City of Lloydminster

Water Master Plan

Final Report

September 2024

ISL Engineering and Land Services Ltd. is an award-winning full-service consulting firm dedicated to working with all levels of government and the private sector to deliver planning and design solutions for transportation, water, and land projects.

At ISL, your identity is part of our identity. Diversity, Equity, and Inclusion (DEI) speaks to our core values and provides space for our teams to bring their authentic selves to work. ISL believes DEI creates the best outcomes for our clients while sustaining a happy and thriving work environment that allows for career development opportunities for all staff. ISL is committed to a focused effort on continuous improvement and development of a respectful and safe workplace.

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4015 7 Street SE, Calgary AB T2G 2Y9, T: 403.254.0544 F: 403.254.9186

September 11, 2024

Our Reference: 28160

City of Lloydminster
4420 50 Avenue
Lloydminster, AB/SK
T9V 0W2

Attention: James Rogers, P.Eng., Senior Manager, Capital Infrastructure

Dear J. Rogers:

Reference: City of Lloydminster Water Master Plan – Final Report

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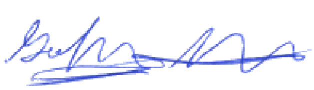
Enclosed is the Final Report for the City of Lloydmindster's Water Master Plan. We trust that it meets your needs.

The key objective of the Water Master Plan is to assess the City's current water distribution infrastructure capacity and the future needs for projected populations and development areas. This document contains the review of the City's water distribution system, which the part of the study considering treatment and storage is included under a separate cover titled Water Treatment Plant (WTP) Assessment/Master Plan Report.

The Water Master Plan will provide the City of Lloydminster with direction on infrastructure implementation and associated timelines to service future growth, while ensuring infrastructure remains fully functional in providing an appropriate level of service. This information will aid in making informed decisions on capital projects and will provide solutions for efficient, economic, and sustainable municipal services to residents and businesses.

We sincerely appreciate the opportunity to undertake this project on behalf of the City of Lloydminster. Should you have any questions or concerns, please do not hesitate to contact the undersigned at 403.254.5044

Sincerely,



Geoffrey Schulmeister, P.Eng., SCPM
General Manager, Water and Environment

Corporate Authorization

This document entitled “Water Master Plan” has been prepared by ISL Engineering and Land Services Ltd. (ISL) for the use of City of Lloydminster. The information and data provided herein represent ISL’s professional judgment at the time of preparation. ISL denies any liability whatsoever to any other parties who may obtain this report and use it, or any of its contents, without prior written consent from ISL.

PROFESSIONAL ENGINEER ALBERTA
SARAH BARBOSA
187386

November 22 2024

Sarah Barbosa, P.Eng., ENV SP Project Lead	Nancy Lai, M.Eng., E.I.T. Project Support

Permit to Practice
ISL Engineering and Land Services Ltd.

RM Signature:
RM APEGA ID: 66731
Date: 2024 November 26

Permit Number P4741
The Association of Professional Engineers and Geoscientists of Alberta

Geoffrey Schulmeister, P.Eng., SCPM
Project Manager

Territory Acknowledgement

City of Lloydminster

The City of Lloydminster acknowledges that we are located on Treaty 6 Territory, and the City of Lloydminster respects the histories, languages, and cultures of First Nations, Metis, Inuit, and all First Peoples of Canada, whose presence continues to enrich our vibrant community.

ISL Engineering and Land Services Ltd.

ISL Engineering and Land Services Ltd. acknowledges that our Calgary office and work takes place on the ancestral, traditional, and present-day territory of the Treaty 7 Nations of Southern Alberta. The confluence of the Bow and Elbow Rivers has been an important meeting place for Indigenous peoples since time immemorial, and we honour the Siksika, Piikani, and Kainai Nations of the Blackfoot Confederacy, the Bearspaw, Chiniki, and Goodstoney First Nations of the Stoney Nakoda Nations, and the Tsuut’ina Nation. We also acknowledge that this is the homeland of the Métis Nation of Alberta, Region 3.

Executive Summary

E1.0 Introduction

The City of Lloydminster (City) retained ISL Engineering and Land Services Ltd. (ISL) to complete a review of its current raw water sourcing, treatment, storage, and distribution systems and assess their capacity to meet the current and future growth water demands effectively culminating in an updated Water Master Plan (WMP). This document contains the review of the City's water distribution system, which the part of the study considering treatment and storage is included under a separate cover titled Water Treatment Plant (WTP) Assessment/Master Plan Report.

E2.0 Report Summary

The overall WMP is summarized as follows:

- **Purpose and scope of the Water Master Plan (WMP):** The WMP is a comprehensive review and assessment of the existing and future water storage, pumping, and distribution system in the City of Lloydminster. It aims to inventory and analyze the existing infrastructure, calibrate and update the hydraulic model, prepare service level assessments, develop servicing plans, and provide a framework for future capital planning.
- **Study area:** The study area covers 24 neighbourhoods and approximately 23.5 quarter sections of recently annexed land, with a total area of about 5,870 ha. The study area is divided by the Alberta/Saskatchewan border and is located within the North Saskatchewan River Basin. The development type is classified by several land use districts, such as residential, commercial, industrial, and public service.
- **Population horizons and growth projections:** The WMP considers six population horizons for the existing and future system assessment, ranging from 2021 to 2051. The growth populations are based on an annual growth rate of 2.2%, a target population allocation of 70% to Alberta and 30% to Saskatchewan, and the anticipated development timelines for each area. The growth projections also account for residential densification, employment population, and land use densities.
- **Design criteria and level of service:** The WMP uses the existing Water Master Plan (ISL, 2016), the City's Municipal Development Standards, and typical municipal servicing standards as the sources for the design criteria. The level of service for the water system is based on average day, maximum day, and peak hour day pressure requirements per Alberta Environment and Protected Areas (AEPA), as well as fire flow requirements from the Fire Underwriters Survey. Storage and pumping requirements are based on the requirements of the Saskatchewan Ministry of Environment (SME). System performance is based on the ability to deliver required water pressures and fire flows, while providing adequate reservoir storage volumes and pumping capacities.
- **Existing water system and hydraulic model development:** The existing water distribution system consists of approximately 208 km of water mains, mostly made of PVC or AC, with diameters ranging from 50 mm to 750 mm. The water distribution system has a variety of larger trunk mains acting as fire flow arteries in the system. The hydraulic model was constructed by updating the prior WaterCAD model using the City's GIS data, record drawings, and assumptions as necessary. The model was calibrated using hydrant flow testing.

- **Existing system assessment and proposed capacity upgrades:** The existing water distribution system assessment identified areas of concern where the system is undersized in terms of being able to deliver fire flows and sufficient resiliency/looping. The proposed capacity upgrades include pipe upsizing and additional looping at 22 locations in the system. The upgrades aim to resolve the capacity constraints and provide better fire flows in order to provide a solid level of service for the existing population.
- **Future system assessment and proposed concepts:** Future servicing concepts were developed, and a recommendation is provided as to a preferred concept. Water distribution system assessments were completed to ensure performance of the water distribution system under future development conditions. Costing is also provided for future concepts as well as existing water distribution system upgrades and proposed staging. Upgrades include new reservoir storage, enhanced pumping capacity, and upsized watermains in addition to the expanded future system layout.
- **Capital planning:** Based upon recommended upgrades and provided staging, a proposed capital planning table is included noting upgrades and recommended timelines for implementation for consideration in the City's overall capital plan.

E3.0 WMP Conclusions

Conclusions for the water distribution system are as follows:

- Locations with insufficient fire flow were identified and flagged in the existing water distribution system assessment, mainly due to the aging infrastructures and long sections of single feed pipes.
- A risk assessment was undertaken to prioritize the capacity and condition upgrades recommended under existing water distribution system conditions.
- Under Ultimate Boundary Growth conditions, the existing water distribution system was generally found to perform adequately.
  - Pumping capacity will need to be upgraded before the 20-Year Growth horizon, storage capacity will need to be upgraded at the Ultimate Boundary Growth horizon.
  - There are areas that are experiencing high pressure and need to be addressed.
  - The future network assumes all the recommended existing water upgrades are implemented. These upgrades should be completed prior to any substantial densification or future development.
  - Hydraulic assessment of the proposed water system is sufficient in managing demand generated from the future development areas given that all proposed upgrades are implemented.

E4.0 WMP Recommendations

Recommendations for the water distribution system are as follows:

- Prioritize upgrades to the existing water distribution system based on those documented in Table 6.16.
- Continue condition assessments and flow testing and aligning infrastructure upgrades with development and roadworks programs to minimize costs.
- Proceed with staging of future developments based on the plan developed herein.
  - The future water distribution system should be designed based on the City's Municipal Development Standards (City of Lloydminster, 2020).
- The WMP should be reviewed and updated after significant periods of growth or every five years to update the hydrodynamic model and analysis with any capital upgrades completed by the City, and the most up-to-date growth plans. This could provide clarity on the planned location of development, the density of the proposed development, and the potential corresponding upgrades. This will ensure capacity is maintained and staging upgrades are advancing as needed.

Table of Contents

APPENDICES

TABLES

FIGURES

ACRONYMS

Acronyms	Description
AC	asbestos cement
ACE	Alberta Central East Water Corporation
ADD	average day demand
AEPA	Alberta Environment and Protected Areas
CI	cast iron
City	City of Lloydminster
EPS	extended period simulation
FF	fire flow
GIS	geographic information system
HDPE	high-density polyethylene
HGL	hydraulic grade line
HLP	high lift pump
ISL	ISL Engineering and Land Services Ltd.
LiDAR	light detection and ranging
MDD	maximum day demand
PE	polyethylene
PHD	peak hour demand
PRV	pressure reducing valve
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
SME	Saskatchewan Ministry of Environment
STL	steel
UFW	unaccounted for water
WER	West End Reservoir
WMP	Water Master Plan
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

UNITS

Unit	Meaning
$	dollars
%	percentage
ft^2	square feet
ft^2/unit	square feet per unit
ha	hectares
km	kilometre
kPa	kilopascals
L/p/d	litres per person per day
L/s	litres per second
L/s/ha	litres per second per hectare
m	metres
m^3	cubic metres
m^3/hr	cubic metres per hour
mm	millimetres
kPa	kilopascal
psi	pounds per square inch

1.0 Introduction

1.1 Authorization

The City of Lloydminster (City) retained ISL Engineering and Land Services Ltd. (ISL) to complete a review of its current raw water sourcing, treatment, storage, and distribution systems and assess their capacity to meet the current and future growth water demands effectively culminating in an updated Water Master Plan (WMP). This document contains the review of the City's water distribution system; the part of the study considering treatment and storage is included under a separate cover titled Water Treatment Plant (WTP) Assessment/Master Plan Report.

