Prepared By:

GM BluePlan ENGINEERING

City of Waterloo

Water Distribution Master Plan

GMBP File: 615036

April 2017

THE CITY OF Waterloo

GUELPH | OWEN SOUND | LISTOWEL | KITCHENER | LONDON | HAMILTON | GTA
410 LEWIS ROAD, UNIT 18, STONEY CREEK, ON L8E 5Y7 P: 905-643-6688
WWW.GMBLUEPLAN.CA

Table of Contents

1 Introduction

1.1 Background

The City of Waterloo is located in the Region of Waterloo covering a total area of 64 km^2. The City comprises a 2011 census population of 102,731 as well as a significant non-permanent student population centered near the City's two major universities.

The City of Waterloo's water system forms part of the Region of Waterloo's Integrated Urban System (IUS). The Region is responsible for the treatment and supply of water to the City's distribution system while the City is responsible for the local distribution and delivery of water to the end user. The Region owns and operates all supply and transmission infrastructure including water treatment plants, supply wells, pumping stations, storage facilities, boundary valves, and transmission watermain infrastructure. The City owns and operates all distribution infrastructure including watermains, hydrants, main valves, and service connections.

Readily available and accessible public infrastructure is essential to the viability of existing and growing communities. As such, the City needs a comprehensive infrastructure planning strategy to help it manage and direct infrastructure investments in order to ensure an efficient, safe, and economically maintenance and expansion of the City's water infrastructure; which is capable of meeting the needs of existing and future users.

The City of Waterloo undertook this Water Distribution Master Plan (WDMP) completed under the Municipal Engineering Association (MEA) Master Plan Class Environmental Assessment Process. The WDMP is a performance-based infrastructure management plan that assess the robustness of the City's local water distribution network on a pipe by pipe basis. The WDMP builds on the Region of Waterloo's existing Water Supply and Distribution Operations Master Plan, which identified short and long term strategies to best distribute water through the Region's Integrated Urban System and trunk infrastructure.

1.2 Master Plan Objectives

The City's WDMP focused on addressing existing hydraulic deficiencies and identified measures to accommodate growth to 2031. Project objectives included:

- Identifying management objectives and priorities through the development of water system management policies, and performance based levels of service targets
- Completing a system wide evaluation of City owned water infrastructure by:
    - Identifying existing water system performance deficiencies
    - Developing 2031 projected water demands and identifying growth related system performance deficiencies in greenfield, intensification, and re-development areas
    - Evaluating and optimizing water system upgrades to address system deficiencies while considering Regional planned upgrades
- Developing a water capital project list to 2031 which will support development charges and the implementation of a preferred solution with clearly defined project costs and project triggers
- Complying with the Municipal Class Environmental Assessment (EA) planning process for Master Plans

1.3 Infrastructure Asset Management Process Integration

The City recently completed the Infrastructure Asset Management Analysis Report (IAMAR). The IAMAR will help the City develop a Comprehensive Asset Management Plan (CAMP) that establishes the infrastructure expenditures that are required to achieve a target performance objective for the services provided by each asset group.

Due to the interconnected nature of the WDMP and IAMAR, both studies were completed in parallel. Interim IAMAR deliverables related to the water system asset condition were considered in the development and evaluation of upgrade alternatives. Further, the initial water capital program resulting from the WDMP will be integrated into the IAMAR analysis tools to allow the City to further refine the timing of the recommended capital projects in an integrated manner with the City's other asset classes.

2 The Municipal Class EA Process Guides the Master Plan

A Master Plan is typically subject to approval by the municipality, but does not normally require approval under the EA Act. However, any specific project within a Master Plan must fulfill the Class EA requirements. At a minimum, Master Plans address Phases 1 and 2 of the Class EA process (see below).

There are generally four approaches to undertaking Master Plans under the Class EA process. The WDMP was undertaken to comply with *Approach 2* of Municipal Class EA Master Planning process. This approach involves the preparation of a Master Plan document at the conclusion of Phases 1 and 2 of the Class EA process, where the level of investigation, consultation and analysis are sufficient to fulfill the requirements for Schedule A, A+ and B projects. While Approach 2 provides the basis for future investigations for specific Schedule C projects, none were identified under this Master Plan.

2.1 Class Environmental Assessment Process

Ontario's **Environmental Assessment (EA) Act*t*** requires proponents to examine and document the environmental effects that could result from major projects or activities and their alternatives.

This **Water Distribution Master Plan** will address Phases 1 and 2 of the Class EA process by defining the relevant problems and opportunities, while identifying a preferred solution(s).

As a result, this **Master Plan** will be used to fulfill the requirements of all Schedule A, A+ and B recommended projects.

The EA Act establishes a framework for systematic, rational and replicable environmental planning process that is based on five key principles:

- Consultation with affected parties;
- Consideration of a reasonable range of alternatives;
- Identification and consideration of the effects of each alternative on all aspects of the environment;
- Systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects; and,
- Provision of clear and complete documentation of the planning process to allow traceability of decision-making with respect to the project.

Projects subject to the Class EA process are classified into four schedules depending on the degree of the projected impacts.

- **Schedule A** projects are minor operation and maintenance activities. These projects as pre-approved and do not require further assessment.
- **Schedule A+** projects are similar to Schedule A project; however, they require the public to be advised prior to project implementation.
- **Schedule B** projects must go through a screening process of alternatives for their environmental impacts as well as Phase 1 and Phase 2 of the Class EA planning process.
- **Schedule C** projects must satisfy all five phases of the Class EA process, and have the potential for more significant environmental impacts. Schedule C projects require the completion of an ESR which is filed for public review.

The five phase Class EA planning process, as outlined by the MEA, is as follows:

- **Phase 1**: Problem and Opportunity Definition
- **Phase 2**: Identification and Evaluation of Alternative Solutions to Determine a Preferred Solution
- **Phase 3**: Examination of Alternative Methods of Implementation of the Preferred Solution
- **Phase 4**: Documentation of the Class EA process in the form of an Environmental Study Report (ESR)
- **Phase 5**: Implementation and Monitoring

2.2 Public Consultation

Public consultation is an important component of the master plan process, allowing the City to inform the public about the study and to obtain input from potentially interested and affected parties during the study process.

The main goals and objectives of the public consultation process were to:

- Present clear and concise information to stakeholders at key stages of the study process;
- Solicit community, regulatory and City staff input; and
- Meet Municipal Class EA consultation requirements.

Technical Appendix #4 provides a detailed summary of the WDMP Public Consultation Process.

3 Related Studies and Background Information

Technical Appendix #1 provides detailed summary of the Related Studies and Background Information supporting the development of the WDMP.

4 Existing Water Distribution System

Figure 1 and **Figure 2** provide an overview of the City's water system, which forms part of the Region of Waterloo's Integrated Urban System. The Region is responsible for the treatment and supply of water to the City's distribution system while the City is responsible for the local distribution and delivery of water to the end user. The Region owns and operates all supply and transmission infrastructure including water treatment plants, supply wells, pumping stations, storage facilities, boundary valves, and transmission watermain infrastructure. The City owns and operates all distribution infrastructure including watermains, hydrants, main valves, and services.

The following provides a brief summary of the City's pressure zones.

4.1.1 Waterloo Pressure Zone 4

Waterloo Pressure Zone 4 (Wat 4), located in northeast Waterloo, is the City's largest pressure zone with the lowest elevation. The pressure zone is supplied by the William Street Water Treatment Plant (WTP) and bulk transfers from the City of Kitchener via:

- Hallman Road Motorized Control Valve #3 (MV3) – Primarily supplied by the Mannheim WTP
- Erb Street Butterfly Valve – Primarily supplied by the Strange Street WTP

Wat 4 also conveys flows to portions of the IUS outside of the City including:

- Kitchener Zone 4A, which is supplied through the unmonitored Hawkswood and Falconridge Pressure Reducing Valves (PRVs)
- Woolwich Stockyards which is supplied through a monitored watermain
- St. Jacobs and Elmira, which is supplied through a monitored transmission main to the St. Jacobs Reservoir and Pump Station for distribution

Pressure Zones 4B and 4C are also supplied by Wat 4 through the Laurel Tank from the Northfield Pumping Station and Lakeshore Pumping Station, respectively.

4.1.2 Waterloo Pressure Zone 4B

Waterloo Pressure Zone 4B (Wat 4B) is a small closed pressure zone that relies on supply from the Laurel Tank located in Wat 4. This zone is boosted through operations at the Northfield Pumping Station.

4.1.3 Waterloo Pressure Zone 4C

Waterloo Pressure Zone 4C (Wat 4C) is a small closed pressure zone that relies on supply from the Laurel Tank located in Wat 4. This zone is boosted through operations at the Lakeshore Pumping Station.

4.1.4 Waterloo Pressure Zone 5

Waterloo Pressure Zone 5 (Wat 5) is the City's second largest pressure zone, and is operated at a slightly higher HGL than Wat 4. The pressure zone is supplied through both internal and external sources. The primary internal supply source comes from the Erb Street Supply and can be supplemented in the future through the Waterloo North supply. Externally, Wat 5 is supplied by the Mannheim Water Treatment Plant as flow is conveyed through the Hallman Road Motorized Control Valve #2 (MV2) from Kitchener Zone 5. Additionally, water from Wat 5 supplements Wat 4 during peak demand periods through the Erb Street PRV.

Wat 5 contains Well W10 which previously supplied the distribution system. This well is currently offline, but is available in the future if needed.

4.1.5 Waterloo Pressure Zone 6

Waterloo Pressure Zone 6 (Wat 6) is the City's third largest pressure zone, and is operated at a higher HGL than Wat 5. Wat 6 is supplied through external sources from the Mannheim WTP through the University Elevated Tank (ET) in Kitchener Zone 6. Under emergency conditions, a check valve opens to allow Wat 7 to be supplied by Wat 6.

4.1.6 Waterloo Pressure Zone 7

Waterloo Pressure Zone 7 (Wat 7) is located farthest west of the City, and operates at the highest HGL within the water system. This zone is internally supplied by the Erb Street Supply through the Zone 7 Pumping Station. Under emergency conditions, a check valve opens to allow Wat 7 to be supplied by Wat 6.

Wat 7 pump station also conveys flows to portions of the IUS outside of the City including:

- St. Agatha water distribution system
- Waterloo Region Emergency Services Training and Research Complex (WRESTRC)

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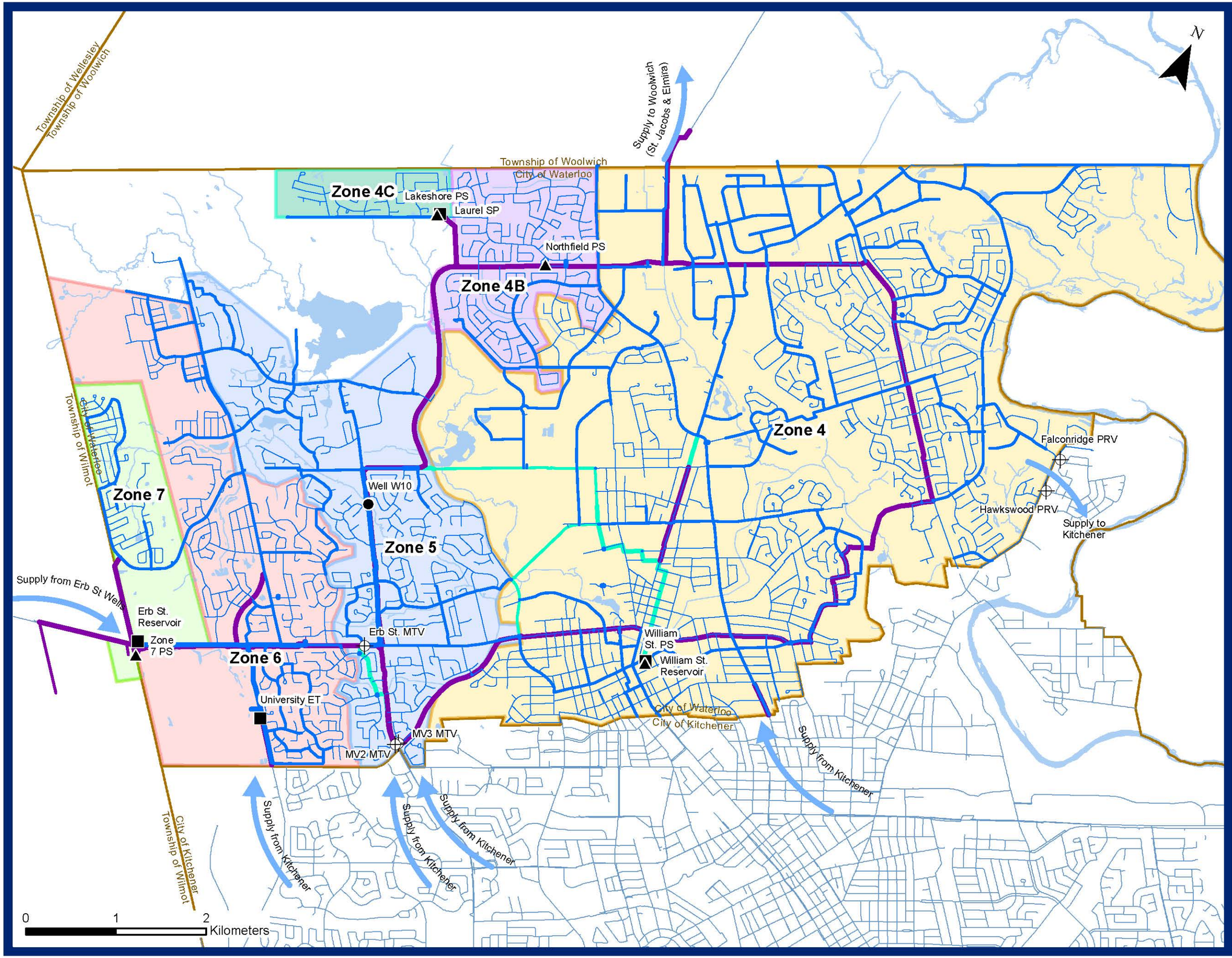
Water Distribution Master Plan

Figure 1 - Existing Water System



Water Infrastructure

- Pumping Station
- Well
- Reservoir
- Valve

Watermain (mm)

- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains

Pressure Zone

- Wat 4
- Wat 5
- Wat 4B
- Wat 6
- Wat 4C
- Wat 7

Environmental Features

- Municipal Boundary
- River, Lake

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615036-1-W
March 2017
Data Source: City of Waterloo
Scale: 1:40,000 | NAD 1983 UTM Zone 17N

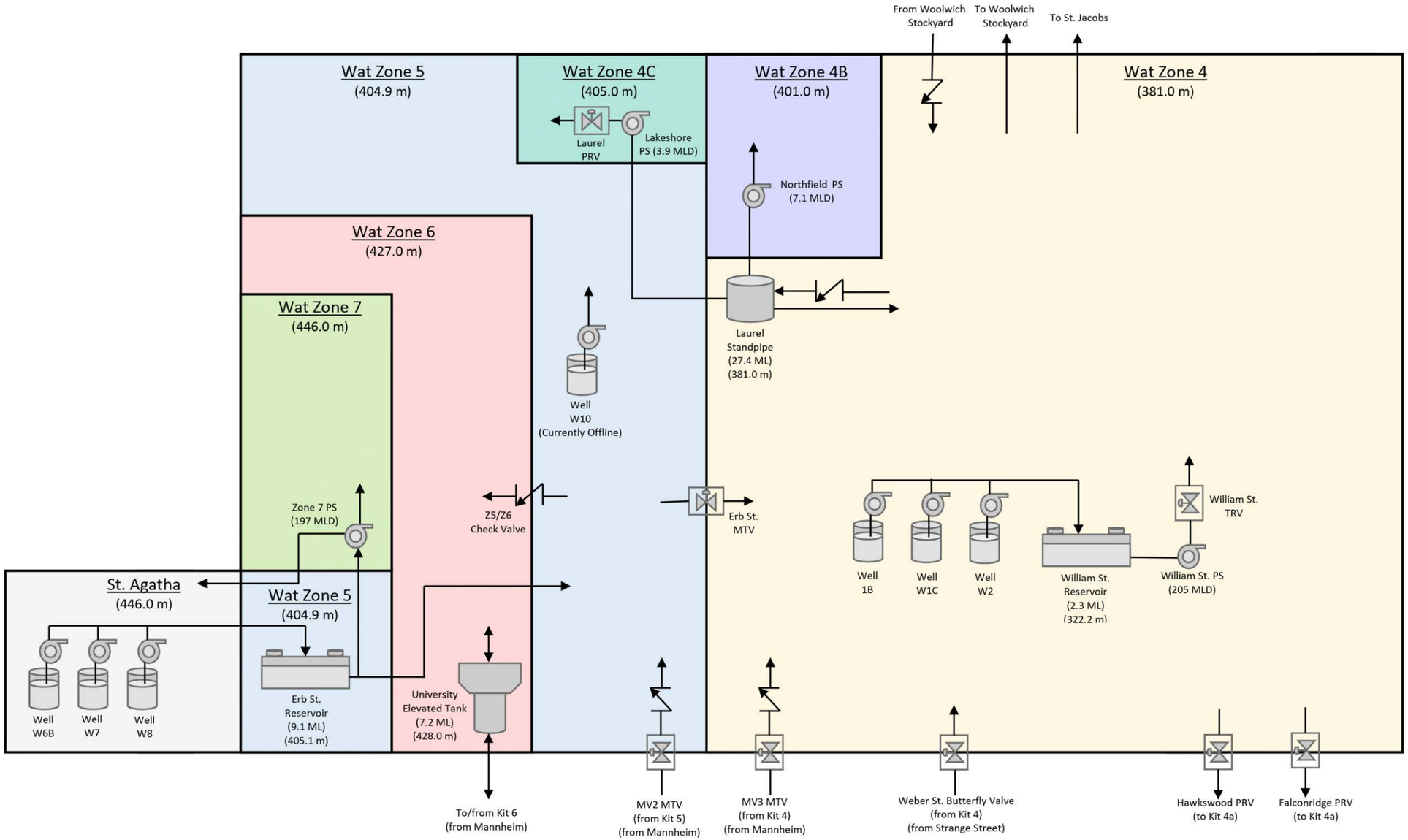

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Figure 2 - Water Schematic

Water Infrastructure

- Reservoir
- Elevated Tank (Volume) (Top Water Level)
- Stand Pipe (Volume)
- Pump (Firm Capacity)
- Well
- Pressure Reducing Valve (PRV)
  Motor Control Valve (MTV)
  Throttle Control Valve (TRV)
- Check Valve

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615036 - Water Schematic
January 2017 | Scale: NTS

4.2 Existing Water System Configuration

Within the City, the water system is configured into six separate pressure zones operating at varying hydraulic grade lines (HGL). The distribution system depends on a number of pumping stations and reservoirs to adequately supply and convey water to the system. **Table 1** and **Figure 1** summarize the existing system's infrastructure.

Table 1 - Existing Water System Configuration and Infrastructure

Pressure Zone	Wat 4	Wat 4B	Wat 4C	Wat 5	Wat 6	Wat 7
HGL (m)	381.0	401.0	405.0	404.9	427.0	446.0
Internal Supply	William St Waterloo North (Future)	-	-	Erb Street Supply Well W10 (Not in Operation) Waterloo North (Future)	-	Erb Street Supply
External Supply	From Wat 5 (through Erb St MTV) Mannheim WTP (through MV3)	From Wat 4 (through Northfield PS)	From Wat 4 (through Lakeshore PS from Laurel Tank)	Mannheim WTP (through MV2)	Mannheim WTP (through University ET) Wat 5 to Wat 6 Check Valve (Emergency)	Wat 6 to Wat 7 Check Valve (Emergency)
Pumping Station	Laurel PS (Not in Operation)	Northfield PS	Lakeshore PS	-	-	Zone 7 PS
Storage Facilities	Laurel Tank	-	-	Erb St Res	University ET	-

4.3 Existing System Demands

Existing system demands were identified through a comprehensive system mass balance review by cross-referencing the City's water billing records, the Region's production and flow records, and the City's non-revenue water audits on a pressure zone basis. **Table 2** summarizes the City of Waterloo's existing water system demands.

Table 2: Existing Water Demands

Pressure Zone 4	254
Pressure Zone 4B	24
Pressure Zone 4C	5
Pressure Zone 5	57
Pressure Zone 6	48
Pressure Zone 7	<1
System	378

4.4 Regional Planned Upgrades

Through the Region's 2015 WSDOMP and additional studies a number of Regional projects are proposed to enhance and optimize the transmission and operations of the City of Waterloo's water supply within the Integrated Urban System. The proposed water system upgrades are intended to occur before 2031. **Figure 3** highlights the proposed Regional WSDOMP projects, as described below.

4.4.1 Upgrade Strange Street Water Treatment to Include William Street Wells

The amalgamation of the William Street Wells and Strange Street Water Treatment Plant into a single treatment work will consist of:

- Conveyance of William Street Wells flows to the Strange Street Water Treatment Plant
- Upgrade Strange Street Water Treatment Plant to accommodate increase flow and treatment requirements

Anticipated Competition Date: 2019

4.4.2 Weber Street MTV Control Valve

Upgrade to Weber Street MTV Control Valve to accommodate increase flow transfers into Wat 4.

Anticipated Competition Date: 2019

4.4.3 Waterloo Pressure Zone 5 Consolidation

As Wat 4B, Wat 4C and Wat 5 operate similar HGLs, the Region plans to merge the three pressure zones into the existing Wat 5. The consolidation of Wat 5 requires reconfiguration of existing valving, the construction of new transmission watermains, and the decommissioning of the Northfield Pumping Station. **Figure 3** identifies the trunk infrastructure required to merge the three pressure zones.

Anticipated Competition Date: 2021

4.4.4 Waterloo North Water Treatment Plant

To enhance the security of supply within the City while reducing the reliance on supply from the Mannheim Water Treatment Plant, an additional groundwater source - Waterloo North - will be constructed and fed directly into the Laurel Tank. This new supply source is intended to provide water to Wat 4 with the option of supplementing flows to Wat 5 through the existing Lakeshore Pumping Station.

Anticipated Competition Date: >2021

4.4.5 Erb Street Facility Capacity Restoration

The Erb Street supply will have restored capacity and improved operations which will also enhance internal security of supply. With this upgrade, an additional pressure reducing valve will be installed to allow water to be transferred from Wat 6 to Wat 5 during emergency conditions when the Erb Street supply is offline.

Anticipated Competition Date: Completed

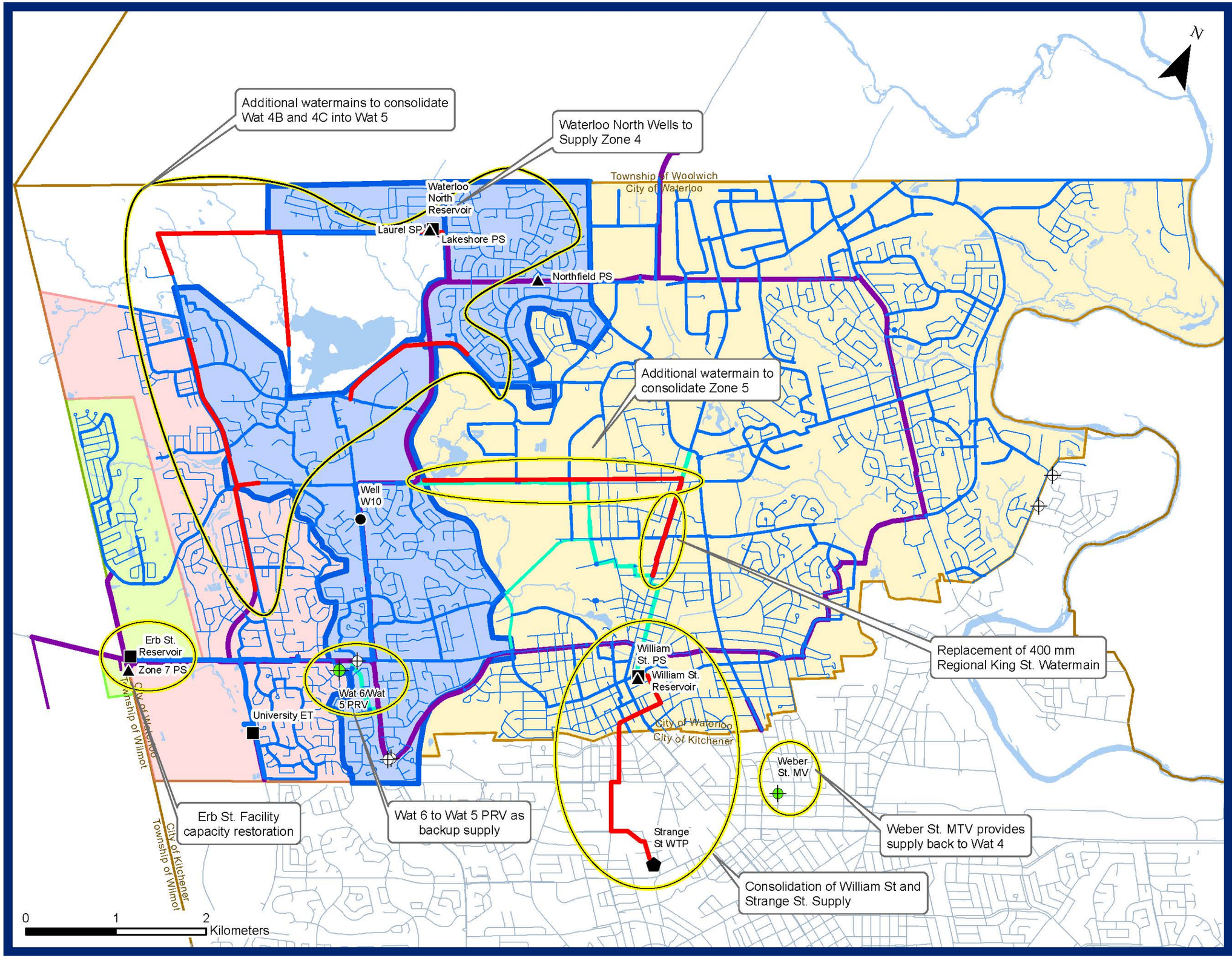

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Figure 3 - Regional WSDOMP Water System Upgrades

Water Infrastructure

- Pumping Station
- Treatment Plant
- Reservoir
- Well
- New Valves
- Valve

Watermain (mm)

- < 200 mm
- 250 - 350 mm
- > 400 mm
- Proposed Watermains
- Regional Watermains
- Dual Watermains

Water Pressure Zone

- Wat 4
- Wat 7
- Wat 6
- 4B, 4C, and 5 to be consolidated into Wat 5

Environmental Features

- Municipal Boundary
- River, Lake

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Data Source: City of Waterloo
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5 Problem and Opportunity Statement

Through the Municipal Class EA process, Phase 1 requires the identification of a problem or opportunity statement that guides the development and evaluation of alternative strategies to address the deficiencies identified in the water distribution system. The following vision statement serves as the foundation for this Master Plan in an attempt to enhance existing and future system performance through 2031.

The Vision Statement is as follows:

"To establish a master plan to achieve a cost effective water distribution system that:

- Meets the needs of existing users, regulatory, and legislative requirements;
- Supports growth;
- Considers system resiliency; and,
- Optimizes the system performance objectives with the long term renewal needs of the system."

6 Water Servicing Principles

The provision of safe and sustainable water services is an important issue to the public and to the municipalities planning, operating and maintaining the system. Execution of reasonable policies is essential to ensure proper planning. For this Master Plan, design principles were developed to support the vision statement, and guide the development of the servicing strategies, implementation of the system capital program, and operations and maintenance practices.

