 825 m** | 192.21 | 423,746 | **1,800,000** |  |
| | 101.82 | 224,472 | | |
| | 234.75 | 517,529 | | |
| | 115.61 | 254,873 | | |
| | 99.81 | 220,041 | | |
| | 33.61 | 50,975 | | |
| | 33.51 | 50,823 | | |
| | 14.26 | 31,438 | | |
| **5:** *Remainder of 3rd Ave, 4st W, 4 Ave, 7St W*<br><br>**Approx. 975 m** | 92.32 | 203,528 | **2,150,000** |  |
| | 182.26 | 401,810 | | |
| | 99.7 | 219,798 | | |
| | 10.28 | 22,663 | | |
| | 6.47 | 14,264 | | |
| | 16.69 | 36,795 | | |
| | 124.85 | 275,244 | | |
| | 142.39 | 313,913 | | |
| | 189.66 | 418,124 | | |
| | 108.97 | 240,235 | | |
| **6:** *Highway 21, remaining of 2nd St W*<br><br>**Approx. 784 m** | 129.04 | 284,481 | **1,700,000** |  |
| | 183.16 | 403,794 | | |
| | 162.89 | 359,107 | | |
| | 46.54 | 102,602 | | |
| | 41.29 | 62,623 | | |
| | 215.76 | 475,664 | | |
| | 5.29 | 11,662 | | |
| **7:** *Main Street*<br><br>**Approx. 810 m** | 150.06 | 330,822 | **1,800,000** |  |
| | 143.29 | 315,897 | | |
| | 169.67 | 374,054 | | |
| | 142.24 | 313,582 | | |

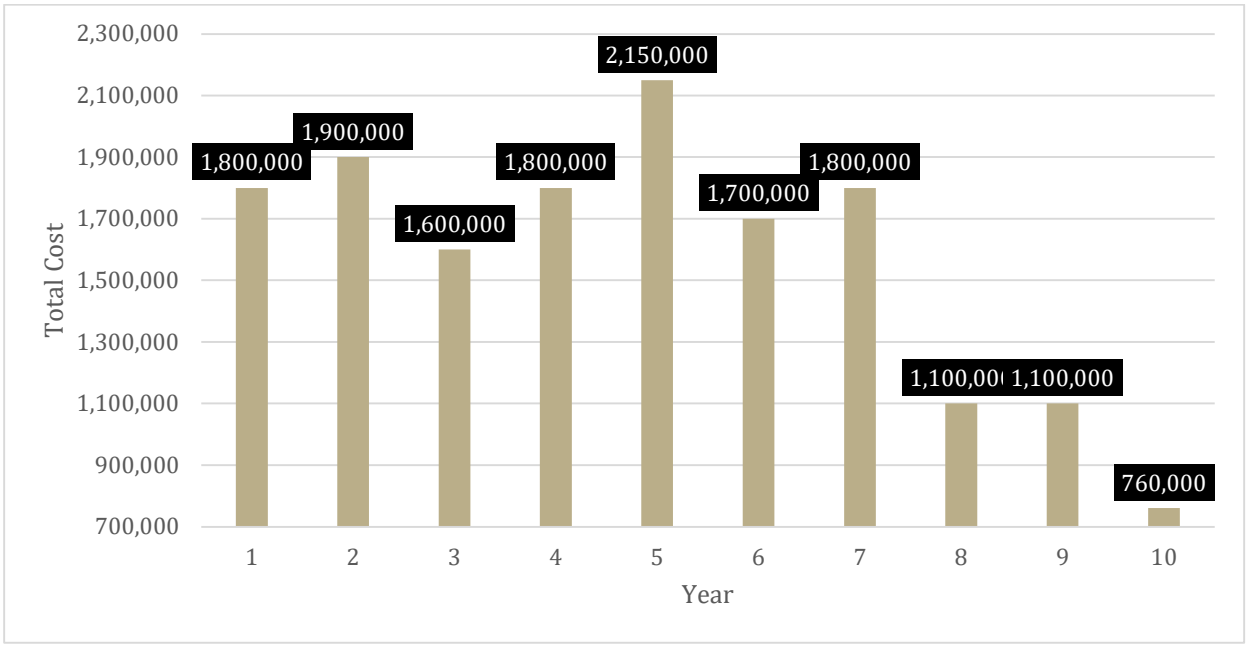
| | | | | |
|---|---|---|---|---|
| | 15.44 | 34,039 | | |
| | 22.57 | 49,758 | | |
| | 169.39 | 373,437 | | |
| **8:**<br>*1st Ave*<br><br>**Approx. 515 m** | 102.12 | 225133 | **1,100,000** |  |
| | 16.86 | 37,170 | | |
| | 100.59 | 221,760 | | |
| | 96.8 | 213,405 | | |
| | 99.13 | 218,542 | | |
| | 99.14 | 218,564 | | |
| **9:**<br>*8th St W.*<br><br>**Approx. 515 m** | 162.92 | 359,173 | **1,100,000** |  |
| | 161.92 | 356,968 | | |
| | 189.16 | 417,022 | | |
| **10:**<br>*Remaining 1st Ave, 9th St W, Copper line off Township RD 224*<br><br>**Approx. 515 m** | 125.11 | 275,817 | **750,000** |  |
| | 213.91 | 324,430 | | |
| | 174.18 | 158,006 | | |