1.2 Background

The WMP was most recently updated by ISL in 2016. Since then, the city limits have been expanded via the 2022 Annexation Lands, along with various significant additions and alterations to the water distribution system. Two (2) new regional potable watermains for supplying water to neighbouring municipalities, west of the city via the Alberta Central East Water Corporation (ACE) Regional Waterline and east of the city via the SaskWater Prairie North Regional Potable Water Supply System, have been completed. The addition of these regional supply lines, the expected additional demand driven by expansion through annexation and population growth of the City, and the normal deterioration of the water distribution system condition that has occurred since 2016 are sufficient reasons to require this updated WMP.

The updated WMP will help the City understand the implications of servicing new developments by recognizing each area's servicing approach and constraints. The updated WMP will guide effective infrastructure implementation by comprehensively reviewing available background data and the water distribution system hydraulic model, maintaining consistent approaches to issues, and using sound engineering principles, all while protecting the natural and human environment. The updated WMP will also examine the capacity of the water distribution system to determine the extent of upgrades required to maintain an appropriate level of service for existing and future residents and businesses.

1.3 Purpose of Study

The purpose of developing an updated WMP is outlined as follows:

- Inventory and analyze the existing water distribution system infrastructure under existing conditions;
- Update the City's existing water distribution system hydraulic model;
- Calibrate the City's water distribution system hydraulic model to accurately represent the City's existing water distribution system;
- Use the calibrated water distribution system hydraulic model to prepare capacity assessments of the existing water distribution system under current and future growth conditions;
- Develop servicing plans for future growth. Locations and timing may be dependent upon the following:
  - Availability of sufficient servicing needs;
  - Annexed land locations; and
  - Community planning;
- Determine the required upgrades for the existing water distribution system based on capacity assessments and recommend future servicing options; and
- Provide a framework for future water distribution system capital planning, including cost estimates and possible staging of infrastructure installations.

2.0 Study Area

2.1 Location

The City of Lloydminster (City) is divided by the Alberta/Saskatchewan border and is located approximately 250 km southeast of the City of Edmonton. The City is bordered by the County of Vermilion River No. 24 on the Alberta side and both the Rural Municipality of Britannia No. 502 and the Rural Municipality of Wilton No. 472 on the Saskatchewan side. The Yellowhead Highway (Highway 16) is an interprovincial highway that connects Manitoba to British Columbia through Lloydminster and is known as 44 Street/Ray Nelson Drive within city limits. Highway 17 runs north/south through Lloydminster along the Alberta/Saskatchewan border and is known as 50 Avenue within city limits. The study area is shown in Figure 2.1.

The study area encompasses 24 neighbourhoods, as well as approximately 23.5 quarter sections of recently annexed land as shown in Figure 2.2. Not all existing neighbourhoods are fully developed; therefore, future growth is anticipated both within these neighbourhoods, as well as within the recently annexed land. The study area encompasses a total area of approximately 5,870 ha.

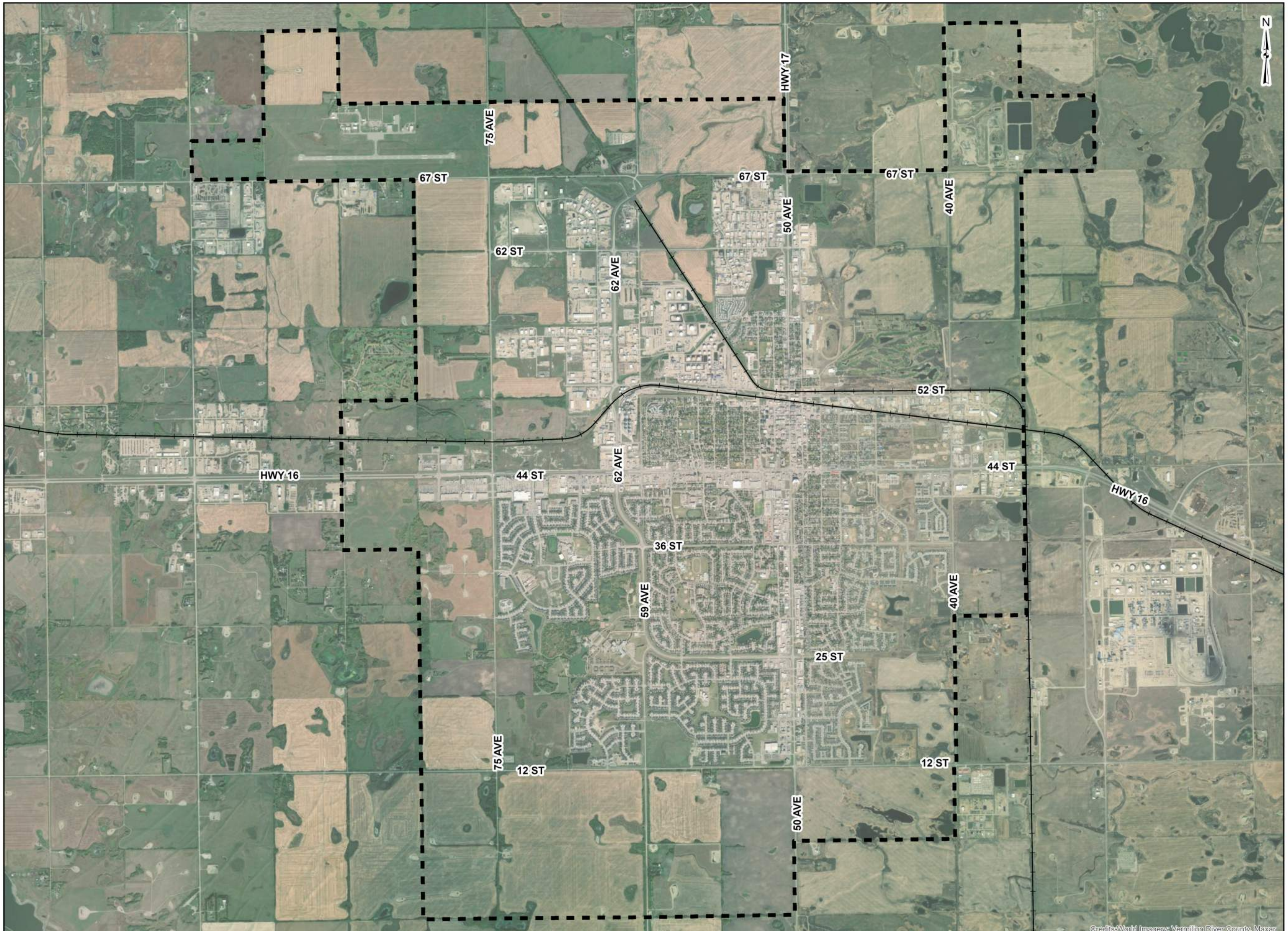
The highest elevation areas within city limits are approximately 670 m in elevation and located within the northwest and southwest corners of the city. The lowest elevation area within city limits is located in the northeast corner of the city at an elevation of approximately 615 m. The topography of the study area is shown in Figure 2.3.

The study area is located almost entirely within the Central North Saskatchewan River Watershed with the southwest corner of the study area adjacent to the boundary of the Battle River Watershed. Both watersheds are part of the North Saskatchewan River Basin, which is part of the Nelson-Churchill (Hudson Bay) Continental Drainage Basin. A map of the watershed boundaries is shown in Figure 2.4.

2.2 Development Type

The development type influences water consumption rates; therefore, obtaining an appropriate classification was vital in ensuring that an accurate representation of the City’s water distribution system could be achieved. When determining development classifications for existing areas within the city, a land use district shapefile provided by the City was used.

A land use district map for existing development is illustrated in Figure 2.5, while Table 2.1 summarizes all land use district codes and their corresponding descriptions. The land uses were compared to aerial maps and Google Street View to confirm that parcels were properly categorized. For the purposes of the project, many of these land use districts were grouped together to form an overall land use. In this manner, the City was classified more broadly by several unique development types, including residential, commercial, industrial, and public service.



Legend

Railway

Study Area

0 500 1,000 2,000 Meters

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FIGURE 2.1
STUDY AREA
LLOYDMINSTER WATER MASTER PLAN

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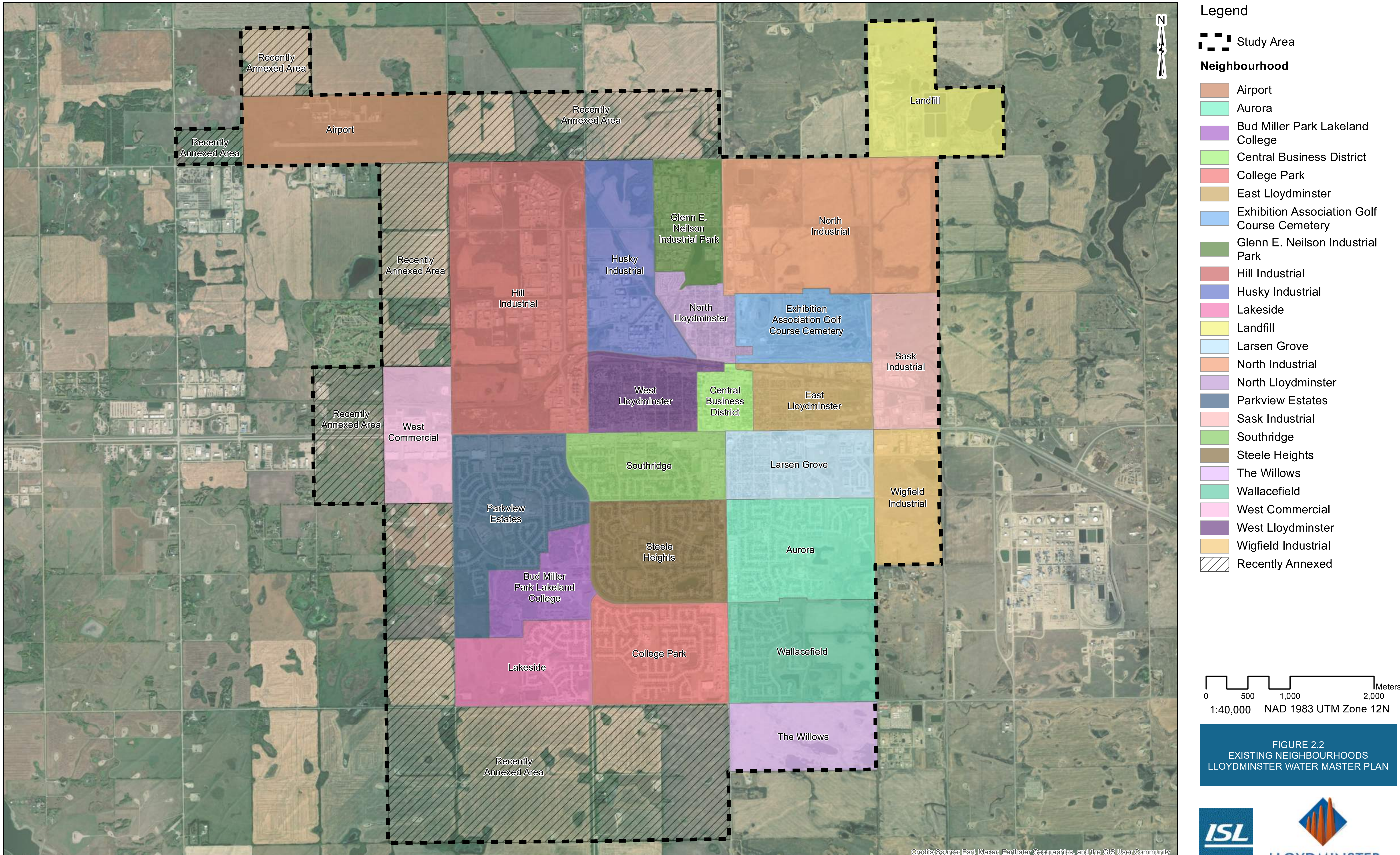