The principles were designed to:

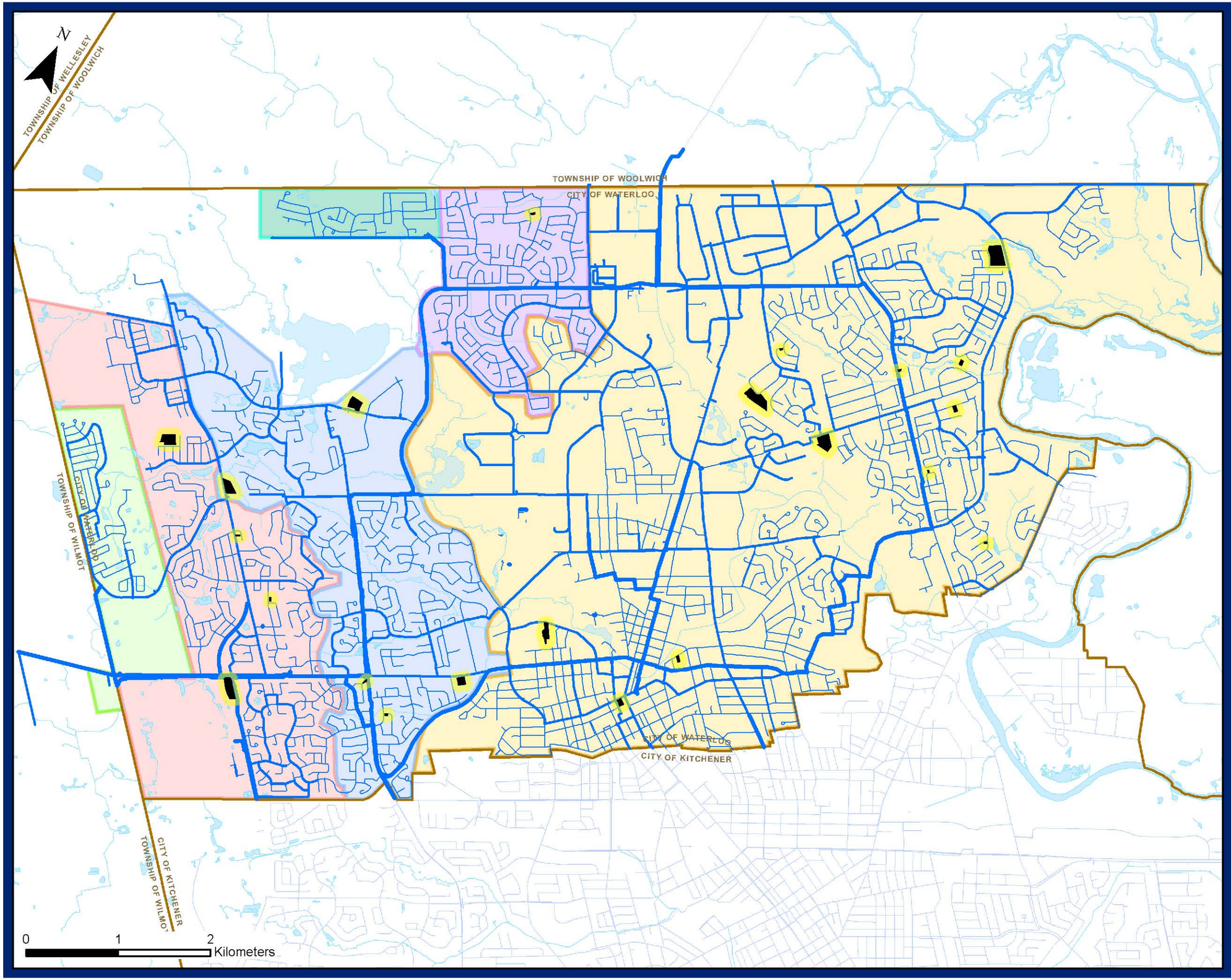
- Provide direction for planning and identifying water servicing issues that may impact growth options;
- Provide direction for normal operation and maintenance of the water systems (the policies do not replace normal operation and maintenance procedures or best practices);
- Provide direction for development and evaluation of servicing strategies for the Water Distribution Master Plan;
- Ensure appropriate design and costing criteria are utilized for developing and evaluating servicing strategies for this Master Plan;
- Setting policies that are reasonable to implement; and,
- Setting policies that are robust and sustainable.

Although best management practices and criteria are updated over time, the context, intent and validity of the principles should remain intact.

Building on the problem and opportunity statement for the Water Distribution Master Plan, specific servicing principles were developed to guide and provide direction for the development and evaluation of servicing strategies. The water servicing principles are outlined in detail in **Technical Appendix #3**.

6.1 Vulnerable Occupancies

Further, water system upgrades should not disrupt/decrease the water flows/pressure available to the City of Waterloo's vulnerable occupancies without mitigation. **Figure 4** identifies currently known vulnerable occupancies within the City of Waterloo.



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Water Distribution Master Plan

Figure 4 - Vulnerable Properties

Local Watermains

- < 200 mm
- 250 - 350 mm
- > 400 mm
- Kitchener Watermains
- Vulnerable Properties

Pressure Zone

- Wat 4
- Wat 4B
- Wat 4C
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

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615036-W
March 2017
Data Source: City of Waterloo
Scale: 1:40,000 | NAD 1983 UTM Zone 17N

6.2 Design Criteria and Level of Service Objectives

In addition to developing water servicing principles, the design criteria outline the methodology and values used to estimate growth related flows as well as the decision-making rationale related to infrastructure capacity and the trigger for upgrades.

The following summarizes the key design criteria and level of service objectives utilized to evaluate water system performance. **Technical Appendix #3** further outlines the design criteria and level of service objectives.

6.2.1 Water Demands

Existing system demands were defined using the "Starting Point" methodology, using the billing data from January 2014 to October 2015 average daily system demands as the baseline 2016 system demands. Existing max day demands were than calculated using a 1.42 peaking factor.

Growth related demands were calculated using the values provided in **Table 3**. The City's WDMP applied slightly more conservative per capita demand rates and peaking factors than utilized in the Region's WSDOMP and WSMPU. This was due to the WDMP analysis and recommendations focus on smaller service areas, than those considered in the evaluation of Regional facilities.

Table 3: Water Design Criteria

Development Type	Average Day Demand	Max Day Peaking Factor
Residential	170 L/c/d	1.65
Employment	108 L/c/d	1.65

The above growth per capita rates, from the Region's WSDOMP, were utilized as they were more conservative than the 2031 rates outlined in the Region's WSMPU. The conservative max day peaking factor, from the MOECC Design Guidelines for Drinking Water System for municipalities with a population between 75,001- 150,000, was applied to growth demands only.

The Non-Revenue Water rate utilized for growth demands was 10%, in line with the WSMPU and WSDOMP.

6.2.2 Level of Service Objectives

The level of service objectives were further categorized by **"Action"** and **"Flag"** items. The following is a summary of Action versus Flag levels of service:

- Action
  - An action level of service deficiency is not within MOECC requirements
  - Action deficiencies require a system upgrade and must be resolved at each instance
- Flag
  - A flagged level of service deficiency is within MOECC requirements but outside City desired level of service
  - Flag deficiencies were evaluated on a case by case basis which took cost vs. benefit of addressing the issue before proceeding with a final alternative recommendation
- Greenfield Growth Areas
  - New growth areas will strive to achieve the City desired level of service targets

Table 4 summarizes the level of service Actions and Flags the City of Waterloo will achieve. **Technical Appendix #3** further details level of service criteria and rationale.

Table 4: Water Distribution Levels of Service

Criteria	Level of Service	Explanation
Pressure	40-100 psi	**Action** – Existing system must maintain pressures between 40-100 psi as per MOECC requirements
	50-90 psi	**Flag** –System upgrades are required to maintain pressures between 50-90* psi to serviced area
Fire Flow (Dead-End Residential)	50 L/s	**Action** – Fire flows unable to maintain above 80% of their target level of service **Flag** – Fire flows are able to maintain a level of service between 80-100% of their target level of service
Fire Flow (Single Family)	75 L/s	
Fire Flow (Multi Family)	150 L/s	
Fire Flow (Commercial)	175 L/s	
Fire Flow (Institutional)	175 L/s	
Fire Flow (Industrial)	250 L/s	
Fire Flow (City Center – Existing)	Based on existing land use	
Fire Flow (City Center – Future)	225 L/s	
Fire Flow (University)	300 L/s	
Chlorine Residuals	>0.5 mg/L	Maintained through management of water age
Water Age	>14 days	**Action** – Water age exceeds 14 days
	8-14 days	**Flag** – Water age is between 8-14 days
Dead End Servicing	Maintain balance between fire flow and water quality	Dead end watermains with reduced fire flow will be addressed on a case-by-case basis
Watermain Velocity	<2 m/s	**Action** – Distribution system must maintain velocities below 2 m/s
Easements	-	Easements will be decommissioned based on redundancy in system performance

* - 50-80 psi in the DGSSMS; however, due to scope of 80-90 psi area with the existing system, reduction in peak pressure requirement from 90 psi to 80 psi was not logistically or financial feasible. The focus of the WDMP was primarily related to minimum pressures issues.

7 System Growth

The residential, employment, and student population growth within the City of Waterloo was reviewed to develop a basis for water demand and ultimately water infrastructure needs through build out conditions of 2031. Initially, three 2031 growth scenarios reflecting different data sources were assessed to determine a preferred growth scenario. Please refer to **Technical Appendix #5** for additional details related to growth scenario and allocation methodology.

The 2031 total population and employment allocations for the three growth scenarios included the following:

- A "**high" growth scenario** - which encompasses more aggressive population and employment growth. The high growth scenario was based on the Region's **Ontario Places to Grow** targets (Region of Waterloo, 2016).
- A **"medium" growth scenario** - which projects moderate growth levels. The medium growth scenario was based on the Region's existing Water Supply Master Plan Update (WSMPU) (Stantec, 2014).
- A **"low" growth scenario** - which includes the most conservative levels of population and employment growth. The low growth scenario was based on the City's current Water and Wastewater Rate Study (DFA, 2016), which utilized residential growth from 2013-2014 issued building permits by billing type. Future growth was extrapolated to 2031 using a constant growth rate from the 2013-2014 numbers.

7.1 Recommended Growth Scenario

Based on the preliminary system analysis, the high growth scenario had lower overall system performance, generating an increased number of system deficiencies, relative to the medium and low growth scenarios. However, the overall difference among the three scenarios was marginal.

Due to the marginal difference in system performance across all growth scenarios, the high growth scenario was selected to represent future growth in all Master Plan analyses, and in evaluating alternative strategies as it would generate the most robust upgrade recommendations.

Table 5 summarizes the City's recommended growth scenario which projects 161,140 people (residents and students) and 89,000 jobs in 2031.

Table 5: Projected Population and Employment Growth

	Baseline (2011)	Future (2031)	Growth
Residential	102,731	140,000	**37,269**
Student	16,940	21,140	**4,200**
Employment	63,473	89,000	**25,527**

7.2 Project 2031 System Demands

Table 6 summarizes the existing and projected 2031 water system demands based on the recommended growth scenario. These demands are based on the Region's WDSOMP which account for declining per capita demand rates.

Table 6: Projected 2031 Populations and Demands by Pressure Zone

		Zone 4	Zone 4B	Zone 4C	Zone 5	Zone 6	Zone 7
Projected 2031 Growth	Residential	12,793	678	5,472	7,712	3,363	7,251
	Student	4,200	0	0	0	0	0
	Employment	17,231	432	712	3,859	1,891	1,402
System Demands	Existing Demands (L/s)	254	22	6	52	44	<1
	Growth Demands (L/s)	55	2	12	20	9	16
	2031 Total Demands (L/s)	309	24	18	72	53	17

In addition to servicing local users, the City's water distribution system directly supplies areas outside of the City limits. Considerations for these external water users was included when developing the Water Distribution Master Plan preferred serving alternatives.

8 Assessment of Local Water Infrastructure Needs (Existing and Future)

In addition to the Regional upgrades planned to enhance the City's water system, local improvements are needed to address existing and future system capacity and supply. This was the focus of the Water Distribution Master Plan.

The first step in the detailed analysis of the Master Plan was to assess the existing infrastructure capacity and conditions. Once the existing system conditions were established, the impacts of future growth demands on the water distribution system were analyzed to develop and evaluate potential servicing alternatives, and address potential deficiencies and opportunities. Please refer to **Technical Appendix #7** for further details results and evaluation.

8.1 System Opportunities and Constraints

System deficiencies were classified in two (2) distinct groups:

1. Existing localized and independent system deficiencies not impacted by growth
2. "Clustered" areas of system deficiencies that may or may not be impacted by growth

8.1.1 Group 1 - Existing Localized Deficiencies

Figure 5 highlights the existing localized system deficiencies not impacted by growth. These deficiencies are mainly at dead ends, which are usually serviced by a older small diameter watermains. Other locations include areas with adjacent land uses requiring high fire flows, areas without proper system looping, or watermains in easements.

These areas are to be addressed by the City's infrastructure renewal program through completion of one of two interventions:

- Rehabilitation or replacement of older watermains with high headlosses (low C factors) with a new watermain that includes the same nominal diameter; or
- Replacement of the existing watermain with a new, larger watermain.

8.1.2 Group 2 - Deficiency Cluster Areas

Where possible, system deficiencies were consolidated into "cluster areas", consisting of grouped deficiencies that can be resolved by the same suite of system improvements.

Addressing deficiency cluster areas issues would not trigger specific new capital projects to be included in the final capital program recommendations.

8.2 Baseline System Performance

The City's water system was assessed using the Region of Waterloo's existing hydraulic all pipes InfoWater model of the IUS.

8.2.1 Existing System Performance

Figure 5 highlights the existing system deficiencies. Presently, distribution areas experiencing level of service deficiencies are presented below.

- High pressures in Wat 6 at the border between Wat 5 and Wat 6
- High pressures in Wat 5 at the border between Wat 4 and Wat 5
- Low pressures in Wat 4 along the border between Wat 4 and Wat 5
- Fire flow deficiencies in the Uptown Core
- Fire flow deficiencies in Wat 4B along the board of Wat 4B and Wat 4
- Water quality deficiencies primarily at dead ends or undeveloped areas
- Localized fire flow deficiencies throughout, primarily concentrated in existing cast iron watermain areas and at dead ends

8.2.2 Future System Performance

Figure 6 highlights the future system deficiencies. The proposed Region of Waterloo IUS system upgrades were assumed to be in place when completing the 2031 growth analysis. The Regional upgrades address a number of the existing system deficiencies; however, several of the identified system issues remain. Additional population and employment growth further results in localized deficiencies.