**Note:** All replacement segments will include the replacement or addition of hydrants and isolation valves.

## 7.2 Budget and Lifecycle Costing

As shown in the figure below, annual costs for the 10-year replacement plan range from $0.76M to $2.15M per year, with higher expenditures front-loaded in the early years to address the most critical and failure-prone segments.

**Figure 14 10-Year Annual Cost**



# 8.0 Scenario C: 15-year

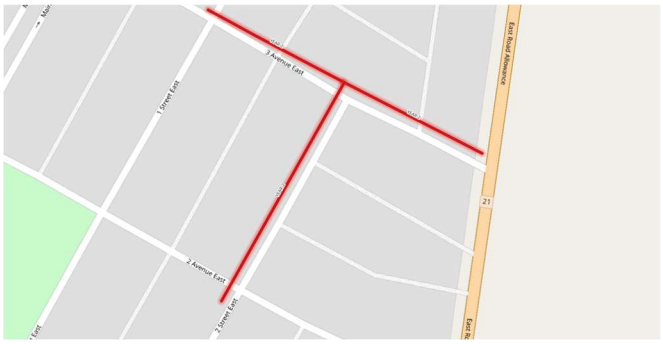
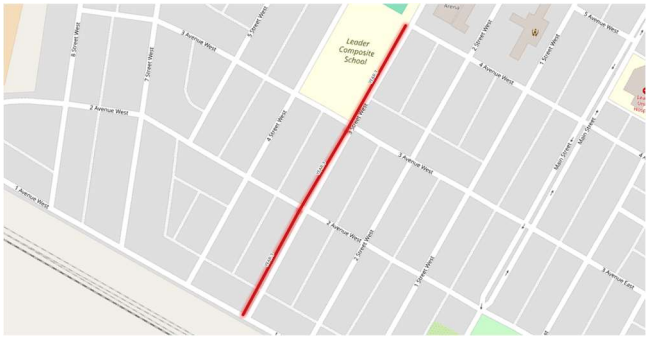
This scenario outlines a longer-term 15-year renewal plan, intended to minimize short-term financial pressure on the Town's utility budget. While slower to address system-wide risk, this approach offers the lowest annual costs and may be more palatable for councils or ratepayers concerned about affordability.

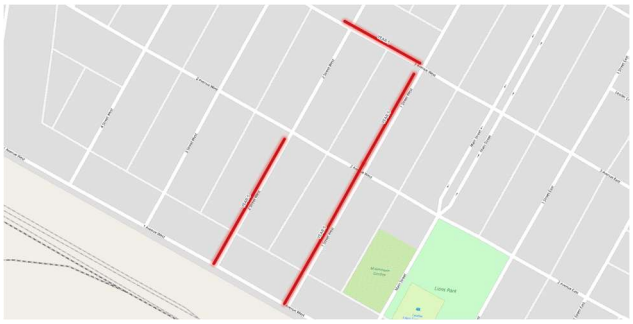
However, delayed action may expose the Town to continued break-related costs, particularly on aging AC segments like the raw water line. As such, this scenario is only recommended if significant external funding is not secured and local contributions must be stretched over a longer period.