FIGURE 2.2
EXISTING NEIGHBOURHOODS
LLOYDMINSTER WATER MASTER PLAN

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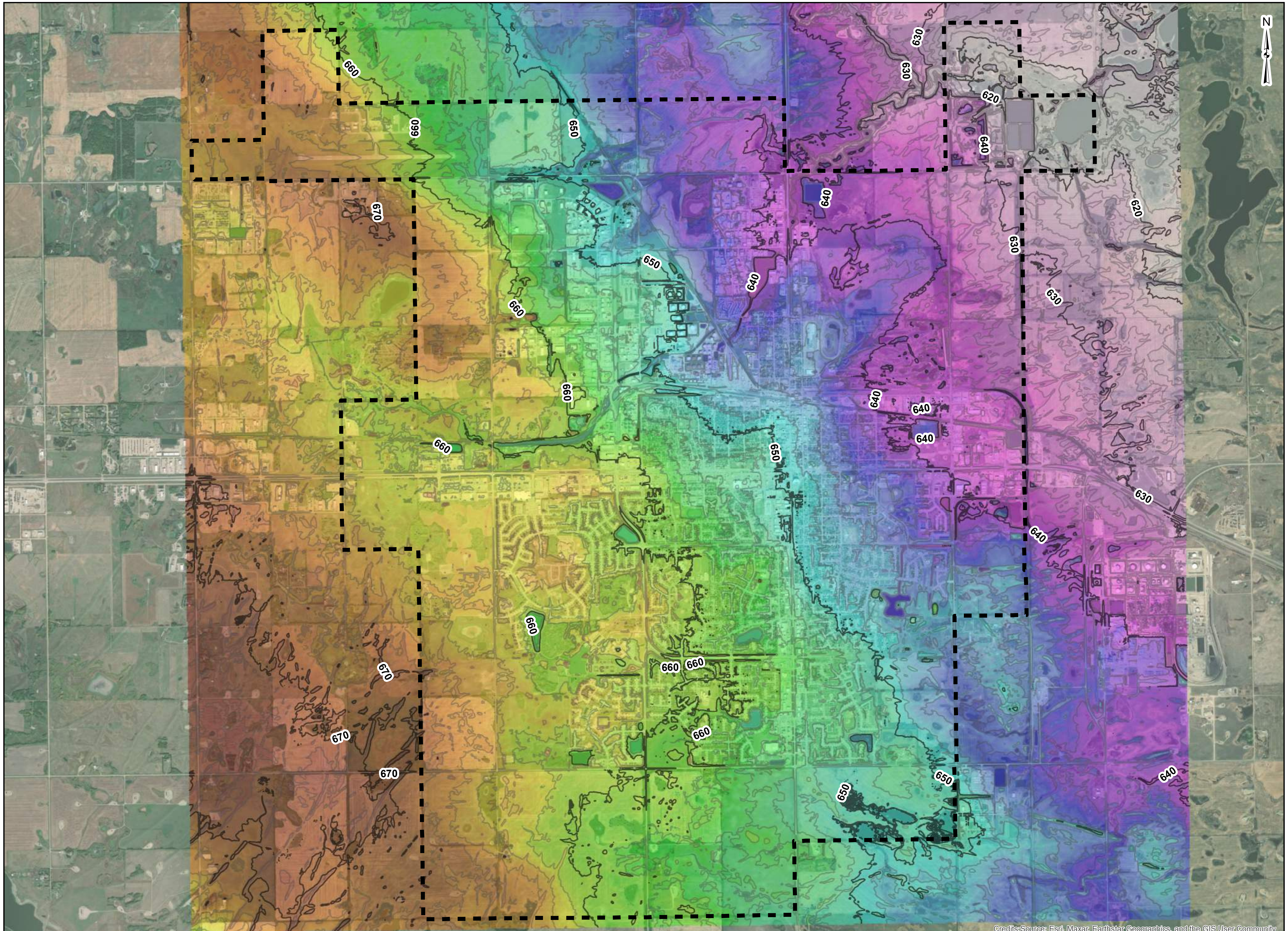

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Major Contour - 10m Interval

Minor Contour 2m Interval

Study Area

Elevation (m)

High : 676.429

Low : 615.14

Note: LiDAR data was acquired on 2019-04-18

0 500 1,000 2,000 Meters

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FIGURE 2.3
TOPOGRAPHY
LLOYDMINSTER WATER MASTER PLAN

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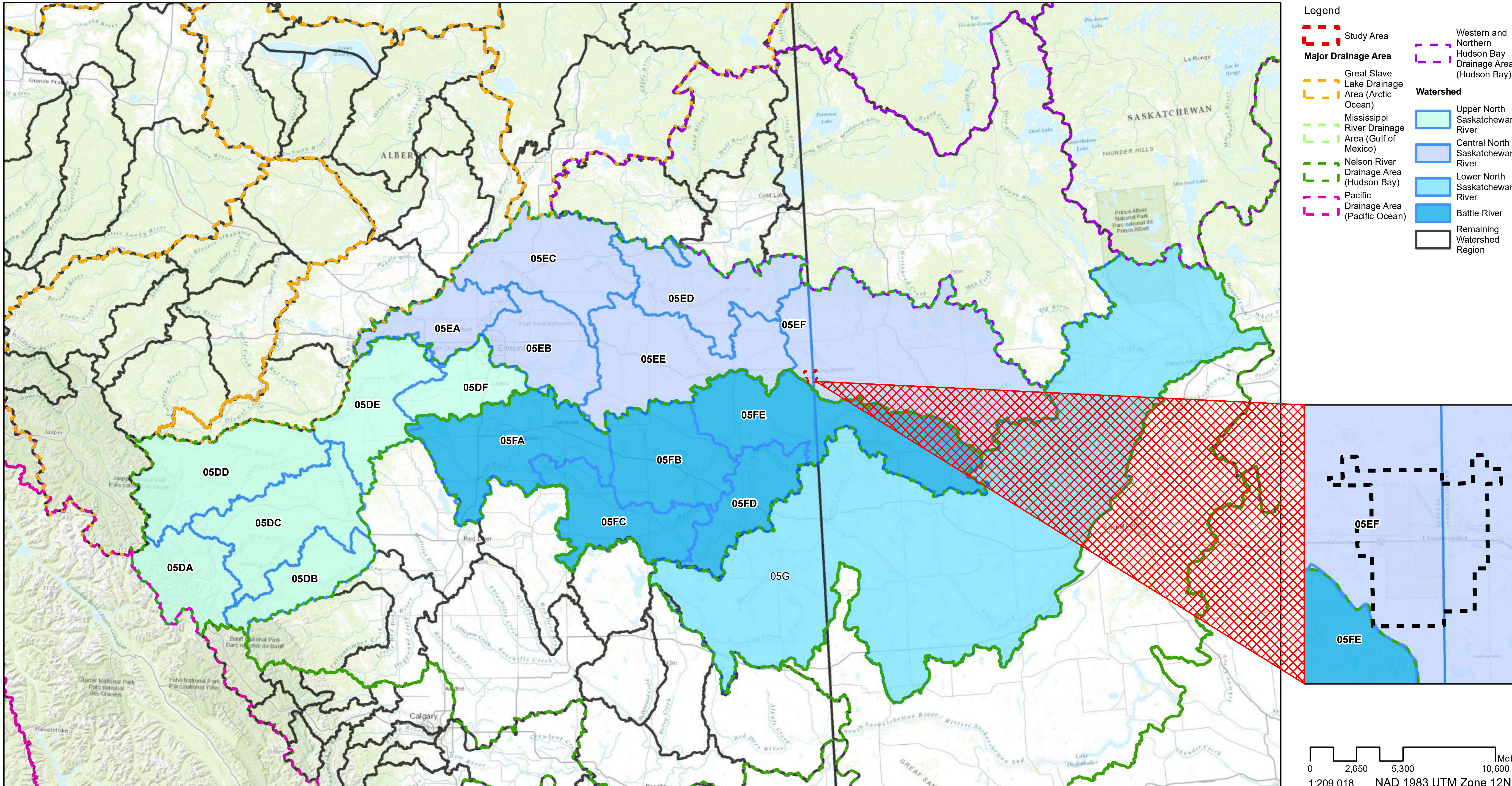