N

TOWNSHIP OF WELLESLEY

TOWNSHIP OF WOOLWICH

TOWNSHIP OF WOOLWICH

CITY OF WATERLOO

TOWNSHIP OF WILMOT

CITY OF WATERLOO

CITY OF KITCHENER

CITY OF KITCHENER

TOWNSHIP OF WILMOT

0 1 2 Kilometers

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Water Distribution Master Plan

Figure 5 - Existing Water System Performance

Local Watermains

- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Pressure Zone

- Wat 4
- Wat 4B
- Wat 4C
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure

- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Available Fire Flow

- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

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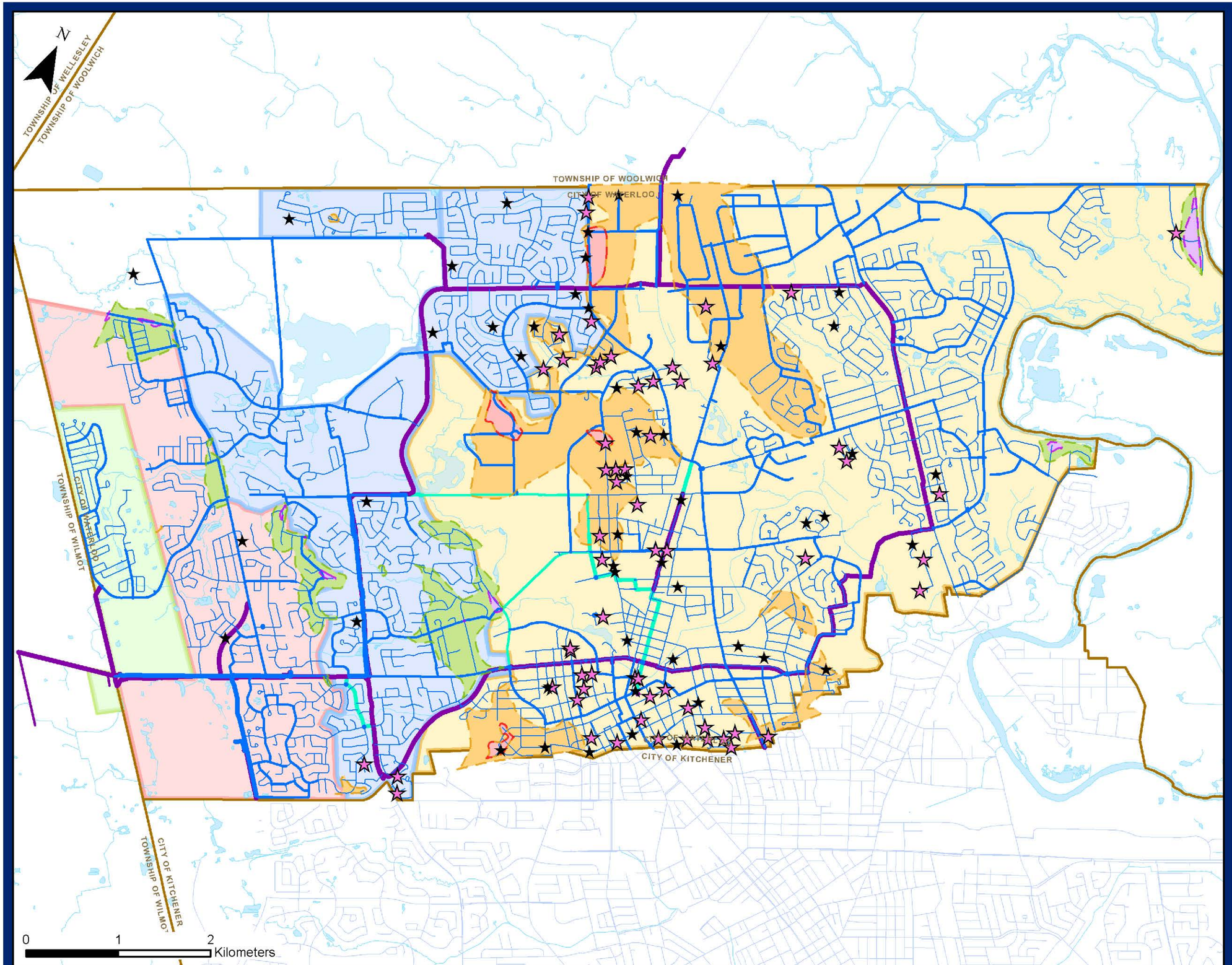
615036-W
March 2017
Data Source: City of Waterloo
Scale: 1:40,000 | NAD 1983 UTM Zone 17N



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Water Distribution Master Plan

Figure 6 - 2031 Water System Performance

Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Available Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

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9 Evaluation of Alternatives Process

System deficiencies were classified in two (2) distinct groups:

1. "Clustered" areas of system deficiencies that may or may not be impacted by growth
2. Existing localized and independent system deficiencies not impacted by growth

The "clustered" system deficiencies were consolidated into a number of cluster areas. These grouped deficiencies can be resolved by a system improvement that impacts the integrated infrastructure components that are in the cluster area. **Technical Appendix #6** describes each cluster area, including a description of the identified deficiencies and potential solutions. In this Technical Memorandum, the potential solutions to address the deficiencies in each Cluster Area were evaluated.

The recommended solutions to address the Group 1 and Group 2 deficiencies were determined using the following approach:

- **Step 1:** Evaluation of improvement options for each Group 1 (cluster area deficiencies) based on technical, environmental, social/cultural, financial, and legal/jurisdictional criteria
- **Step 2:** Selection of preferred alternative for each Group 1 cluster area using the Reasoned Argument Approach
- **Step 3:** Optimization of each cluster area through identification of related infrastructure improvements in the City's existing infrastructure renewal program
- **Step 4:** Identification of localized upgrades required to address Group 2 deficiencies remaining not already addressed by recommendations to address the Group 1 cluster area deficiencies

9.1 Reasoned Argument Approach

Each alternative was evaluated through the reasoned argument approach which provided a clear and thorough rationale of the trade-offs among the various options based on the anticipated impacts caused by various evaluation criteria and factors. The basis of this approach is to qualitatively evaluate the relative advantages, disadvantages, and impacts of each alternative against the established criteria. This process was intended to highlight why the preferred alternative was chosen through evaluation of technical, environmental, social/cultural, financial, and legal/jurisdictional criteria which is detailed in **Technical Appendix #6**.

9.2 Development of Feasible Alternatives

The development of feasible alternatives to address the Group 1 cluster area deficiencies relied on both technical viability and the costs versus benefits of the alternatives.

Technical feasibility utilized the concept of the two types of deficiencies, Action and Flag. Action deficiencies, which do not meet MOECC levels of service, must be addressed through a system upgrade. Flag deficiencies, which are within the MOECC requirements but do not meet City desired levels of service, will be evaluated on a case-by-case basis using cost-benefit analysis of addressing the deficiency.

The cost-benefit analysis for each alternative was evaluated in terms of a total cost, cost per improvement, and cost per weighted improvement:

- The **total cost** is the costs associated with the supply and installation of infrastructure, as well as operational changes.
- The **cost per improvement** is total cost divided by the number of properties that experience an improvement to an action deficiency.
- The **cost per weighted improvement** is the total cost divided by the number of properties that experience an improvement to an Action and/or Flag deficiency. The Action and Flag deficiencies are weighted appropriately as an improved Action deficiency is more important than a Flag deficiency.

The costing methodology is outlined in **Technical Appendix #9**.

9.3 Alternatives Screened for More Detailed Evaluation

Several alternatives in each cluster area were developed to address their deficiencies; however, only the alternatives that provided a technically viable solution were moved forward to the more robust evaluation process. Alternatives were screened out if one of following three conditions were met:

- The alternative did not address the Action deficiency in the cluster area
- The alternative generated new system deficiencies when implemented
- The alternative required excessive costs, relative to other alternatives, to resolve the deficiencies. For non-action deficiencies an upper limit of $5,000 per property was targeted.

10 Upgrade Analysis and Recommendations

The following section describes the identified system deficiencies and evaluation of upgrade alternatives.

10.1 Cluster Area A

Cluster Area A is located in Wat 6 at the border of Wat 5 and Wat 6 bordering along Leighland Drive and Keats Way. This area currently experiences high water pressure exceeding 90 psi due to low elevations. Pressures exceed 100 psi on Amberwood Drive, Knightsbridge Court, and Clair Creek Boulevard due to lower elevations. This area impacts 266 properties.

Figure 7 illustrates the high water pressure areas in Cluster Area A.

Alternatives to address Area A included:

- Cluster Area A: Option 1 – Do Nothing
- Cluster Area A: Option 2 – Pressure Zone Boundary Adjustment through Valving Only
- Cluster Area A: Option 3 – Pressure Zone Boundary Adjustment through Valving and Looping

10.1.1 Cluster Area A: Evaluation

The evaluation process is summarized in **Table 7** and further detailed in **Technical Appendix #7**.

Table 7: Cluster Area A - Evaluation

Technical Viability			
Meets Pressure Objectives			
Meets Fire Flow Objectives			
Operation and Maintenance			
Impact to Criticality			
Property Impacts			
Traffic Impacts			
Capital Costs			
Cost per Improvement			
Evaluation			

10.1.2 Cluster Area A: Recommended Solution

The recommended solution for the deficiencies in Cluster Area A was ***Option 2: Pressure Zone Boundary Adjustment through Valving Only,*** which presented the lowest cost alternative to address the identified Action items. While this solution creates new system dead-ends, the associated water quality issues generated by the new dead ends can be mitigated through the installation of boundary valves. **Figure 8** summarizes this recommendation.

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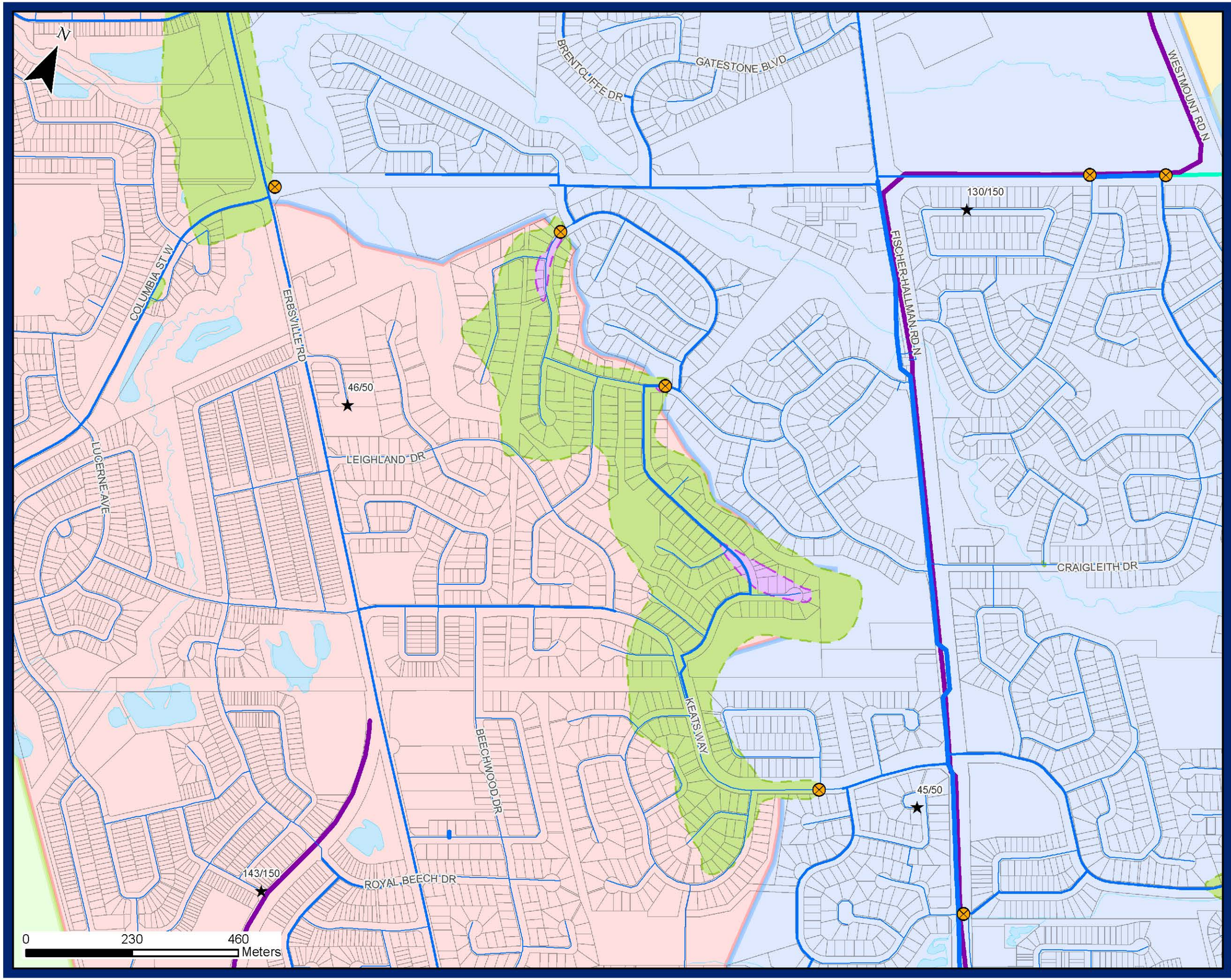
Figure 7 - Water System Upgrade Alternative Cluster Area A - Baseline



Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

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Figure 8 - Water System Upgrade Alternative Cluster Area A - Preferred Alternative

N

BRENTCLIFFE DR
GATESTONE BLVD
WESTMOUNT RD N
COLUMBIA ST W
ERBSVILLE RD
FISCHER-HALLMAN RD N
LUCERNE AVE
LEIGHLAND DR
CRAIGLEITH DR
KEATS WAY
BEECHWOOD DR
ROYAL BEECH DR

10033966
10029557
10034175
130/150
46/50
45/50
143/150

0 230 460 Meters

Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

Changes in Infrastructure
- New Watermain
- New Open Valves
- New Closed Valves
- New Install Closed Valves
- New Check Valve

Pressure Zone Realignment
- Zone 4 to 5
- Zone 6 to 5

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10.2 Cluster Area B

Cluster Area B is located in Wat 5 at the border of Wat 5 and Wat 6 along Westvale Drive. This area experiences low pressures between 40-50 psi due to high elevations at the pressure zone boundary. This area impacts 74 properties.