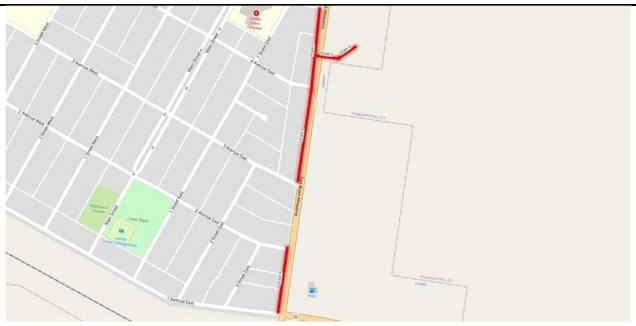
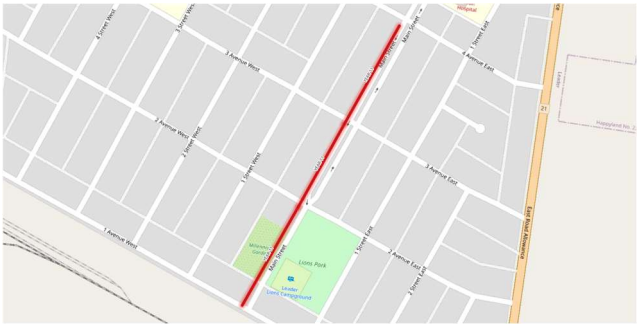
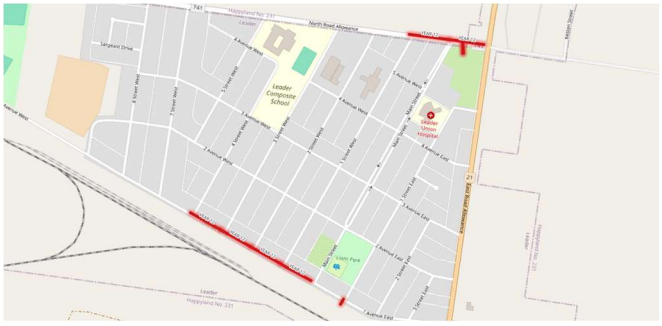
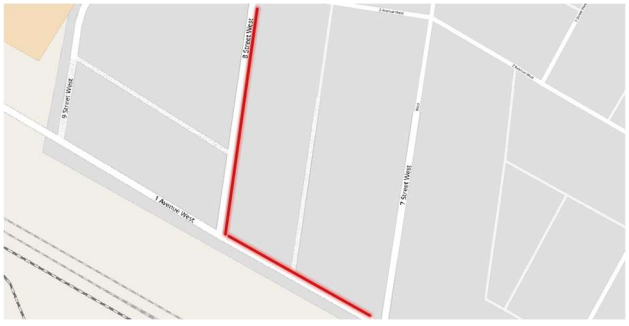
## 8.1 Replacement Strategies

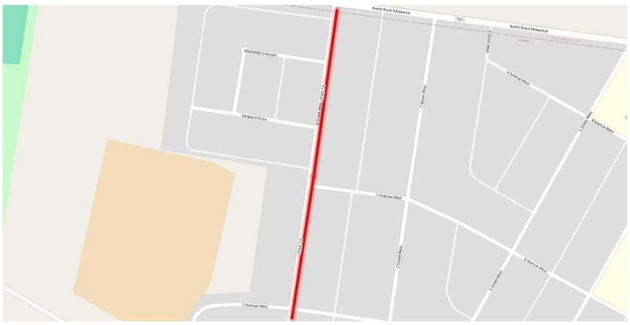
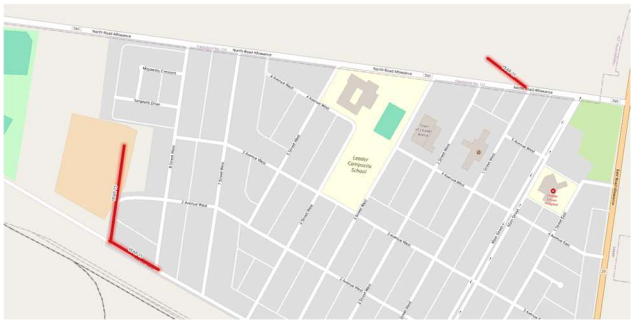
Segments have been grouped into logical annual packages, each targeting **480m** of water main per year on average. The proposed phasing is visualized on the following pages.