FIGURE 2.4
WATERSHED BOUNDARIES
LLOYDMINSTER WATER MASTER PLAN

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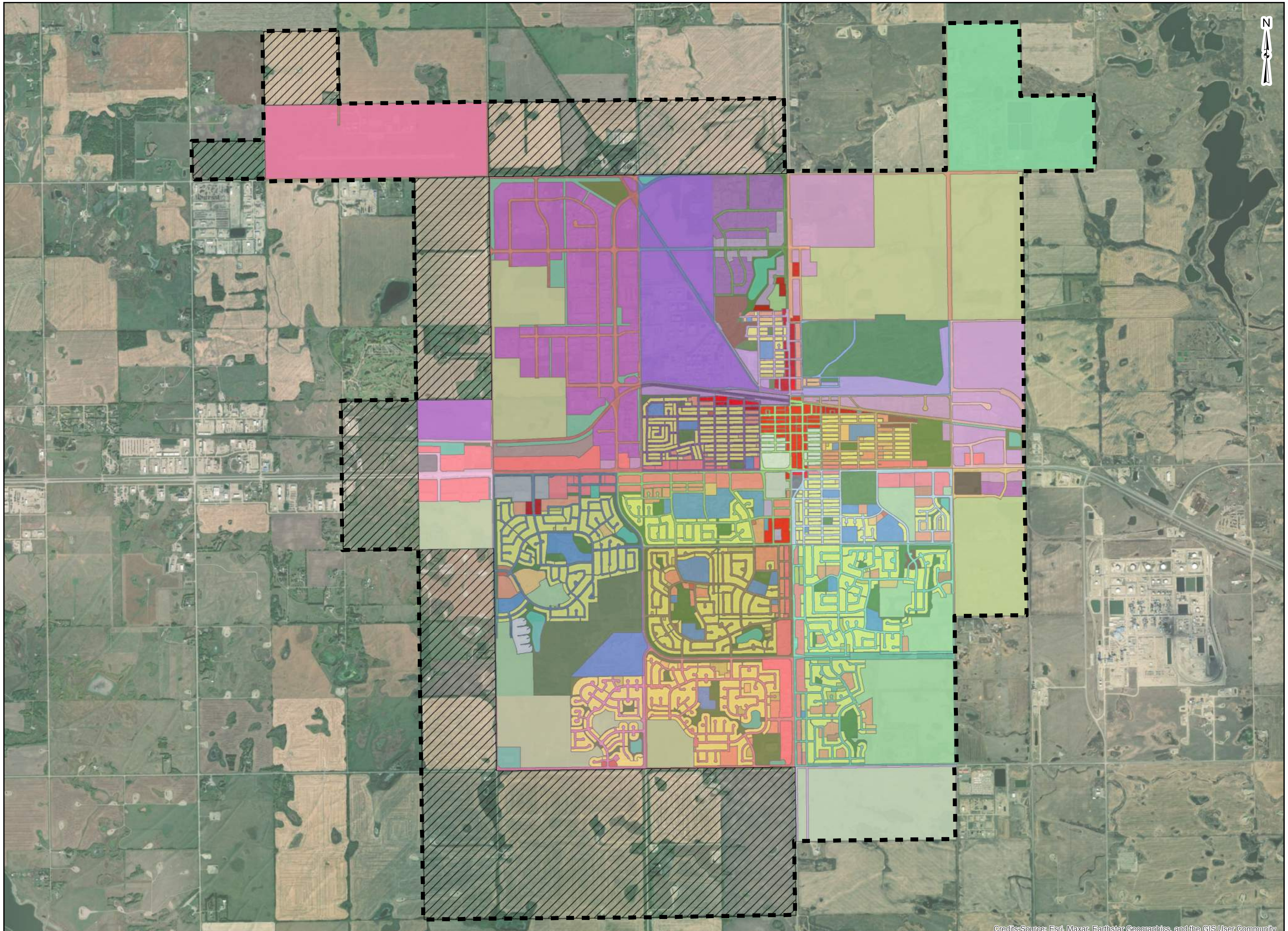

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Study Area

Existing Land Use

- R1: Single-Detached Residential
- R2: Semi-Detached Residential
- R3: Row House Residential
- R4: Medium-Density Residential
- R5: High-Density Residential
- RMH: Residential Manufactured Home
- C1: Central Commercial
- C2: Highway Corridor Commercial
- C3: Neighbourhood Commercial
- C5: Service Commercial
- I1: Light Industrial
- I2: Medium Industrial
- PS: Public Services
- PU: Public Utility
- UP: Urban Park
- MA1: Municipal Airport Airside
- UT: Urban Transition
- DC1: Direct Control 1
- DC2: Direct Control 2
- DC3: Direct Control 3
- DC4: Direct Control 4
- DC5: Direct Control 5
- DC6: Direct Control 6
- DC7: Direct Control 7

Annexed Area-Urban Transition

0 500 1,000 2,000 Meters

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FIGURE 2.5
EXISTING LAND USE
LLOYDMINSTER WATER MASTER PLAN

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Table 2.1: Land Use District Descriptions

District Code	District Description	District Code	District Description
R1	Single-Detached Residential	C5	Service Commercial
R2	Semi-Detached Residential	I1	Light Industrial
R3	Row House Residential	I2	Medium Industrial
R4	Medium-Density Residential	PS	Public Services
R5	High-Density Residential	PU	Public Utility
RMH	Residential Manufactured Home	UP	Urban Park
C1	Central Commercial	MA1	Municipal Airport Airside
C2	Highway Corridor Commercial	UT	Urban Transition
C3	Neighbourhood Commercial	DC	Direct Control

2.3 Population Horizons

The City's water distribution system was assessed for six (6) scenarios as summarized in Table 2.2.

Table 2.2: Population Horizon Assessment Scenarios

Scenario[1]	Year	Cumulative Population		
		Alberta	Saskatchewan	Total
Existing Conditions[2]	2021	19,739	11,843	31,582
3-Year Growth	2025	22,081	12,570	34,651
5-Year Growth	2027	22,475	13,658	36,132
10-Year Growth	2032	23,564	17,584	41,148
20-Year Growth	2042	37,085	20,185	57,271
Ultimate Boundary	**2051**	**46,461**	**20,688**	**67,149**

[1] The growth year scenario is based on the year at the start of the project, which is 2022.
[2] The population for the existing conditions scenario is based on the 2021 Census (Statistics Canada, 2022).

The growth populations were initially determined by applying an annual growth rate of 2.2%. This growth rate was kept consistent with that applied within the design of the City's Wastewater Treatment Plant (WWTP). This was based on the City of Lloydminster and County of Vermilion River Joint Regional Growth Study (Applications Management, et.al, 2019). Additionally, the target population allocation of 70% to the Alberta side of the city and 30% to the Saskatchewan side of the city was used to scale the populations for the future development areas.

Staging of growth areas was then refined by the City to align with the anticipated growth horizon for each future development area. This results in a non-linear growth rate that deviates from the annual growth rate of 2.2% that was initially applied across the city.

Additionally, the 3-Year Growth Horizon incorporates a densification population of 1,579. This population is based on a densification rate of 5% applied to the existing population obtained from the 2021 Census. This densification rate is also outlined within the Joint Regional Growth Study as part of the 2016 Draft Land Demand Generators Summary (Applications Management, et.al, 2019).

Growth did not occur at the rate anticipated within the 2019 Joint Regional Growth Study between 2019 and 2021; therefore, the population growth assumptions were reset to reflect the actual 2021 Census population (Statistics Canada, 2022). A comparison of these population projections is shown in Figure 2.6.

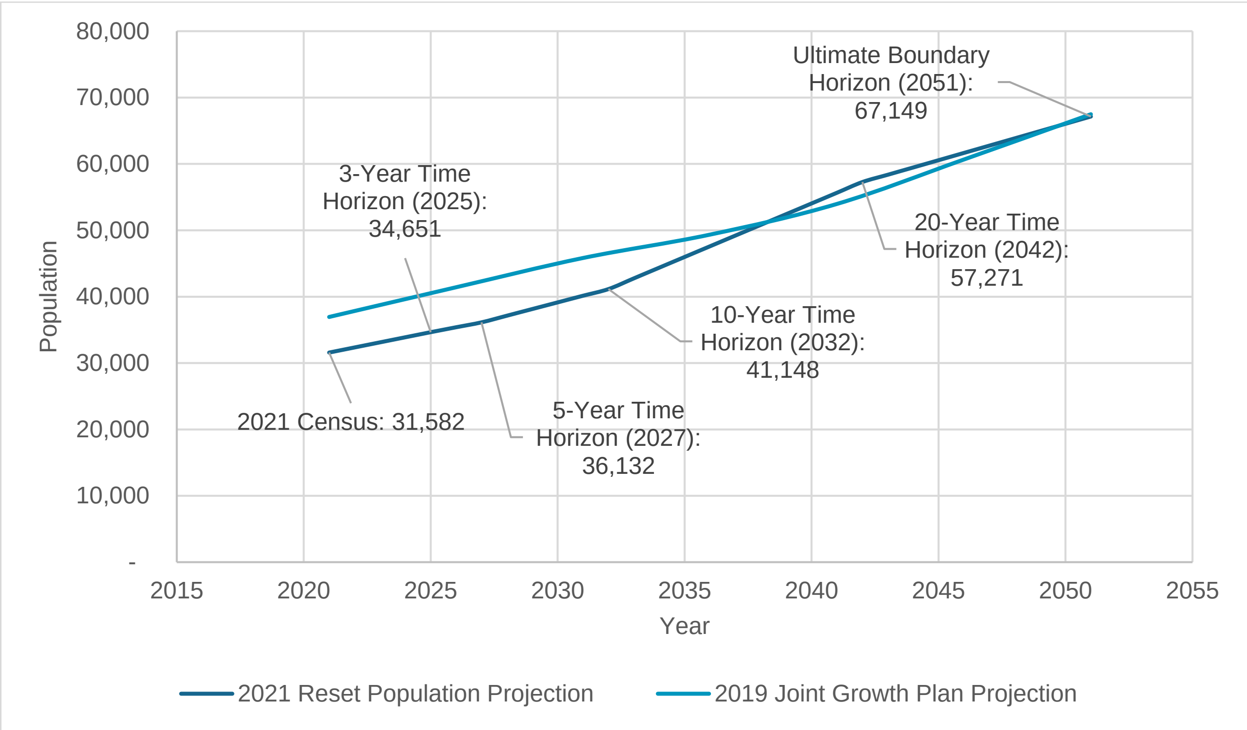


Figure 2.6: 2021 Population Projection Comparison

2.4 Growth Projections

Residential population estimates were generated based on the 2021 reset population projections, as well as net developable areas stipulated within local Area Structure Plans (ASPs), the 2013 Comprehensive Growth Strategy, the 2019 Joint Regional Growth Study, and the 2020 Annexation Application. These were applied on a people/ha basis for the residential future development areas.

Approximately one and a half (1.5) quarter sections of future residential area were added to the anticipated growth areas between 75 Avenue and the city's west limit. The densities for these areas were based on the equivalent populations specified within the City's Municipal Development Standards for low-density and medium-density residential. It should be noted that this results in a deviation from the target population allocation of 70% to the Alberta side of the city and 30% to the Saskatchewan side of the city.

Employment population estimates were generated based on the 2019 Joint Regional Growth Study and interpolated for each of the population horizon assessment scenarios. These were applied on an employees/ha basis for the non-residential future development areas. Future development areas and land use classifications are shown in Figure 2.7.

As previously noted, staging of the City's future development areas was refined by the City to align with the anticipated development timelines for each area.

The growth considered in the City's development areas is summarized incrementally in Tables 2.3 to 2.7 for each of the growth horizons. Staging of the development areas by growth horizon is presented in Figure 2.8.

Table 2.3: Incremental 3-Year Horizon (2025) Development Areas and Populations

District Code	District Description	Area	Population	
		Ha	Residential	Employment
RES-SF	Single-Family Residential	52.29	1,402	0
RES-MF	Multi-Family Residential	1.45	88	0
CBD	Commercial Business District	25.38	0	309
IND	Industrial	137.17	0	1,668
PS	Public Services	7.74	0	98
Total		**224.03**	**1,490**	**2,074**

As previously noted, the 3-Year Growth Horizon also incorporates residential densification based on a densification rate of 5% applied to the existing population within existing residential areas. This is equal to a densification population of 1,579 in addition to the growth population in the future development areas noted in Table 2.3.