Figure 9 highlights the low pressures in Cluster Area B.

Alternatives to address Area B included:

- Cluster Area B: Option 1 – Do Nothing
- Cluster Area B: Option 2 – Pressure Zone Boundary Adjustment through Valving Only
- Cluster Area B: Option 3 – Pressure Zone Boundary Adjustment through Valving and Looping

10.2.1 Cluster Area B: Evaluation

The evaluation process is summarized in **Table 8** and further detailed in **Technical Appendix #7**.

Table 8: Cluster Area B - Evaluation

Criteria	Option 1 Do Nothing	Option 2 Valving Only	Option 3 Valving and Looping
Technical Viability	No work required	Generally easy	Generally easy
Meets Pressure Objectives	Regulatory only	Yes	Yes
Meets Fire Flow Objectives	Yes	Regulatory only	Yes
Operation and Maintenance	Dead end flushing required	Boundary valves eliminate need for dead end flushing	Addition of 150 m of WM to O&M
Impact to Criticality	No change	No change	No change
Property Impacts	None	None	None
Traffic Impacts	None	Minimal	Moderate
Capital Costs	$0	$0.06 million	$0.15 million
Cost per Improvement	$0	$8000/weighted improvement	$12,000/weighted improvement
Evaluation	Flag deficiencies do not justify excessive costs	High costs associated with system modifications	High costs associated with system modifications

10.2.2 Cluster Area B: Recommended Solution

The recommended solution for the deficiencies in Cluster Area B was ***Option 1 – Do Nothing***, which will not require any works as shown in **Figure 10**. The identified deficiencies are Flag deficiencies, which would only be resolved if financially feasible. Based on the alternatives evaluation the monetary costs of addressing the "flag" deficiencies exceeds the benefit provided.

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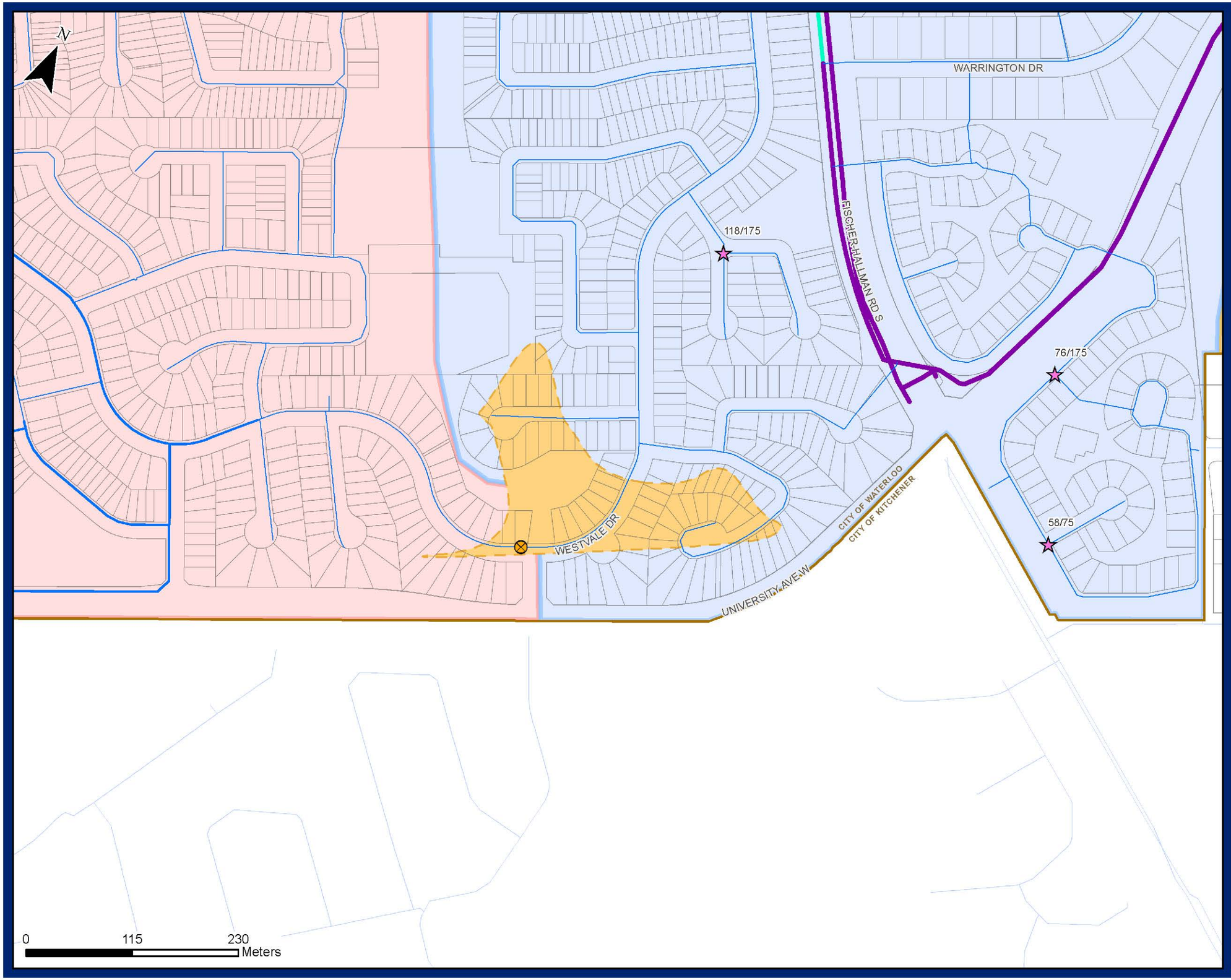
Figure 9 - Water System Upgrade Alternative Cluster Area B - Baseline



Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

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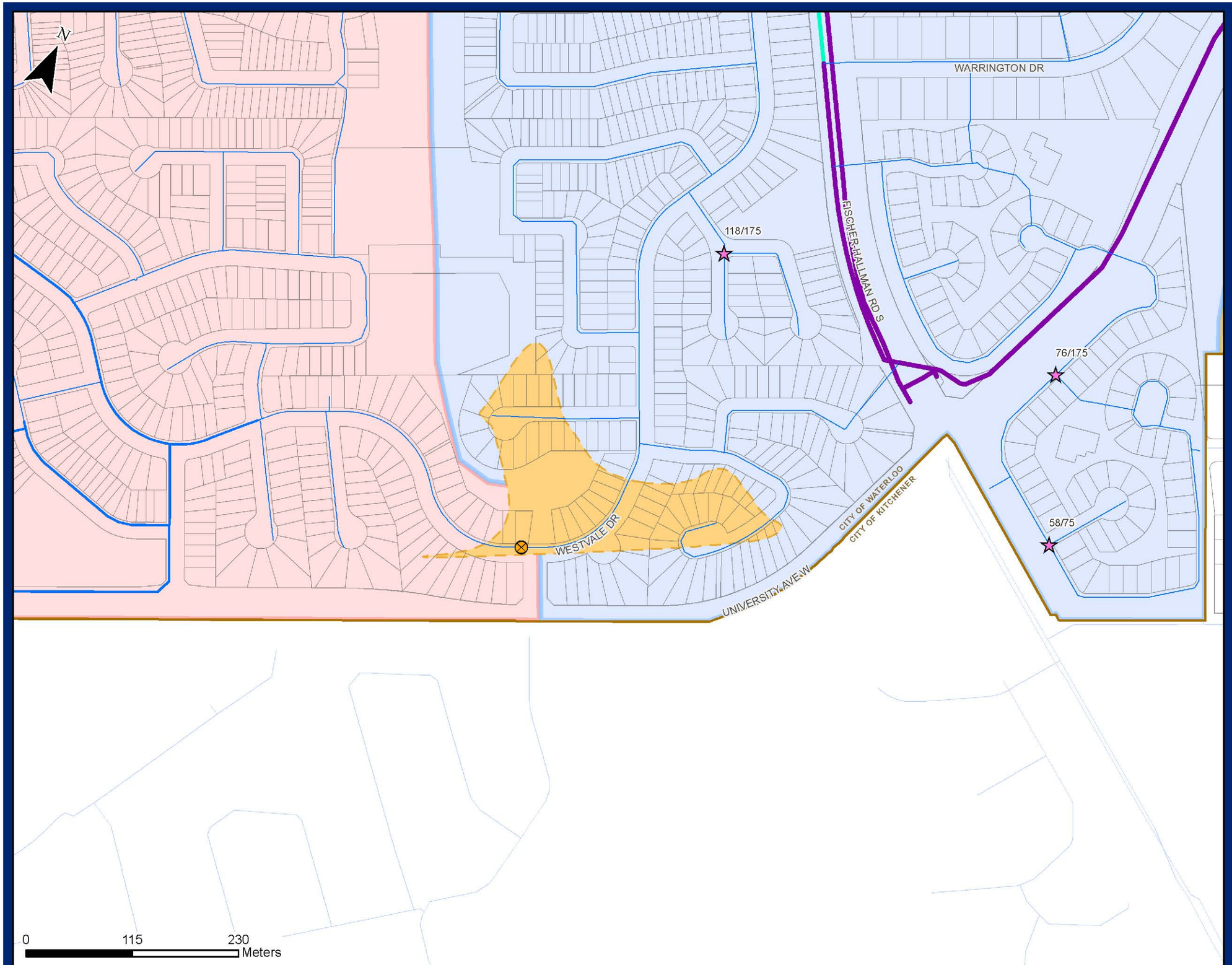
Data Source: City of Waterloo
Scale: 1:4,000 | NAD 1983 UTM Zone 17N



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Water Distribution Master Plan

Figure 10 - Water System Upgrade Alternative Cluster Area B - Preferred Alternative

Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

Changes in Infrastructure
- New Watermain
- New Open Valves
- New Closed Valves
- New Install Closed Valves
- New Check Valve

Pressure Zone Realignment
- Zone 4 to 5
- Zone 6 to 5

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10.3 Cluster Area C

Cluster Area C is located in Wat 4 at the Wat 5 boundary, bordering Westmount Road South, William Street West, and Avondale Avenue South. This area experiences low water pressures between 40-50 psi resulting from high elevations at the pressure zone boundary. Pressures below 40 psi are experienced along McDonald Place, Stanley Drive, and Laurier Place due to even higher elevations at these locations. This area impacts 334 properties.

Figure 11 highlights the low pressures in Cluster Area C.

Alternatives to address Area C included:

- Cluster Area C: Option 1 – Do Nothing
- Cluster Area C: Option 2 – Pressure Zone Boundary Adjustment to Westmount Drive
- Cluster Area C: Option 3 – Pressure Zone Boundary Adjustment to Dawson Street
- Cluster Area C: Option 4 – Pressure Zone Boundary Adjustment to Avondale Avenue South

10.3.1 Cluster Area C: Evaluation

The evaluation process is summarized in **Table 9** and further detailed in **Technical Appendix #7.**

Table 9: Cluster Area C - Evaluation

Criteria	Option 1 Do Nothing	Option 2 Boundary Adjustment to Westmount	Option 3 Boundary Adjustment to Roslin	Option 4 Boundary Adjustment to Avondale
Technical Viability	No work required	Generally easy	Generally easy	Generally easy
Meets Pressure Objectives	No	Yes	Regulatory only	Regulatory only
Meets Fire Flow Objectives	No	Improved (Addressed through SOGR program)	Improved (Addressed through SOGR program)	Improved (Addressed through SOGR program)
Operation and Maintenance	Dead end flushing required	Addition of 660 m of WM to O&M	Addition of 500 m of WM to O&M	Addition of 500 m of WM to O&M
Impact to Criticality	No change	No change	No change	No change
Property Impacts	None	None	None	None
Traffic Impacts	None	Major	Moderate	Moderate
Capital Costs	$0	$0.8 million	$0.7 million	$0.7 million
Cost per Improvement	$0	$8000/weighted improvement	$8000/weighted improvement	13,000/weighted improvement
Evaluation	Does not meet Action pressure or fire flow requirements	Planned road reconstruction and stormwater works on Westmount Road minimizes traffic impacts and costs	Creates additional pockets of high pressure	Creates additional pockets of high pressure and has high costs associated with system modifications

10.3.2 Cluster Area C: Recommended Solution

The recommended solution for the deficiencies in Cluster Area C was ***Option 2 – Pressure Zone Boundary Adjustment to Westmount Drive.*** Option 2 provided the best cost per improvement of all options. Further, both Options 3 and 4 substantially increased the total area transferred to Wat 5, and would result in a number of new areas within the New Wat 5 to have "Flag" deficiencies with pressure greater than 90 psi, where previously they were meeting the City's pressure objectives.

Option 2 will experience more significant property and traffic impacts during construction as the watermain works are located within an arterial road - Westmount Drive; however, these impacts can be mitigated through the alignment of the watermain works with already planned road and stormwater projects along the same alignment.

Figure 12 summarizes the recommended solution.