**Table 14 Program Annual Breakdown**

| Plan Year | Length (m) | Cost ($) | Estimated Total Cost ($) | Figure |
|---|---|---|---|---|
| **1:** *3rd Street East, 2ns Street East, 2nd Avenue East* **Approx. 450m** | 118.21 | 260,605 | **1,000,000** |  |
| | 7.52 | 16,579 | | |
| | 14.23 | 31,371 | | |
| | 59.98 | 132,232 | | |
| | 87.8 | 193,564 | | |
| | 164.75 | 363,207 | | |
| **2:** *Remaining 2nd Street East, 3rd Avenue East* **Approx. 350m** | 157.73 | 347,731 | **775,000** |  |
| | 98.66 | 217,506 | | |
| | 95.66 | 210,892 | | |
| **3:** *3rd Street West* **Approx. 490m** | 174.76 | 385,275 | **1,000,000** |  |
| | 136.03 | 299,891 | | |
| | 178.91 | 394,424 | | |

| | | | | |
|---|---|---|---|---|
| **4:**<br>*2nd Street West, 3rd Avenue West, 4th Avenue West*<br><br>**Approx. 510m** | 142.09 | 313,251 | **1,100,000** |  |
| | 100.24 | 220,989 | | |
| | 172.59 | 380,491 | | |
| | 93.89 | 206,990 | | |
| **5:**<br>*2nd Street West, 1st Street West, 3rd Avenue West*<br><br>**Approx. 580m** | 168.85 | 372,246 | **1,200,000** |  |
| | 189.93 | 418,719 | | |
| | 120.71 | 266,117 | | |
| | 101.53 | 223,833 | | |
| **6:**<br>*1st Street West, 4th Avenue East*<br><br>**Approx. 540m** | 192.21 | 423,746 | **1,200,000** |  |
| | 101.81 | 224,450 | | |
| | 234.75 | 517,529 | | |
| | 14.26 | 31,438 | | |
| **7:**<br>*3rd Avenue West,4th Street West, 4th Avenue West, 5th Street West*<br><br>**Approx. 500m** | 92.32 | 203,528 | **1,100,000** |  |
| | 182.26 | 401,810 | | |
| | 16.69 | 36,795 | | |
| | 99.7 | 219,798 | | |
| | 108.97 | 240,235 | | |
| **8:**<br>*Remaining 3rd Avenue West, 7th Street West*<br><br>**Approx. 475m** | 124.28 | 273,987 | **1,000,000** |  |
| | 10.28 | 22,663 | | |
| | 189.66 | 418,124 | | |
| | 6.47 | 14,264 | | |
| | 142.39 | 313,913 | | |

| | | | | |
|---|---|---|---|---|
| **9:**<br>*Highway 21*<br>**Approx. 560m** | 129.04 | 284,481 | **1,200,000** |  |
| | 46.54 | 102,602 | | |
| | 41.29 | 91,028 | | |
| | 183.16 | 403,794 | | |
| | 162.89 | 359,107 | | |
| **10:**<br>*2nd Street West, Main Street*<br>**Approx. 545m** | 215.76 | 475,664 | **1,200,000** |  |
| | 15.44 | 34,039 | | |
| | 150.06 | 330,822 | | |
| | 142.29 | 313,692 | | |
| | 22.57 | 49,758 | | |
| **11:**<br>*Remaining Main Street*<br>**Approx. 480m** | 143.29 | 315,897 | **1,000,000** |  |
| | 169.67 | 374,054 | | |
| | 169.39 | 373,437 | | |
| **12:**<br>*1st Avenue East, Township Road 224, WTP*<br>**Approx. 595m** | 16.86 | 37,170 | **1,200,000** |  |
| | 100.59 | 221,760 | | |
| | 96.8 | 213,405 | | |
| | 99.13 | 218,542 | | |
| | 115.61 | 254,873 | | |
| | 99.81 | 220,041 | | |
| | 33.51 | 50,823 | | |
| | 33.61 | 50,975 | | |
| **13:**<br>*1st Avenue West, 8th Street West*<br>**Approx. 460m** | 102.12 | 225,133 | **1,000,000** |  |
| | 115.61 | 254,873 | | |