Table 2.4: Incremental 5-Year Horizon (2027) Development Areas and Populations

District Code	District Description	Area	Population	
		Ha	Residential	Employment
RES-SF	Single-Family Residential	40.80	1,158	0
RES-MF	Multi-Family Residential	2.12	324	0
CBD	Commercial Business District	44.52	0	544
IND	Industrial	45.25	0	545
PS	Public Services	21.90	0	288
Total		**154.59**	**1,481**	**1,376**

Table 2.5: Incremental 10-Year Horizon (2032) Development Areas and Populations

District Code	District Description	Area	Population	
		Ha	Residential	Employment
RES-SF	Single-Family Residential	156.26	4,250	0
RES-MF	Multi-Family Residential	13.69	614	0
CBD	Commercial Business District	53.95	60	709
IND	Industrial	148.40	0	1,992
PS	Public Services	2.65	92	0
Total		**374.95**	**5,016**	**2,700**

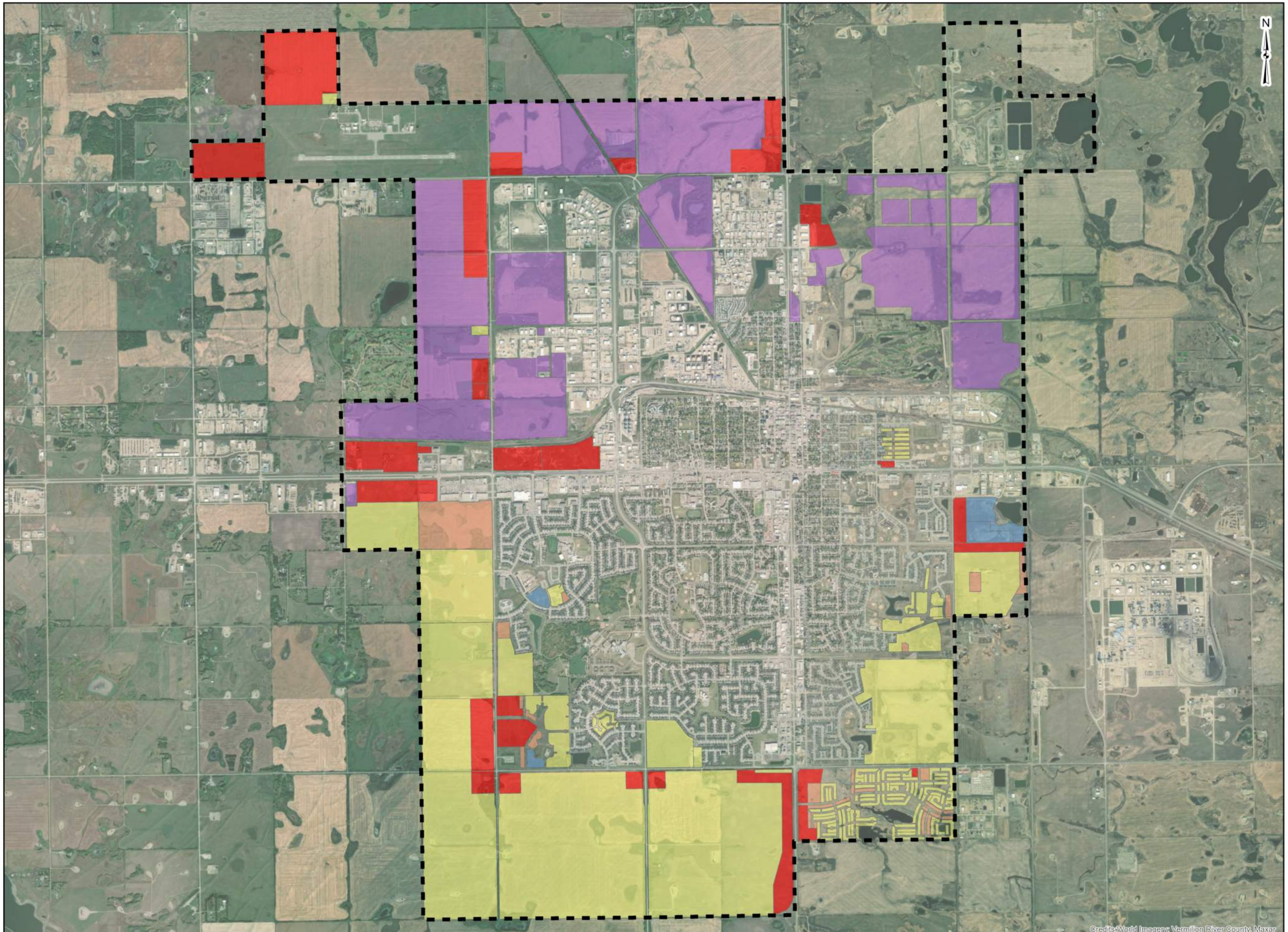
Table 2.6: Incremental 20-Year Horizon (2042) Development Areas and Populations

District Code	District Description	Area	Population	
		Ha	Residential	Employment
RES-SF	Single-Family Residential	434.48	11,770	0
RES-MF	Multi-Family Residential	53.29	4,353	0
CBD	Commercial Business District	69.63	0	957
IND	Industrial	247.05	0	3,453
PS	Public Services	0.00	0	0
Total		**804.45**	**16,123**	**4,410**

Table 2.7: Incremental Ultimate Boundary Horizon (2051) Development Areas and Populations

District Code	District Description	Area	Population	
		Ha	Residential	Employment
RES-SF	Single-Family Residential	399.19	9,878	0
RES-MF	Multi-Family Residential	0.00	0	0
CBD	Commercial Business District	175.70	0	2,137
IND	Industrial	378.30	0	4,578
PS	Public Services	0.00	0	0
Total		**953.19**	**9,878**	**6,715**

The Municipal Development Plan only specifies residential areas, not the density of those areas. In the 2042 to 2051 timeframe to reach the Ultimate Boundary, there is not any other detailed information on the differentiation between single-family and multi-family residential parcels, so all were assigned as single-family residential. Though the increase in population density would result in a higher demand, this is offset by a decrease in outdoor watering requirements. Therefore, as the exact split is unknown between single-family and multi-family residential parcels, it is assumed that the difference between indoor and outdoor water usage would be negated for this purpose.



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Study Area

Future Land Use

- Commercial Business District
- Industrial
- Public Service
- Medium Density Residential
- Low Density Residential

Note: Parcels shown are those to be serviced.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 2.7
FUTURE LAND USE
LLOYDMINSTER WATER MASTER PLAN

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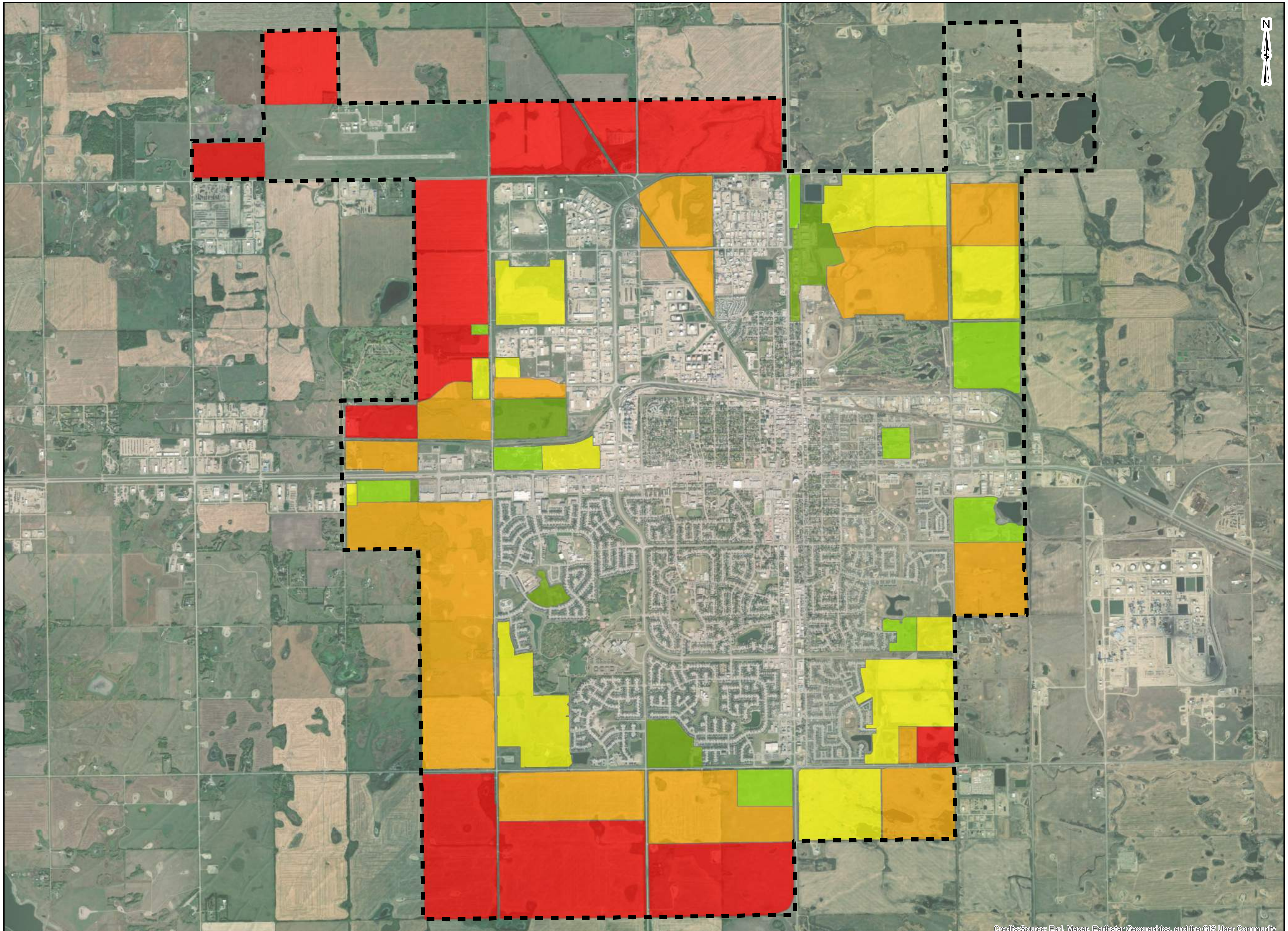

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Study Area

Staging

- 3-Years
- 5-Years
- 10-Years
- 20-Years
- Ultimate

Note: map does not include any vacant parcels under existing conditions that would be developed in the future, or densification to existing development.

0 500 1,000 2,000 Meters

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FIGURE 2.8
FUTURE DEVELOPMENT AREA STAGING
LLOYDMINSTER WATER MASTER PLAN

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3.0 Design Criteria

The design criteria used to assess the City's water distribution system were derived from the existing Water Master Plan (ISL, 2016), the City's Municipal Development Standards, typical municipal servicing standards in the Province of Alberta and the Province of Saskatchewan, and fire flow requirements from the Fire Underwriters Survey. Both Alberta Environment and Protected Areas (AEPA) and Saskatchewan Ministry of Environment (SME) guidelines were considered, with the more stringent guideline used when designing the system so both are satisfied. In addition, water consumption rates were derived based on the City's population rates, service areas, and historic consumption and production data.