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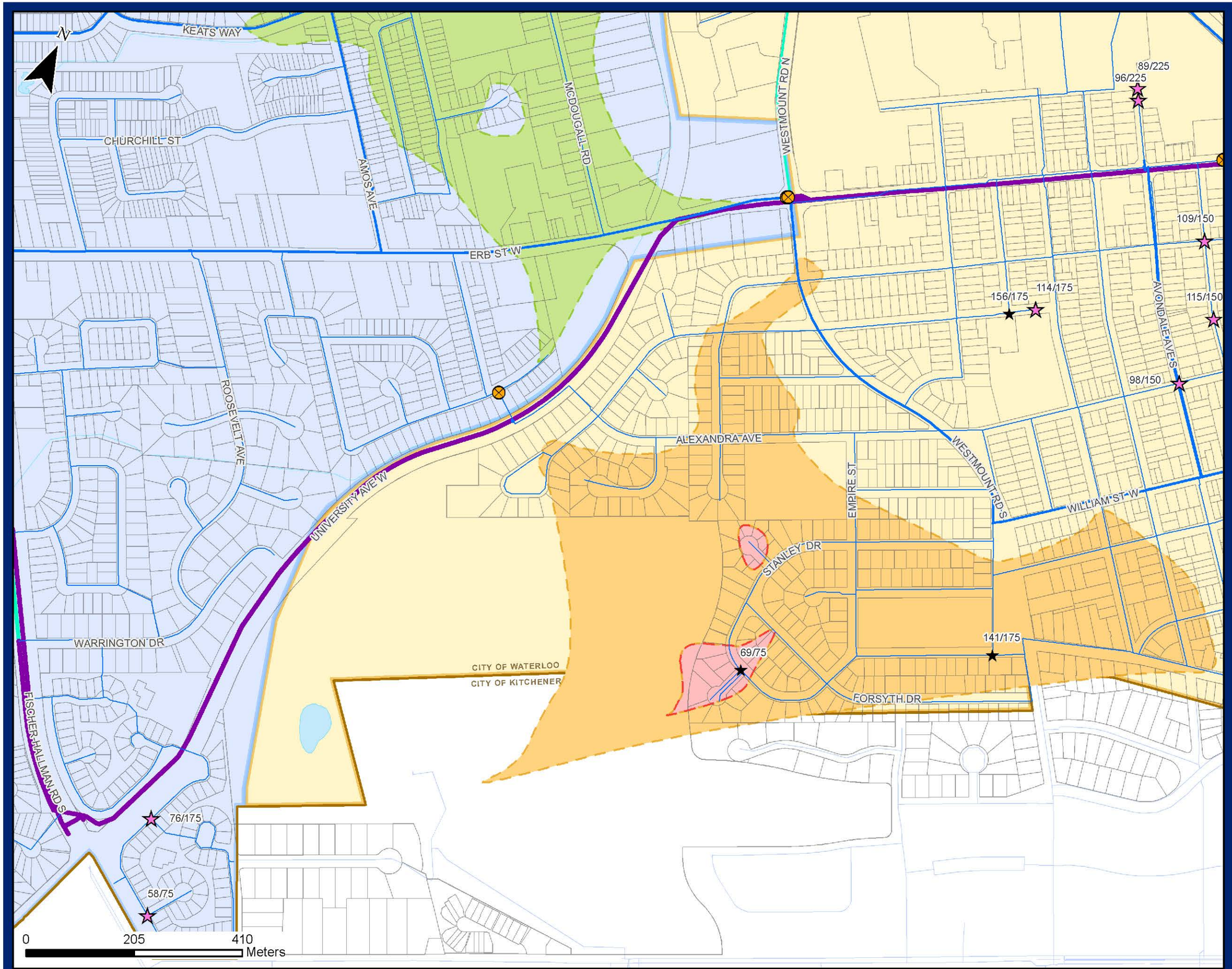
Figure 11 - Water System Upgrade Alternative Cluster Area C - Baseline



Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

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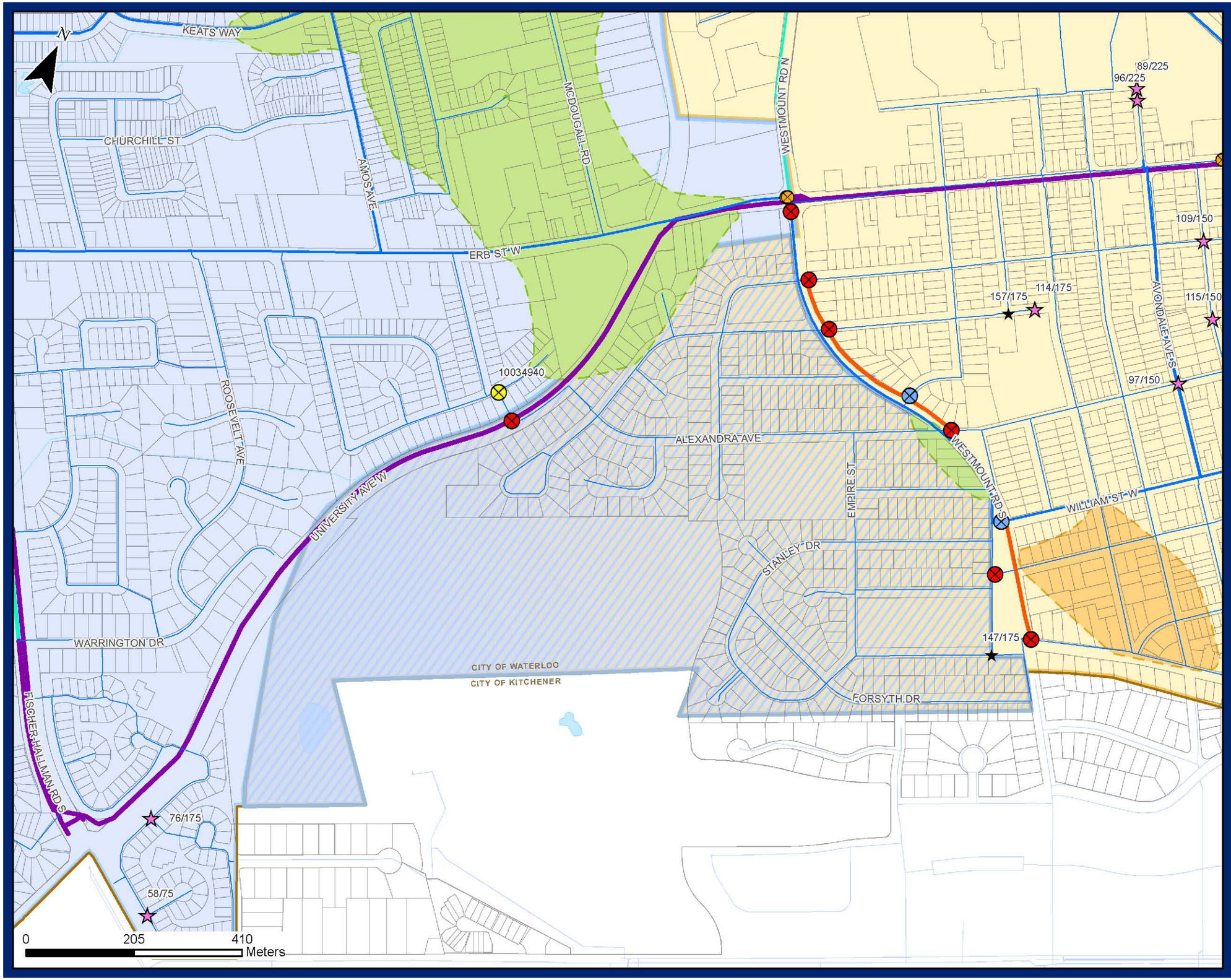
Figure 12 - Water System Upgrade Alternative Cluster Area C - Preferred Alternative



Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

Changes in Infrastructure
- New Watermain
- New Open Valves
- New Closed Valves
- New Install Closed Valves
- New Check Valve

Pressure Zone Realignment
- Zone 4 to 5
- Zone 6 to 5

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10.4 Cluster Area D

Cluster Area D is located in Wat 4 at the Wat 5 boundary, and along Columbia Street West, Weber Street North, Northfield Drive West and the area directly east of Highway 85 north of Lexington Road. This area currently experiences low water pressures between 40-50 psi resulting from high elevations at the pressure zone boundary. Pressures below 40 psi are experienced along Hagey Boulevard, Albert Street and Phillip Street, and Weber Street North in the industrial area due to higher elevations. Recently, several properties experiencing water pressures below 40 psi have installed privately owned booster pumps on their property to increase water pressure levels. Fire flow is also limited at a number of these locations as they comprise older and smaller diameter watermains which do not receive adequate flow at their hydrants. This area impacts 1,632 properties.

Figure 13 highlights the low pressures in Cluster Area D.

Alternatives to address Area D included:

- Cluster Area D: Option 1 – Do Nothing
- Cluster Area D: Option 2 – Minor Adjustment to Zone Boundary
- Cluster Area D: Option 3 – Marginal Adjustment to Zone Boundary
- Cluster Area D: Option 4 – Medium Adjustment to Zone Boundary
- Cluster Area D: Option 5 – Major Adjustment to Zone Boundary

Note: That solutions to address Cluster Area D require the following Regional Upgrade Projects to be completed before they can be fully implemented:

- Wat 5 Consolidation
- Waterloo North WTP

10.4.1 Cluster Area D – Woolwich Stockyards Considerations

Wat 4 pressure zone directly supply the Woolwich Stockyards, which primarily consists of commercial and industrial properties system, via a feed along Kumpf Drive. The Woolwich Stockyards, under the existing system configuration, experiences deficient pressures and fire flows as per the City's criteria outlined in the WDMP.

10.4.2 Cluster Area D: Evaluation

The evaluation process is summarized in **Table 10** and further detailed in **Technical Appendix #7**.

Table 10: Cluster Area D - Evaluation

Criteria	Option 1 Do Nothing	Option 2 Minor Boundary Adjustment	Option 3 Marginal Boundary Adjustment	Option 4 Medium Boundary Adjustment	Option 5 Major Boundary Adjustment
Technical Viability	No work required	Generally easy	Generally easy	Generally easy	Generally easy
Meets Pressure Objectives	No	No (Albert properties with privately serviced boosters)	Yes	Yes	Yes
Meets Fire Flow Objectives	No	Improved (Addressed through SOGR program)	Improved (Addressed through SOGR program)	Improved (Addressed through SOGR program)	Improved (Addressed through SOGR program)
Operation and Maintenance	Dead end flushing required	Addition of 600 m of WM to O&M	Addition of 600 m of WM to O&M	Addition of 600 m of WM to O&M	Addition of 5,450 m of WM to O&M
Impact to Criticality	No change	No change	No change	No change	No change
Property Impacts	None	None	Impact to privately serviced booster pumps	Impact to privately serviced booster pumps	Impact to privately serviced booster pumps
Traffic Impacts	None	Moderate	Moderate	Moderate	Moderate
Capital Costs	$0	$0.8 million	$0.9 million	$1.0 million	$3.0 million
Cost per Improvement	$0	$4,000/weighted improvement	$4,500/weighted improvement	$4,000/weighted improvement	$6,000/weighted improvement
Evaluation	Does not meet Action pressure or fire flow requirements	Does not meet Action pressure requirements	Pressure deficiencies are addressed through low costs and minimal valve changes	Requires more valve modification than Option 3	High costs associated with system modifications

10.4.3 Cluster Area D: Preferred Solution

The recommended solution for the deficiencies in Cluster Area D was ***Option 3 – Marginal Adjustment to Zone Boundary.*** Both Option 3 and Option 4 provided similar benefits and demonstrated similar costs per benefit. However, Option 3 was selected as the most feasible option as it provided the lowest total capital cost to address all of the "Action" deficiencies. Further, the new pressure zone boundary created by Option 3 is easier to construct than Option 4, and presents fewer system dead-ends, which may lead to future operational issues.

Figure 14 summarizes the recommended solution.

The Zone boundary realignment modifies the Woolwich Stockyards supply feed from a Wat 4 watermain to a Wat 5 watermain. The modified Wat 5 supply results in improved Stockyard pressures and fire flows. Under the proposed configuration the available fire flows within the Stockyards are maintained above the "Flag" level of service objective for Industrial properties.

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Figure 13 - Water System Upgrade Alternative Cluster Area D - Baseline

Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

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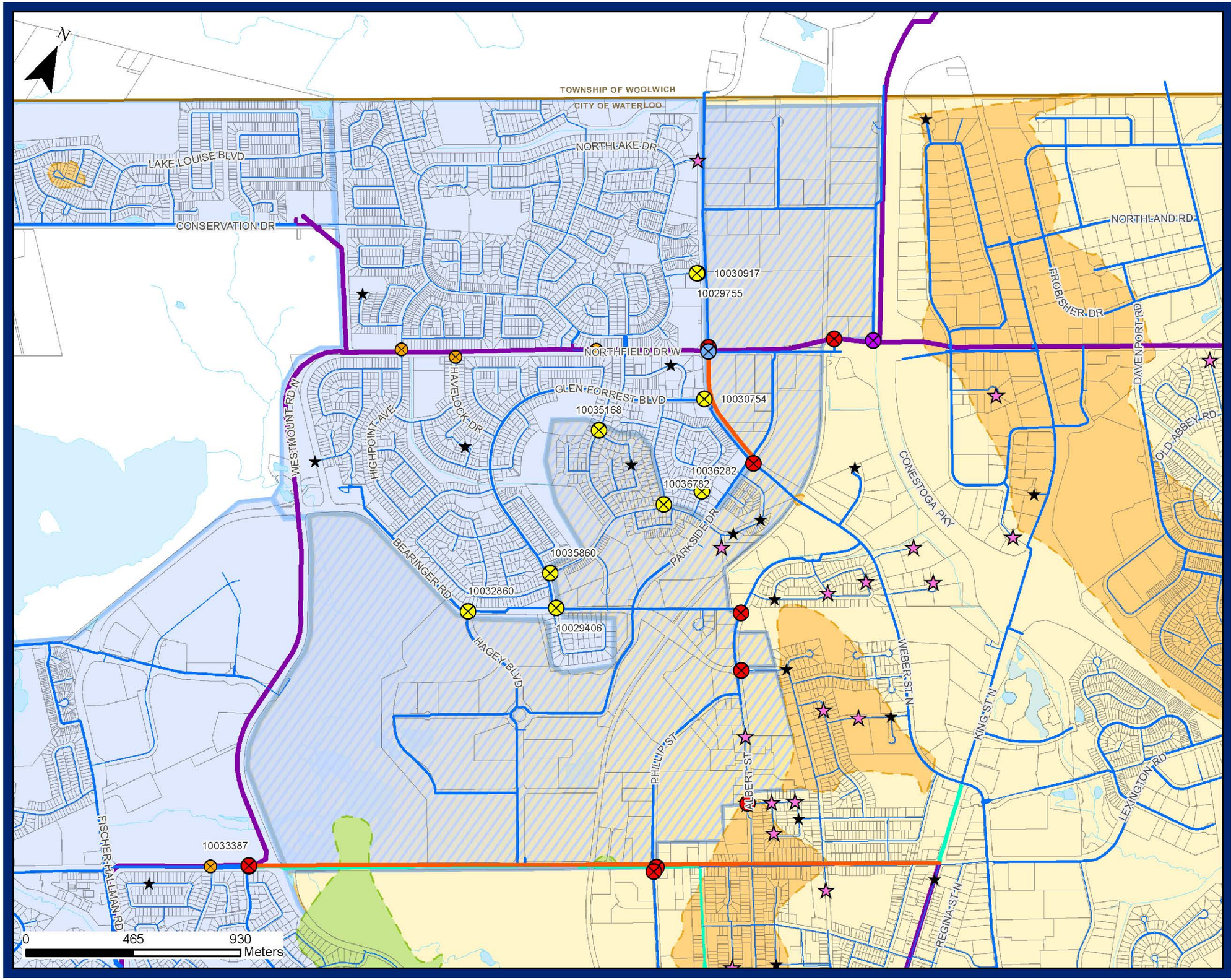
Data Source: City of Waterloo
Scale: 1:16,000 | NAD 1983 UTM Zone 17N

0 465 930 Meters



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Water Distribution Master Plan

Figure 14 - Water System Upgrade Alternative Cluster Area D - Preferred Alternative

Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

Changes in Infrastructure
- New Watermain
- New Open Valves
- New Closed Valves
- New Install Closed Valves
- New Check Valve

Pressure Zone Realignment
- Zone 4 to 5
- Zone 6 to 5

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Scale: 1:16,000 | NAD 1983 UTM Zone 17N

10.5 Cluster Area E

Cluster Area E is located in Wat 4 in the intensification area of Uptown Waterloo, the Northdale Neighbourhood, and surrounding area. Increasing densities have resulted in fire flow deficiencies.