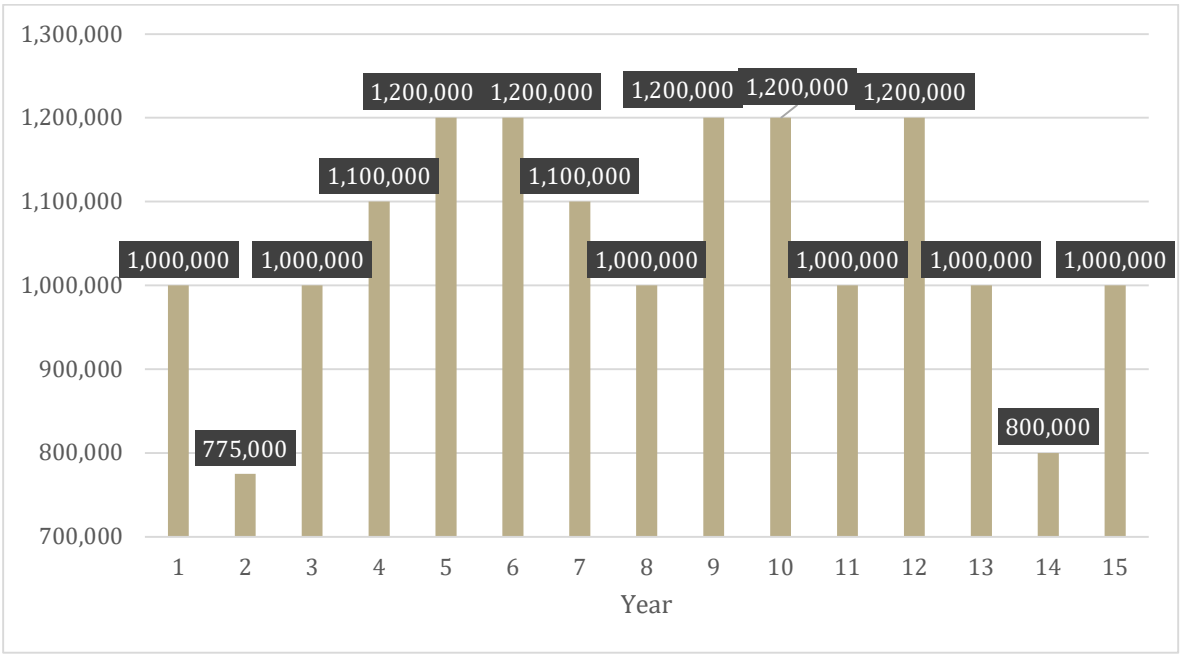
| | | | | |
|---|---|---|---|---|
| | 99.81 | 220,041 | | |
| | 144.08 | 317,638 | | |
| **14:** *Remaining 8th Street West* **Approx. 350m** | 161.92 | 356,968 | **800,000** |  |
| | 189.16 | 417,022 | | |
| **15:** *Remaining 1st Avenue, 9th Street West, Copper line to farm* **Approx. 445m** | 125.11 | 275,817 | **1,000,000** |  |
| | 104.18 | 229,675 | | |
| | 213.91 | 471,585 | | |

**Note:** All replacement segments will include the replacement or addition of hydrants and isolation valves.

## 8.2 Budget and Lifecycle Costing

As shown in the figure below, annual costs for the 15-year replacement plan range approximately $0.8M to $1.2M per year.

**Figure 15 15-Year Annual Cost**



# 9.0 Recommendations

Key recommendations for the Town based on the findings in this plan include:

1. **Adopt a 10-Year Replacement Plan Focused on High-Risk Infrastructure**
   Implement the 10-year phased water main replacement plan outlined in *Section 7.0*, targeting approximately 7.3 km of aging water mains at a total estimated cost of $15.8 million. This strategy focuses on the Town's most failure-prone segments—including Ductile Iron (DI), Cast Iron (CI), Asbestos Cement (AC), and Copper—as detailed in *Section 5.2 Prioritization Strategy* and the system inventory in *Section 2.2*. The plan balances cost, risk, and service reliability while phasing construction to align with the Town's financial capacity.

2. **Secure Council Support, Increase Budget, and Pursue Grant Funding**
   Work with Council to implement the financial pathway recommended in *Section 5.5 Financial Strategy*, including annual capital budget increases. Pursue external grant funding through the CHIF program, combined with other sources such as Municipal Revenue Sharing (MRS) and the Canada Community-Building Fund (CCBF), as outlined in *Section 5.4 Funding Scenario Overview*, to reduce the financial burden on local ratepayers and accelerate implementation.

3. **Plan for Replacement of the Raw Water AC Pipeline**
   As recommended in *Section 5.3 Total Cost of Renewal Plan*, defer the replacement of the 8.5 km raw water AC pipeline from the South Saskatchewan River until after the 10-year replacement program concludes. Continue monitoring its condition and include it in the next capital planning cycle if signs of deterioration or failure emerge.

4. **Strengthen Inter-Municipal Coordination**
   Engage neighboring RMs to explore cost-sharing opportunities for infrastructure renewal along shared corridors such as Township Road 224 and Range Road 3264, as discussed in *Section 3.1* on future land use and development areas.

----------End of Document----------