3.1 Assessment Scenarios

Model runs to analyze the water distribution system under existing and future conditions were undertaken. Scenarios reviewed included:

- Steady State:
  - Average day demand (ADD);
  - Maximum daily demand (MDD); and
  - Peak hour demand (PHD); and
- Steady State with Fire Flow Analysis:
  - Maximum day demand plus fire flow (MDD + FF).

3.2 Existing System Consumption Rates

The existing system consumption rates used in this analysis were derived through historic production and consumption data provided by the City. Consumption rates for residential, non-residential, irrigation, and unaccounted for water (UFW) were determined, in addition to the application of high-water users throughout the city. The derivation of rates is based on 2021 to 2024 water metering data obtained from Advanced Metering Infrastructure (AMI) and is discussed in detail below. These rates are summarized in Table 3.1. It is noted that the rates provided below are the overarching rates derived from the provided AMI data. These differ from the unit demand rates in the WaterCAD model, as the demands for the high-water users were deducted (see Section 3.2.3 below).

Table 3.1: Existing System Consumption Rates

Type	Classification	Rate
Residential	Residential Consumption	170 L/p/d[1]
Non-Residential	Commercial Consumption	5,883 L/ha/d
	Industrial Consumption	3,697 L/ha/d
	Public Services Consumption	3,611 L/ha/d
Other	Irrigation Demand	689 L/ha/d
	High-Water User Demand	Varies by High-Water User
	Unaccounted for Water Rate	524 L/ha/d

[1] This rate is based on the 2021 population, as this population was applied in the model. This deviates from the rate in the WTP Assessment / Master Plan Report (ISL, 2024), as the 2022 population was used for that assessment.

3.2.1 Residential Consumption Rate

The residential consumption rate was calculated by dividing the average residential consumption by the 2021 census population. Each residential area has a dedicated representative node to account for the consumption. This is to achieve an appropriate spatial representation of residential demands based on the residential types, such as single family, medium density multi-family, and high-density multi-family. The residential consumption rate is lower than those stipulated in Lloydminster's Municipal Development Standards. This is because newer developments have good water efficiency systems built in; thus, the actual water consumption rate is much lower than the standard consumption rate.

3.2.2 Non-Residential Consumption Rates

The non-residential consumption rates were calculated by dividing the average non-residential consumption by the associated development type area. Consumption for each area is represented by a model node adjacent to the non-residential development parcels. The calculated non-residential consumption rate is lower than Lloydminster's standard consumption rate. This is due to the different service types. An industrial equipment storage facility, for example, will consume lower volume compared to a refinery. The higher water users were therefore separated out into separate system demands, to account for spatial demand distribution between various non-residential facilities. This is described further in Section 3.2.3.

3.2.3 High-Water Users Demand

The total annual consumption data for the top forty (40) water users throughout the city was provided for 2021 and 2022. The locations of these high-water users are shown in Figure 3.1. Data was analyzed for a twenty (20) month period. Consumption per utility account was generally consistent beyond seasonal demands (i.e., higher usage in the summer) as expected. There were two (2) outliers – the Border Inn and Suites and the Dr. Cooke Extended Care Centre. In both cases, these properties had a noticeable drop in consumption between the end of 2021 and the start of 2022. These are both properties that are anticipated to have higher water demands due to their land use type; thus, they were included as high-water demands despite the drop in 2022.

To better represent these demands, these high-water users were deducted from the general consumption rate derivation. The demands from these users were assigned to the model individually through fixed demands at the nearest nodes to each property. This was completed to ensure proper demand allocations throughout the network, so that areas with higher water usage received a larger portion of the flows.

3.2.4 Unaccounted for Water (UFW) Rate

The total UFW was determined by finding the difference between the consumption volume and the production volume. The UFW volume is approximately 8% of the total production volume based on the AMI dataset. Water lost in the water distribution system is considered common due to system deterioration that may cause leakage between the pumping stations (Water Treatment Plant and the West End Reservoir) and the metered client. To account for these UFW volumes within the model, the UFW flow was applied globally to any modelled nodes with a demand. This was assigned to the model in this manner as the exact locations of potential UFW are difficult to pinpoint without further investigation through a leakage detection program. Further discussion on the UFW rate is located in Section 6.6.

3.2.5 ACE Regional Waterline Demands

The ACE Regional Waterline supplies potable water to several communities to the west of the city in Alberta. This regional system has been in operation since October 2018.

The City provided historical daily potable water flows supplied to the ACE Regional Waterline system from October 2018 to February 2024. Table 3.2 summarizes the minimum, average, maximum, 99th percentile and 95th percentile of the annual potable volumes supplied to the ACE Regional Waterline system for 2019 to 2023 (i.e., whole years only).

Table 3.2: Historical ACE Regional Waterline Demands

Year	Minimum Daily Flow	Daily Average Flow	Daily Maximum Flow	99th Percentile Flow	95th Percentile Flow
	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
2019	0	447	1,993	976	750
2020	0	475	1,600	961	754
2021	173	477	1,069	957	725
2022	116	528	1,136	941	782
2023	170	539	1,106	1,024	792

Within the agreement with the City, the ACE Regional Waterline is entitled to draw the following flows/volumes:

- 2020 to 2024 - 2,471 m^3/day;
- 2025 to 2034 - 2,842 m^3/day;
- 2035 to 2039 - 3,464 m^3/day; and
- 2040 to 2041 - 3,824 m^3/day.

Based upon the last three (3) years of data (during which the daily maximum flow stabilized), the ratio of the allowable daily maximum flow to actual daily average flow is 4.83. This peaking factor will be applied to the future flow projections.

3.2.6 Prairie North Regional Potable Water Supply System Demands

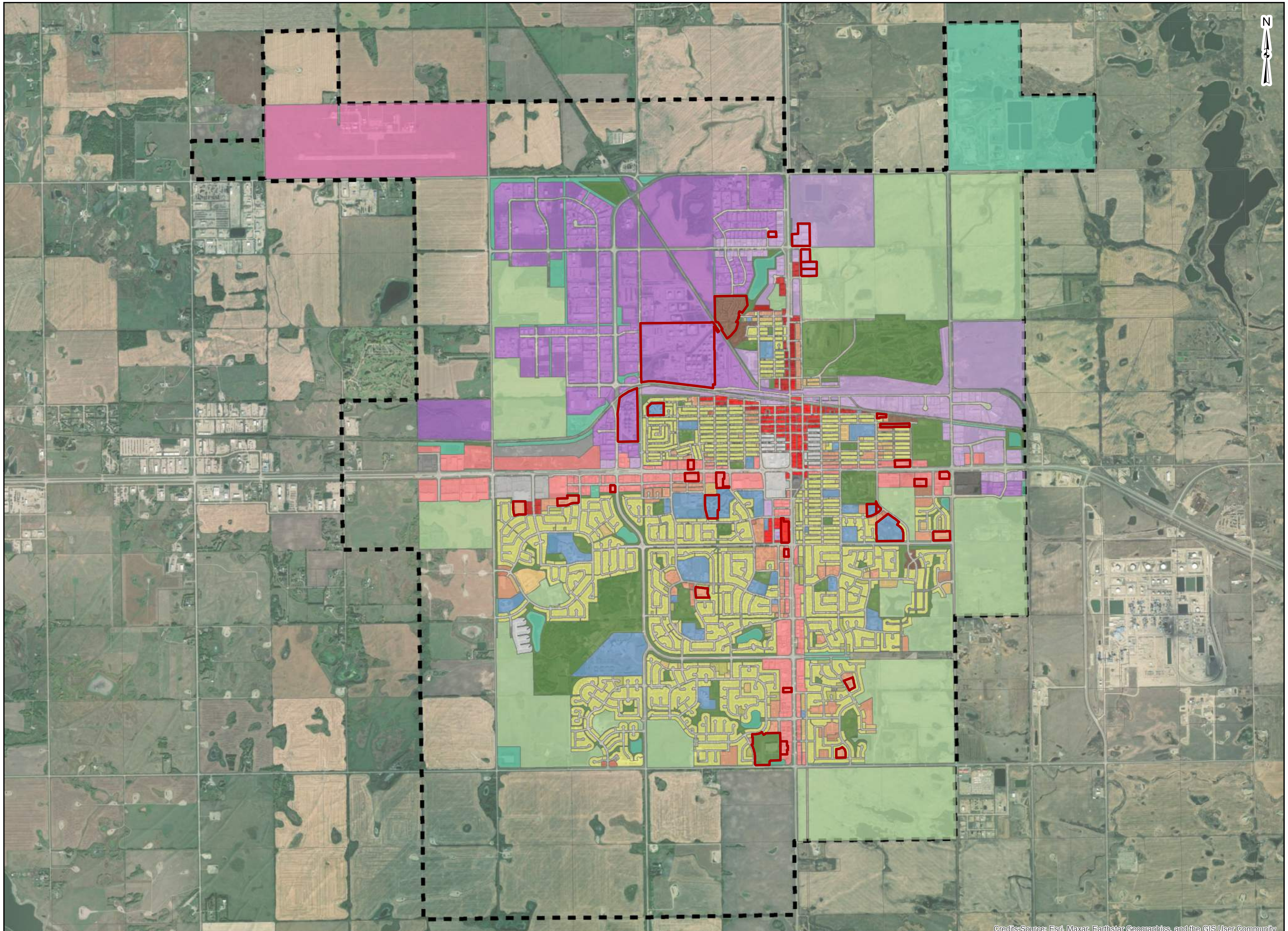
Through the Prairie North Regional Potable Water Supply System, the City supplies potable water from its WTP to various communities following the approved agreement located in the Province of Saskatchewan. The system was commissioned in December 2022 and minimum, average, maximum, 99th percentile and 95th percentile of the annual potable volumes supplied in 2023 are shown below in Table 3.3.

Table 3.3: Historical Prairie North Regional Waterline Demands

Year	Minimum Daily Flow	Daily Average Flow	Daily Maximum Flow	99th Percentile Flow	95th Percentile Flow
	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
2023	206	311	564	482	405

As per the agreement with the Prairie North Regional Potable Water Supply System, the City is expected to provide a maximum daily flow of 800 m^3/day with an allowance to provide flows up to 1,000 m^3/day for ten days per year. The agreement is currently in place for 20 years, with the possibility to review the maximum daily flows supplied in the first five (5) years of operation and adjust the agreement accordingly.

Based upon the 2023 data, the ratio of the allowable daily maximum flow to actual daily average flow is 3.22. This peaking factor will be applied to the future flow projections.