Figure 15 highlights the low fire flows in Cluster Area E.

Alternatives to address Area E included:

- Cluster Area E: Option 1 – Do Nothing
- Cluster Area E: Option 2 – Local Upsizing

10.5.1 Cluster Area E: Evaluation

The evaluation process is summarized in **Table 11** and further detailed in **Technical Appendix #7**.

Table 11: Cluster Area E - Evaluation

Criteria	Option 1 Do Nothing	Option 2 Local Upsizing
Technical Viability	Generally Easy	Yes
Meets Pressure Objectives	Not required	Yes
Meets Fire Flow Objectives	No	Yes
Operation and Maintenance	-	No change
Impact to Criticality	No change	No change
Property Impacts	None	None
Traffic Impacts	None	Major
Capital Costs	$0	$40 million
Cost per Improvement	$0	-
Evaluation	Does not meet fire flow requirements needed for growth in the intensification core	Requires upsizing to meet fire flow objectives relative to growth

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Figure 15 - Water System Upgrade Alternative Cluster Area E - Baseline

Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

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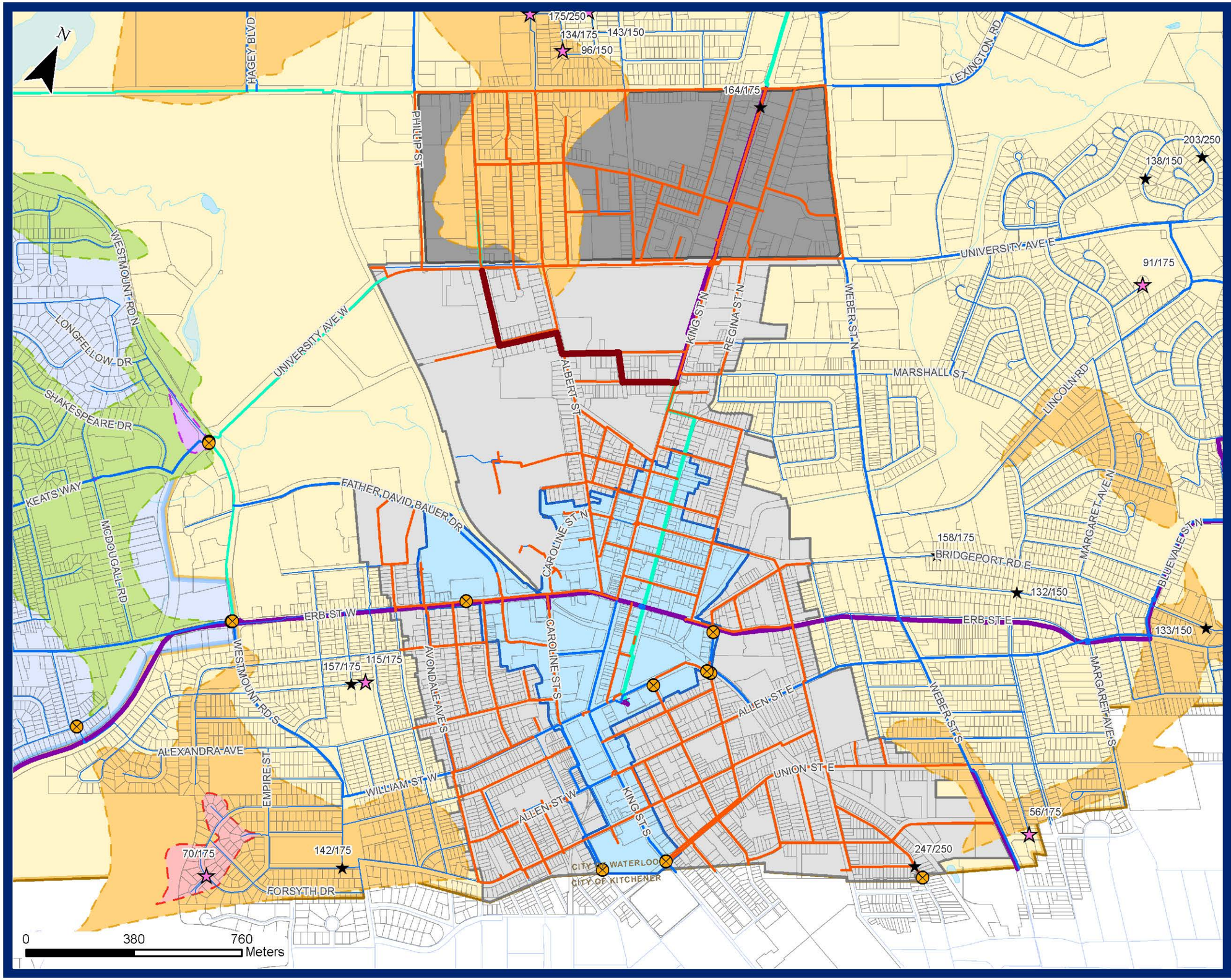
Figure 16 - Water System Upgrade Alternative Cluster Area E - Option 2



Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Valves
- Closed Valve

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

Changes in Infrastructure
- New Watermain
- Watermain Downsized to 200 mm
- New Open Valves
- New Closed Valves
- New Install Closed Valves
- New Check Valve

Intensification Areas
- Uptown
- Northdale
- Uptown Buffer

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Data Source: City of Waterloo
Scale: 1:13,000 | NAD 1983 UTM Zone 17N

10.5.2 Cluster Area E: Preferred Solution

The recommended solution for the deficiencies in Cluster Area E was ***Option 2 – Local Upsizing*** as the existing water infrastructure within the core intensification areas is not sufficient to meet the desired fire flow targets. Option 2, with the targeted upsizing of local watermains, will allow for supplementation of fire flows within these core intensification areas.

Additional information regarding which watermains require upsizing are provided in the electronic deliverables submitted to the City as part of the WDMP. **Figure 16** shows the location of the watermains to be upsized.

11 Localized System Deficiencies

Additional areas throughout the system experience fire flows below level of service flags and requirements. These deficiencies do not occur within a specific cluster zone but are localized and distributed across the system. Alternatives to address these deficiencies included:

- **Localized System Deficiencies: Option 1 – Do Nothing**
- **Localized System Deficiencies: Option 2 – State of Good Repair Program**: The rehabilitation, replacement, or upsizing of deficient watermains as part of the state of good repair program, excluding system dead ends.
- **Localized System Deficiencies: Option 3 – State of Good Repair Program and Dead End Upsizing**: The rehabilitation, replacement, or upsizing of deficient watermains as part of the state of good repair program, including system dead ends. The process of upsizing dead end watermains requires an assessment of water quality and water demands.

11.1 Localized System Deficiencies: Recommended Solution

The recommended solution to address cluster-wide fire flows was ***Option 3 – Infrastructure Improvements Including Dead End Upsizing*** as it best addressed the Group 1 deficiencies. While the infrastructure improvements (replacement or upsizing of watermains) on system dead ends will result in improved fire flows, it will also increase water age, which is the primary proxy indicator for water quality. However, a dead end analysis (**Technical Appendix #6)** determined that the majority of system dead ends could be upsized to improve fire flow performance without significantly impacting water quality.

11.2 Easement Watermains

Easement watermains are difficult to maintain due to the limited space available for construction activities. The City would like to eliminate as many of these watermains as possible without causing additional system deficiencies. The City currently maintains 84 watermains which pass through an easement, of which 22 can be decommissioned with minimal impact on system performance and levels of service. **Technical Appendix #7** further summarizes the easement analysis and recommendations**.**

12 Project Implementation Plan

12.1 Recommended Servicing Strategy

The recommended short and long-term servicing strategy for the City's water distribution system encompasses the cluster area recommendations and local improvements. **Figure 17** presents the final alternative encompassing the recommended local improvements.

12.1.1 Vulnerable Occupancies

In line with the WDMP servicing principles, the recommended upgrades are not expect to not disrupt/decrease the water flows/pressure available to the City of Waterloo's vulnerable occupancies. **Table 2** in **Technical Appendix #9** summarizes the pre/post performance at all Vulnerable Occupancies.

It should be noted that all provincially defined vulnerable occupancies are required-or will be required over the next eight years-to have sprinkler systems. These sprinkler systems are required to meet one of several NFPA standards (i.e. 13, 13R, or 13D) depending on what type of vulnerable occupancy is being protected. The presence of a compliant sprinkler system allows a vulnerable occupancy's evacuation time to be increased, and therefore, water system upgrades that disrupt water flows/pressures could negatively impact the occupancy's ability to comply with required evacuation times. As a result, impacted vulnerable occupancies may not be able to comply with the OFC, and a fire safety risk may also be created.

Waterloo Fire Rescue's Fire Prevention Division should be informed whenever a water system upgrades is going to occur that will negatively impact a vulnerable occupancy's sprinkler system water supply. A request for service should be sent to WFR-FPD's Admin.

12.2 Project List

Table 1 in **Technical Appendix #8** summarizes the recommended system upgrades along with the estimated cost and Class EA schedule.

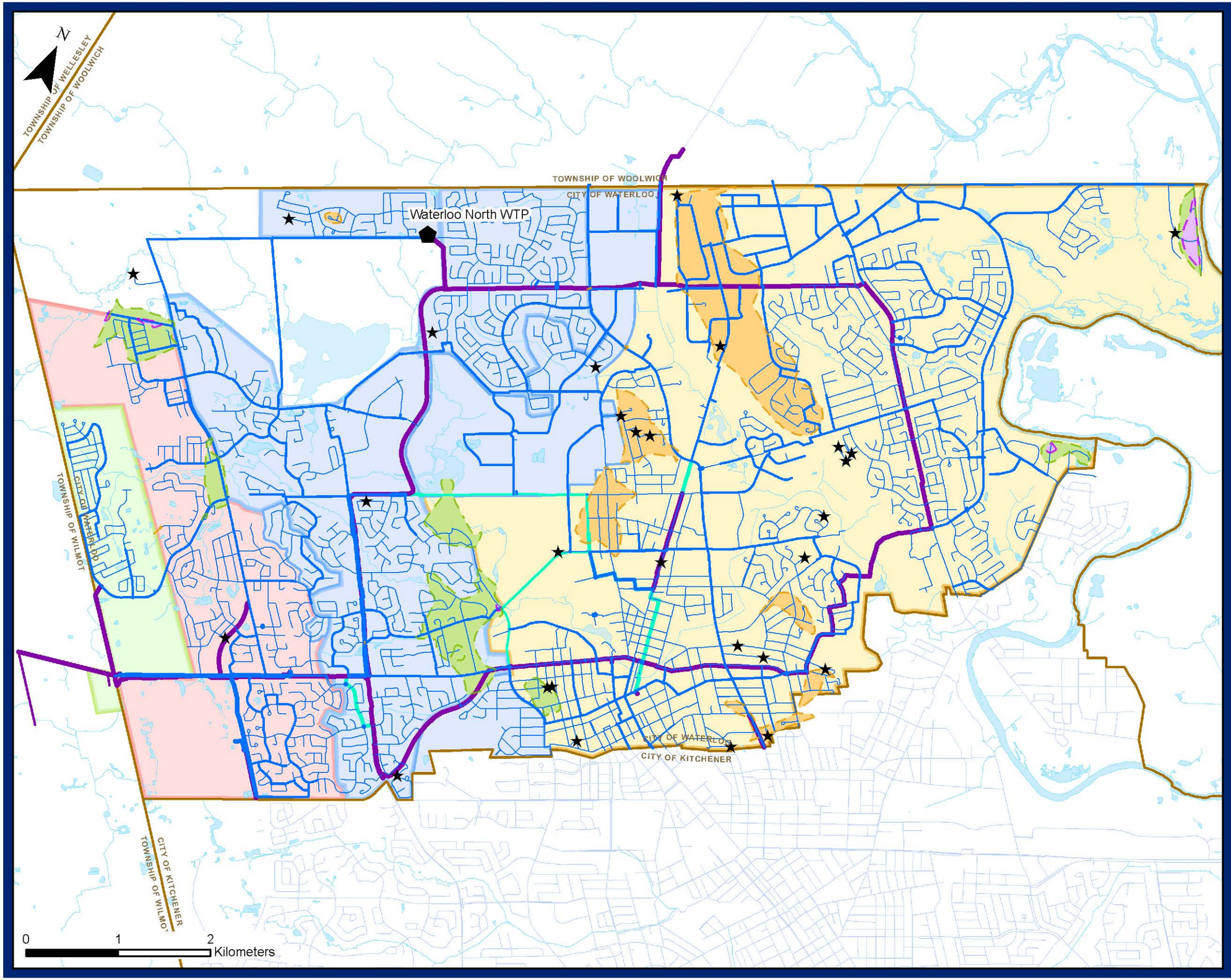

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Figure 17 - 2031 Water System Performance With All Preferred Alternatives

Local Watermains
- < 200 mm
- 250 - 350 mm
- > 400 mm
- Regional Watermains
- Dual Watermains
- Kitchener Watermains

Pressure Zone
- Wat 4
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

Max Day Demand - Minimum Pressure
- <40 PSI
- 40-50 PSI
- 90-100 PSI
- >100 PSI

Available Fire Flow
- <80% of Target Fire Flow
- 80%-100% of Target Fire Flow

BluePlan ENGINEERING

615036-W
January 2017
Data Source: City of Waterloo
Scale: 1:40,000 | NAD 1983 UTM Zone 17N

12.3 Studies and Other Initiatives

In addition to the specific recommendations to address the system deficiencies, the following general recommendations are provided for consideration by City staff in their efforts to manage the water distribution system.