Legend

Study Area

Top Water Users

Existing Land Use

- R1: Single-Detached Residential
- R2: Semi-Detached Residential
- R3: Row House Residential
- R4: Medium-Density Residential
- R5: High-Density Residential
- RMH: Residential Manufactured Home
- C1: Central Commercial
- C2: Highway Corridor Commercial
- C3: Neighbourhood Commercial
- C5: Service Commercial
- I1: Light Industrial
- I2: Medium Industrial
- PS: Public Services
- PU: Public Utility
- UP: Urban Park
- MA1: Municipal Airport Airside
- UT: Urban Transition
- DC1: Direct Control 1
- DC2: Direct Control 2
- DC3: Direct Control 3
- DC4: Direct Control 4
- DC5: Direct Control 5
- DC6: Direct Control 6
- DC7: Direct Control 7

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 3.1
TOP WATER USERS
LLOYDMINSTER WATER MASTER PLAN

ISL

LLOYDMINSTER

Date: 2024-04-17 Document: Q:\Projects\28160_Lloyd_Water_Master_Plan\251_Figures\3_Reporting\Figure 3.1_High Water Users.mxd

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3.3 Future System Consumption Rates

The consumption rates for future developments are consistent with the City's Municipal Development Standard consumption rates. Using the design consumption rates outlined in the City's Municipal Development Standards is more conservative and provides a buffer for development changes at a detailed level. The future development consumption rates are outlined in Table 3.4.

Although actual consumption rates in the existing water distribution system may be less than those outlined above for some areas, the use of these rates is a more conservative approach for future design over adopting historic generation trends, which are subject to change.

Water conservation measures in recent years across various municipalities have shown a positive trend in global consumption rate reductions. However, for the design of new infrastructure systems, a more conservative rate is generally adopted. It is noted that 250 L/p/d is generally on the lower range of adopted residential consumption rates in Western Canada, balancing historic conservation trends and water infrastructure resiliency.

Table 3.4: Future Development Consumption Rates

Type	Consumption Classification	Future Development Rate
Residential	Residential	250 L/p/d
Non-Residential	Commercial	15,000 L/ha/d (local) 26,000 L/ha/d (highway)
	Industrial	10,000 L/ha/d (light) 20,000 L/ha/d (heavy)
	Public Services	10,000 L/ha/d (schools) 20,000 L/ha/d (hospitals)

3.4 Peaking Factors

The following peaking factors were used to establish MDD and PHD for both the existing and future scenarios:

- MDD = 2 x ADD; and
- PHD = 3 x ADD.

The MDD peaking factor is comparable to historic consumption data. The hourly consumption data was not provided in a format to perform a comparison of the PHD peaking factor, however, in theory, monitoring peaking factors on an hourly basis is possible with the continual monitoring system. The factors are consistent with those applied in previous studies within the City and are sufficient based on Alberta Environment and Protected Areas (AEPA) guidelines.

3.5 Operating Pressure Criteria

The City's water distribution system was assessed using the following criteria based on a variety of standards, including the City's Municipal Development Standards, and those stipulated by Saskatchewan Ministry of Environment (SME) and Alberta Environment and Protected Areas (AEPA). The most stringent standard was used to ensure both standards were satisfied. All sets of criteria are generally consistent in terms of pressure criteria:

- Maximum allowable pressure in the water distribution system under any demand scenario is 700 kPa (100 psi);
- Minimum residual pressure in the water distribution system under PHD of 273 kPa (40 psi);
- Minimum pressure with automatic fire protection sprinklers is 350 kPa (50 psi); and
- Minimum residual pressure in the water distribution system under MDD + FF of 138 kPa (20 psi).

3.6 Fire Flow Criteria

The City's Municipal Development Standards recommend fire flow requirements for various overarching land use types. Table 3.5 below outlines these fire flow rates, durations, and storage volumes required for various development types.

Table 3.5: Fire Flow Requirements

Land Use Type	Fire Flow Required	Duration	Fire Storage Required
	L/s	Hours	m^3
Residential – Single Family	100	2.0	720
Residential – Multi-Family (Townhouses)	150	2.0	1,080
Residential – Multi-Family (Medium Density)	185	2.5	1,665
Residential – Multi-Family (High Density)	225	3.0	2,430
Commercial – Local	185	2.5	1,665
Commercial – Highway	225	3.0	2,430
Industrial	225	3.0	2,430
Institutional	225	3.0	2,430

The values for high density residential, highway commercial, industrial and institutional govern for the required fire storage as they are the most conservative.

Typically, fire flow requirements can be reduced by up to 50% for facilities equipped with sprinkler systems (i.e., reduce by 50% and add required sprinkler flow, which is typically 20 L/s to 30 L/s). This reduction is based on the Water Supply for Public Fire Protection (Fire Underwriters Survey, 2020), which states that fire flow may be reduced by up to 50% for facilities with adequately sized and designed automatic fire sprinkler protection systems.

The values in Table 3.5 are generally in alignment with typical fire flow recommendations for various municipalities across Western Canada and with the Fire Underwriters Survey. That said, fire flow requirements could be evaluated on a per-development basis using the Fire Underwriters Survey as needed.

3.7 Reservoir Storage

Reservoir storage volumes were calculated using two (2) methods for comparison purposes: the formulas recommended by SME and AEPA. Though both storage requirements are provided for comparison, as the SME criteria governs, it was assumed for storage upgrade recommendations under both existing and future conditions.

Saskatchewan Ministry of Environment (Waterworks Design Standard)

$$Volume = ADD\ x\ 2$$

Where,

Volume = Total storage requirement, m^3

ADD = Average day demand, m^3

Alberta Environment and Parks (Standards and Guidelines for Municipal Waterworks, Wastewater and Stormwater Drainage Systems)

$$S = A + B + (\text{the greater of } C \text{ or } D)$$

Where,

S = Total storage requirement, m^3

A = Fire storage, m^3

B = Equalization storage (25% of MDD), m^3

C = Emergency storage (minimum of 15% of ADD), m^3

D = Disinfection contact time (CT) storage to meet CT requirements, m^3

In terms of fire storage, the fire flow rate of 225 L/s for 3 hours was selected. These represent the largest required fire flow criteria and duration noted in Table 3.5.

4.0 Existing Water System

4.1 Water Supply

The City is supplied by the North Saskatchewan River through raw water supply infrastructure that was commissioned in 1983. The facility was updated to an increased pumping capacity in 1991 with the construction of the upgrader, and a third high lift pump (HLP) was added in 1999. The facilities include the river intake structure pumphouse that delivers water to the settling pond with low lift pumps and a raw water reservoir that receives water by a raw water supply line with high lift pumps. The raw water supply infrastructure supplies water to the Water Treatment Plant (WTP), Cenovus Energy Upgrader, agriculture parcels, and recreational users.

4.2 Water Treatment Plant

The WTP is located south of 67 Street and east of 50 Avenue in the northeast corner of the city. The WTP has one (1) clearwell with a capacity of 1,090 m^3, and the clearwell serves two (2) purposes:

1. The three (3) distribution pumps draw from the clearwell to supply water to the water distribution system and to fill the West End Reservoir (WER) when the WTP is operating. The distribution pumps were designed such that it must draw from a reservoir and cannot directly pump from the treatment line to the distribution system hence it draws the treated water from the clearwell.
2. The clearwell holds treated water primarily used as a source of filter backwash water where the filter backwash pump draws from to backwash filters when the WTP is not operating.

The clearwell does not contribute toward storage for the water distribution system. When the WTP is not operating each evening, the WTP is back-fed potable water from the distribution system and the WER. Table 4.1 summarizes the WTP storage characteristics.

Table 4.1: Water Treatment Plant Characteristics

Parameter		Value
Capacity	m^3	1,090
Reservoir Slab Elevation	m	631.95
Normal Operating Pressure[1]	kPa	665
Hydraulic Grade Line[2]	m	704.1

[1] Normal operating calculated by taking the difference between the hydraulic grade line and the reservoir slab elevation.
[2] Hydraulic grade line represents the average of the two loggers that were monitored during hydrant testing.

The WTP has three (3) vertical turbine pumps in a two (2) duty/one (1) standby configuration. These pumps pump treated water from the clearwell to the water distribution system. Two (2) of the three (3) pumps are constant speed pumps and rated to operate at a duty flow of 13,360 m^3/d at 59.15 m head. The third pump is a variable frequency drive (VFD) pump and rated to operate at a duty flow of 13,488 m^3/d at 59 m head. Table 4.2 shows the pump characteristics at the WTP.

Table 4.2: Water Treatment Plant Pump Characteristics

Pump	Type	Design Point			
		Flow			Head
		m^3/d	m^3/hr	L/s	m
Water Treatment Plant					
P1 and P2	Fixed Speed Pumps	13,360	557	155	59.15
P3	Variable Frequency Drive Pumps	7,631	318	88	59.15

4.2.1 Water Consumption and Production

The water consumption and production data between January 2021 and December 2023 was provided by the City to ISL. The total water consumed from January 2021 to December 2023 was 9,923,250 m^3 (per 36 months) while the production during the same period was 10,780,821 m^3 (per 36 months). The difference of 857,571 m^3 (per 36 months) between the production and consumption translates to an overall UFW of 8%. Over the dataset, the difference fluctuates between 3% to 11%. The UFW could be due to leaking connections or deteriorating system components. It is considered common to have some difference between consumption and production, indicating UFW within the system. Continuing with the leakage detection through the City's AMI program could assist in reducing this percentage further. Further discussion of UFW relative to the system performance is in Section 6.6.

4.3 Water Reservoir

In addition to the WTP, potable water is also stored at the West End Reservoir (WER) located at 6301 43 Street. The WER consists of an above ground concrete tank constructed in 1974 and two (2) underground cells constructed in 2006. The reservoir is filled via the water distribution system from the WTP and has been in operation since 1984.

The WER stores treated water from the WTP and supports the water distribution system during high demand conditions such as during fire flow events as well as during non-operational times at the WTP. The WER has a total storage capacity of 24,796 m^3. The above-ground concrete tank provides 4,545 m^3 of storage, and the two (2) underground reservoirs provide an additional 20,250 m^3 of storage. Table 4.3 summarizes the WER storage characteristics.

Table 4.3: West End Water Reservoir Characteristics

Parameter		Value
Capacity	m^3	24,796
Reservoir Slab Elevation	m	656.70
Normal Operating Pressure[1]	kPa	295
Hydraulic Grade Line[2]	m	694.8

[1] Normal operating calculated by taking the difference between the hydraulic grade line and the reservoir slab elevation.
[2] Hydraulic grade line represents the average of the two loggers that were monitored during hydrant testing.

The WER has four (4) pumps, and each pump has a capacity of 103 L/s at 43.2 m head. Two (2) of the pumps are variable and two (2) are constant. Table 4.4 shows the pump characteristics at the WER.

Table 4.4: West End Reservoir Pump Characteristics

Pump	Type	Design Point			
		Flow			Head
		m^3/d	m^3/hr	L/s	m
West End Reservoir					
P1 and P2	Variable Frequency Drive Pumps	8,904	371	103	43
P3 and P4	Variable Speed Pumps[1]	8,904	371	103	43

[1] P3 and P4 were converted to variable speed in December 2023.