12.3.1 Master Planning Renewal

The City is recommended to complete regular updates to its Water Distribution Master Plan, on a five-year cycle, to review and revise the proposed water system upgrade strategy to account for:

- The implementation of the recommended upgrade projects,
- The implementation of Regional projects and/or changes in the Region's long term system operational strategy
- Changes in baseline system demands and projected growth
- Changes in federal and/or provincial regulations and/or City level of service objectives

12.3.2 Boundary Meter Program

As identified in this Master Plan, the City's water system has several interconnections to external systems. These interconnections consist of closed and unmetered valve connections, open metered connections, and open unmetered connections. **Figure 18** illustrates the system's current interconnections.

Upon completion and approval of this Master Plan, it is recommended that the City undertake a review to investigate and confirm the status of all existing system inter-connections, and implement a program to install, monitor, and maintain boundary billing meters at all open interconnections.

12.3.3 Zone Boundary Implementation and Consultation Plan

This Master Plan identifies several zone boundary realignments. As such, it is recommended that the City create a general zone boundary implementation and consultation plan to outline:

- The process to consult with and inform the public of any planned change(s) in system pressure
- Development of a clear implantation plan to ensure maintenance of service, which would include a valve opening-and-closing staging program and the required flushing process to ensure adequate water quality
- Any changes required of the City's current local operation and maintenance practices, including modifications to the City's regular flushing program

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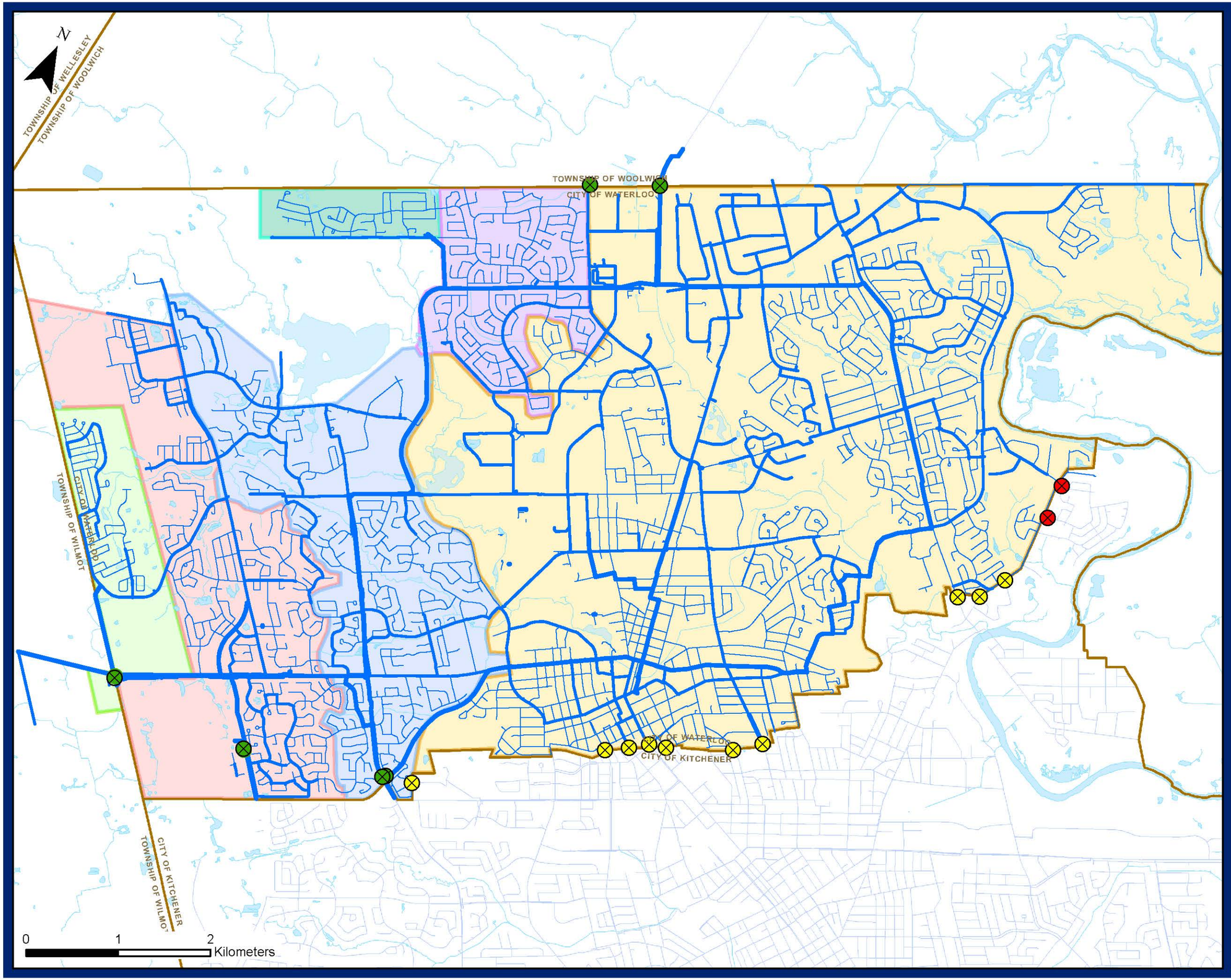
Water Distribution Master Plan

Figure 18 - Existing Intermunicipal Connections



Local Watermains

- < 200 mm
- 250 - 350 mm
- > 400 mm
- Kitchener Watermains

Boundary Meters and Valves

- Closed Valves
- Unmetered
- Metered

Pressure Zone

- Wat 4
- Wat 4B
- Wat 4C
- Wat 5
- Wat 6
- Wat 7
- Municipal Boundary
- River, Lake

BluePlan ENGINEERING

615036-W
January 2017
Data Source: City of Waterloo
Scale: 1:40,000 | NAD 1983 UTM Zone 17N

12.3.4 Review of Hydrant Flushing Program

As part of City's ongoing chlorine residual management, operations should review the results of the system's water age analysis and identify existing hot sports of high water age.

The City should continue their ongoing in field chlorine measurements as part of the hydrant flushing, and continue to revise the frequency of the flushing program based on the results of the field investigation

- Identified hot spots not currently within the City current flushing program, as well as,
- Flushing locations not identified as water age hot spots

The City should consider ongoing refinement of the hydraulic water quality model using infield chlorine residual reading in an effort to further optimize the City residual management program.

Further, at locations requiring regular system flushing, the City should explore the installation of automated flushing devises, equipped with water meter to track usage, in an effort to reduce the total operational and maintenance costs associated with the City's residual management program.

12.3.5 Hydrant Testing Program

Improvements and/or modifications of the City's flushing program should incorporate the collection of hydrant flow and pressure readings. This information should tie directly to hydrant asset ID and be recorded within the City's GIS database. This additional system performance information will improve current system understanding and support future infrastructure planning studies and updates to the hydraulic model.

12.3.6 Valve Turning Program

The valve exercising program should be adjusted to include using a hydrophone to confirm that certain critical isolation valves are properly seated and are operating as intended when in a closed position.

As part of the valve turning program, the City should establish appropriate protocols to track and replace any/all valves that do not fully operate.

12.3.7 Non-Revenue Water Audit and Reduction Strategy

The City should undertake non-revenue water reduction analysis in an effort to develop a comprehensive Non-Revenue Water Reduction Strategy and Remediation Plan. The goal of the strategy would to identify operational procedures and to identify locations where the rehabilitation or replacement of existing watermains in order reduce the total volume of lost water. This Non-Revenue Water Reduction Strategy and Remediation Plan will support the City's long-term non-revenue water targets.

The scope of activities that may be included in Non-Revenue Water Reduction Strategy and Remediation Plan includes:

- Annual residential water meter replacements;
- Large industrial, commercial or institutional (ICI) meter replacements;
- Testing of decommissioned water meters to establish degradation curves (aids in estimating NRW and establishing life-cycle replacement schedules);
- Leak detection programs for watermains;
- Watermain replacements
- Tracking fire use more accurately
- Tracking new construction use (non-metered)
- Zone metering to determine NRW
- Undertaking annual water audit and Infrastructure Leakage Index exercises

12.3.8 Zone Metering Leak Detection Program

Key component of the Remediation Plan, is the implementation of advanced metering capabilities in the form of a Zone Metering and Leak Detection Plan. Full implementation of the Zone Metering and Leak Detection Plan Consist would consist of the following phases:

Step 1. **Confirm Zone Meter Location:** Complete additional field investigation and hydraulic modelling to confirm viability of Zone Metering locations and boundary delineations. Included in this step is the detailed design of new metering chambers.

Step 2. **Develop Leak Detection Program:** Develop Leak Detection Program, system isolation plan and strategy for adjustment of zone boundary's to further isolate/discretize the system with the objective of further isolating the system leakage areas. Implementation plan should also identify duration of system isolation, data collection frequency, and any temporary reduction in system pressure or fire flows that may need to be communicated to the public or fire department ahead of implementation.

Step 3. **Zone Meter Installation:** Installation of Zone Meter chambers. Full integration of Zone meter with the Region's SCADA system is required to effectively manage the leak detection investigation.

Step 4. **Implementation of Leak Detection Program:** Complete leak detection program and identify existing system leaks by location and loss potential

Step 5. **Leak Remediation Plan:** Establish the minimum level of leakage recovery to justify the remediation cost and implement system repairs to system leak exceeding the minimum recovery threshold

The above plan can be incorporated with advanced real-time metering of services to allow for near immediate notification and locating of watermain breaks.

12.4 Implementation of Capital Program

The implementation of the recommended alternatives is guided by an understanding of the specific triggers that will result in the need for the alternative. This process allows for construction to be initiated as it is needed to meet MOECC requirements, support water demands, and/or align with other projects within the IUS.

The implementation strategy of the recommended alternatives fall into three categories:

- Type 1
    - The recommended alternative can be implemented without any preceding activities being completed.
    - These activities are funded by the operating budget.
- Type 2
    - The recommended alternative requires the completion of specific Regional projects before it can be implemented.
    - Implementation of the recommended alternative requires a full design, tender and inspection project.
    - These projects are funded by the capital budget.
- Type 3
    - Implementation of the recommended alternative should be aligned with related capital projects or operating activities.
    - Implementation of the recommended alternative requires a full design, tender and inspection project.
    - These projects are funded by the capital budget.

Table 12 summarizes each recommended alternative by trigger type and if needed, required construction activities. **Technical Appendix #8** outlines the prioritization of each project.

Table 12: Implementation Triggers for Preferred Alternatives

Recommended Upgrades	Trigger Type	Project Trigger	Assumed Budget
Cluster Area A – Pressure Zone Boundary Adjustment along Keats Way	Type 1 – Project can commence at any time	The pressure zone boundary adjustment can occur at any time.	Operating
Cluster Area C – Pressure Zone Boundary Adjustment to Westmount	Type 3 – Project can commence as aligned work commences	The pressure zone boundary adjustment requires the watermain along Westmount Drive South to be twinned. A Regional project to repave Westmount Drive South is planned for 2020-2021 and the watermain installation and valve installation/ reconfiguration should be aligned with this project.	Operating
Cluster Area D – Pressure Zone Boundary Adjustment to Parkside Drive	Type 2 – Project can commence once Regional projects have been completed	The pressure zone boundary adjustment requires the completion of the Regional trunk watermain along Columbia Street West from Westmount Road North to King Street North which will service Wat 4. The existing Columbia Street watermain will service the new Wat 5. The Waterloo North Water Treatment Plant (Regional project) must be completed with servicing capabilities to the existing Lakeshore Pumping Station from the Laurel Tank. The Lakeshore Pumping Station will provide the new Wat 5 with adequate supply to meet water demands to 2031. The completion of these works are planned for after 2020.	Operating
Cluster Area E – Upsizing of Watermains in Uptown, Northdale, and Intensification Areas	Type 3 – Project can commence as aligned work commences	The upsizing and/or replacement of watermains in Uptown, Northdale or surrounding intensification areas will be aligned with specific development proposal or other right-of-way infrastructure renewal plans.	Capital
Additional Fire Flow Deficiencies – Rehab, Replacement, or Upsizing	Type 3 – Project can commence as aligned work commences	The rehabilitation, replacement, and/or upsizing of watermains causing fire flow deficiencies should be incorporated into the City's integrated infrastructure renewal planning processes to align with specific development proposal or other right-of-way infrastructure renewal plans.	Capital
Easement Watermain Decommissioning	Type 1 – Project can commence at any time	The abandonment or decommissioning of easement watermains can occur at any time.	Operating

12.4.1 Asset Management Systems Integration

To support the integration of the recommendations provided in this Water Distribution Master Plan, the electronic deliverables (excel table and shapefile) contain a complete list of the City's watermains, including their recommended future diameter and classification as a growth or non-growth related project. This information, along with the upgrade prioritization outlined in the Master Plan, will be utilized by the City to support their asset management planning process and project prioritization and phasing.

12.5 Impacts on Regional Infrastructure

The system alternatives recommended in this Master Plan will result in changes to the overall transmission pumping and storage needs, due primarily to the re-alignment of pressure zone boundaries. A number of the identified zone boundary changes had previously been identified and accounted for in the Region's 2015 WSDOMP; however, this Master Plan has identified additional zone boundary changes and in particular, the significant expansion of the Wat 5 service area. In order to support this expansion, there will be an increased reliance on the new Waterloo North Water Treatment Plant and Laurel Tank through the Lakeshore Pumping Station to support peak flows. As such, the Region should continue to operate and maintain the Lakeshore Pumping Station indefinitely.

In reviewing the changes to the water system supply needs, there is sufficient capacity in the Region's infrastructure to support the proposed changes in this Master Plan. **Technical Appendix #8** provides a detailed breakdown of the supply needs of Wat 5.