Table 4.5 shows the total and firm pumping capacity for both WTP and WER. The firm capacity is the total pumping capacity, assuming that the largest pump has been taken offline, and is used to assess the pumps under a more redundant scenario, resulting in a more resilient system. Total pumping capacity is the sum of all the pumps turned on at design flow rate.

Table 4.5: Total Pumping Capacity and Firm Capacity

Reservoir	Water Treatment Plant	West End Reservoir	Total Capacity	Water Treatment Plant	West End Reservoir	Total Capacity
	L/s			m^3/hr		
Pumping Capacity	398	412	810	1,433	1,483	2,916
Firm Capacity	243	309	552	875	1,112	1,987

4.4 Water Distribution System

Lloydminster is currently serviced by approximately 210 km of water distribution mains. The water distribution system details with regards to pipe diameter, material, and installation period are shown in Figures 4.1, 4.2, and 4.3, respectively. The watermains are predominantly polyvinyl chloride (PVC) or asbestos cement (AC) with pipe diameters ranging from 50 mm to 750 mm, with most diameters being between 150 mm and 250 mm.

Tables 4.6 to 4.8 below summarize the water distribution system based on pipe diameter, material, and installation period, respectively. 85% of the water distribution system's age is less than 54 years old and approximately 38% is less than 24 years old. Over 50% of the system is PVC pipes, which suggests that the overall water distribution system condition is good. Older asbestos cement (AC) and cast iron (CI) pipes should be replaced where applicable to ensure adequate condition of the overall water distribution system.

Table 4.6: Existing System Diameter Summary

Diameter	Total Length	Percentage of Total Length
mm	M	%
50	32	0.02
100	816	0.39
150	58,271	27.96
200	62,651	30.07
250	32,307	15.50
300	20,372	9.78
350	677	0.32
400	21,225	10.19
500	2,975	1.43
600	177	0.08
750	1,592	0.76
Unknown	7,278	3.49
Total	**208,372**	**100.00**

Table 4.7: Existing System Material Summary

Material	Total Length	Percentage of Total Length
	m	%
Asbestos Cement (AC)	75,551	36.26
Cast Iron (CI)	16,738	8.03
High-Density Polyethylene (HDPE)	204	0.10
Polyethylene (PE)	71	0.03
Polyvinyl Chloride (PVC)	111,177	53.36
Steel (STL)	2,018	0.97
Unknown	2,612	1.25
Total	**208,372**	**100.00**

Table 4.8: Existing System Installation Period Summary

Installation Period	Total Length	Percentage of Total Length
	M	%
1940-1949 (84-75 years)	2,488	1.19
1950-1959 (75-65 years)	11,067	5.31
1960-1969 (64-55 years)	16,580	7.96
1970-1979 (54-45 years)	46,289	22.21
1980-1989 (44-35 years)	36,992	17.75
1990-1999 (34-25 years)	15,987	7.67
2000-2009 (24-15 years)	39,980	19.19
2010-2021 (14-3 years)	31,899	15.31
Unknown	7,091	3.40
Total	**208,372**	**100.00**

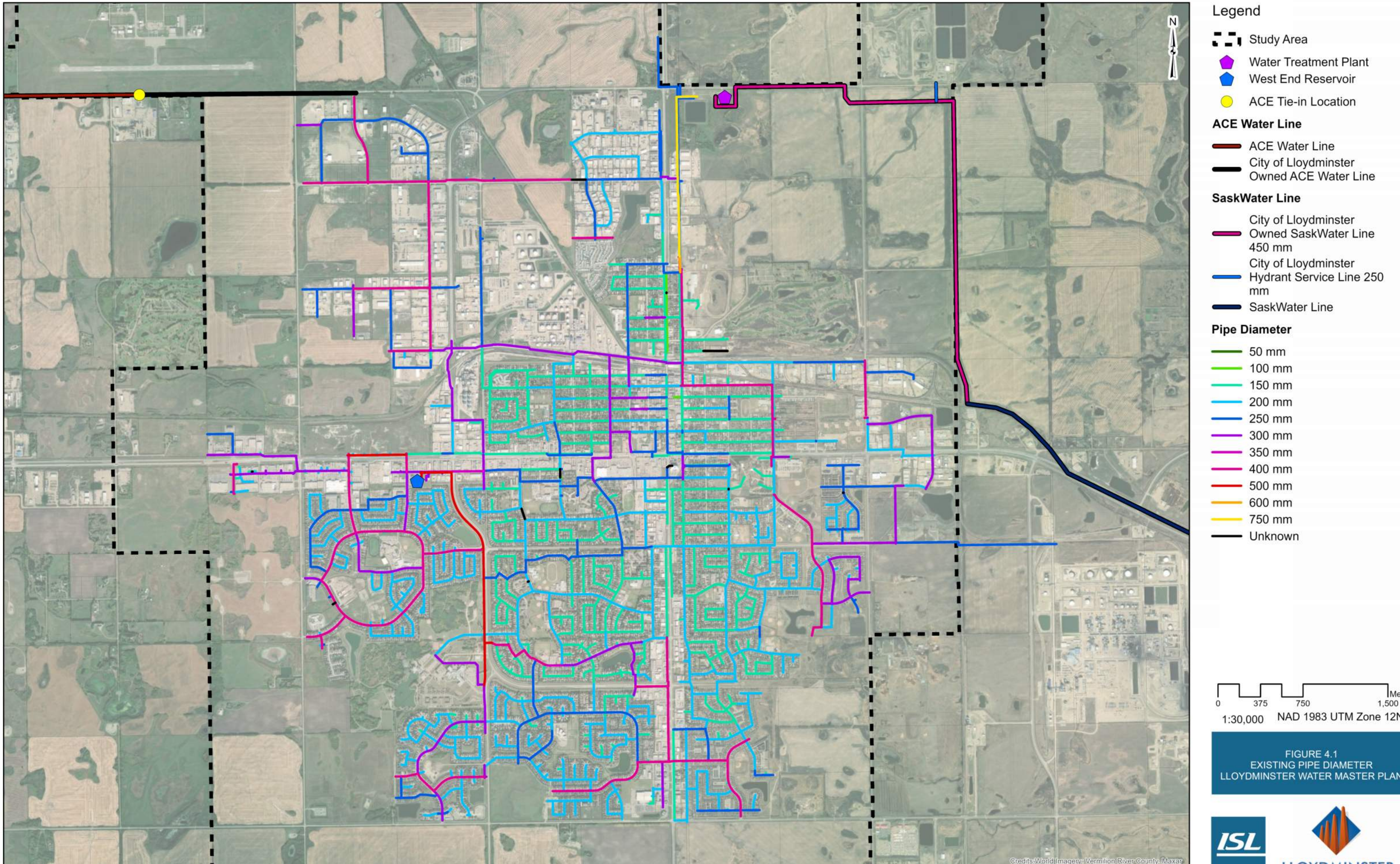

FIGURE 4.1
EXISTING PIPE DIAMETER
LLOYDMINSTER WATER MASTER PLAN

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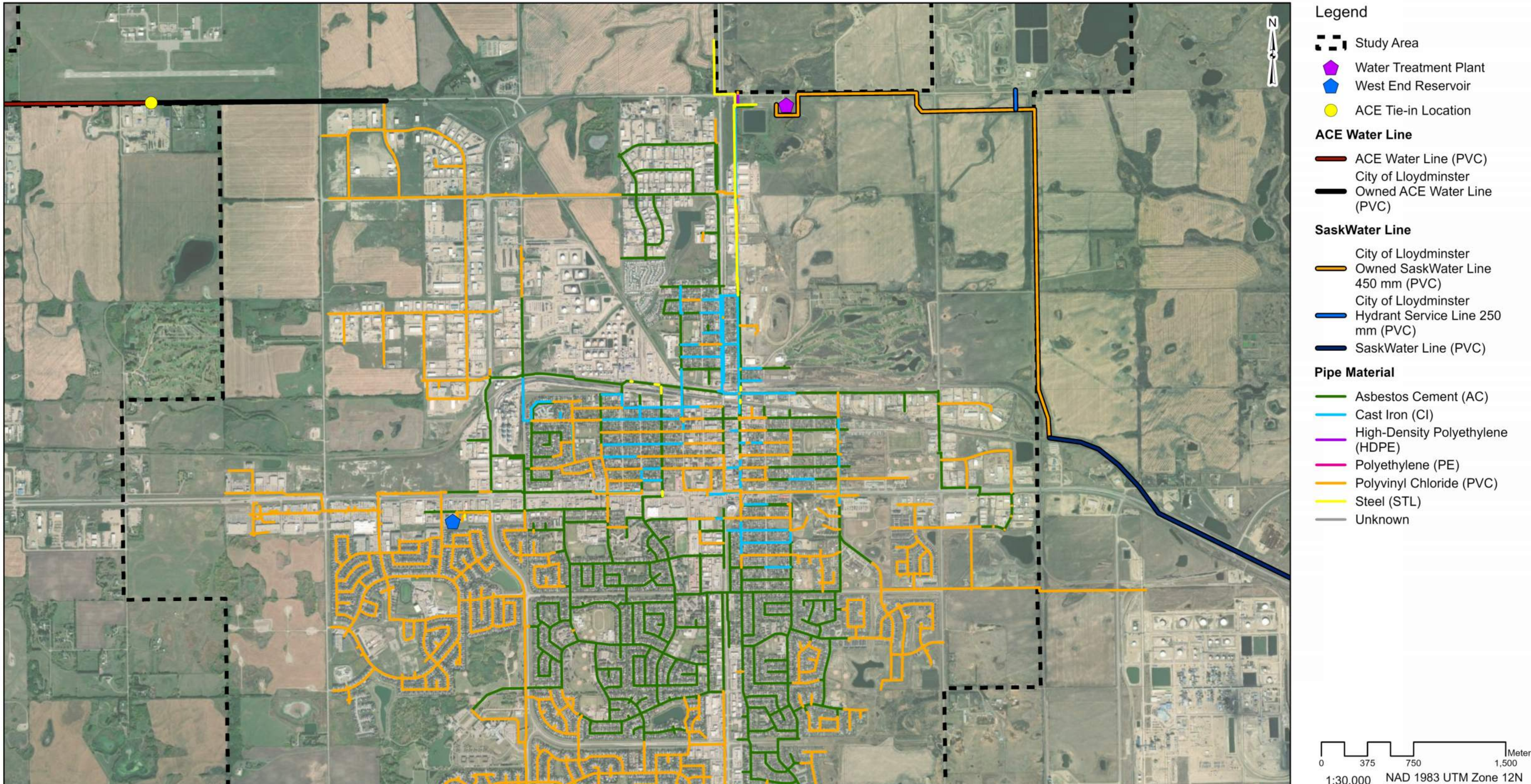

FIGURE 4.2
PIPE MATERIAL
LLOYDMINSTER WATER MASTER PLAN

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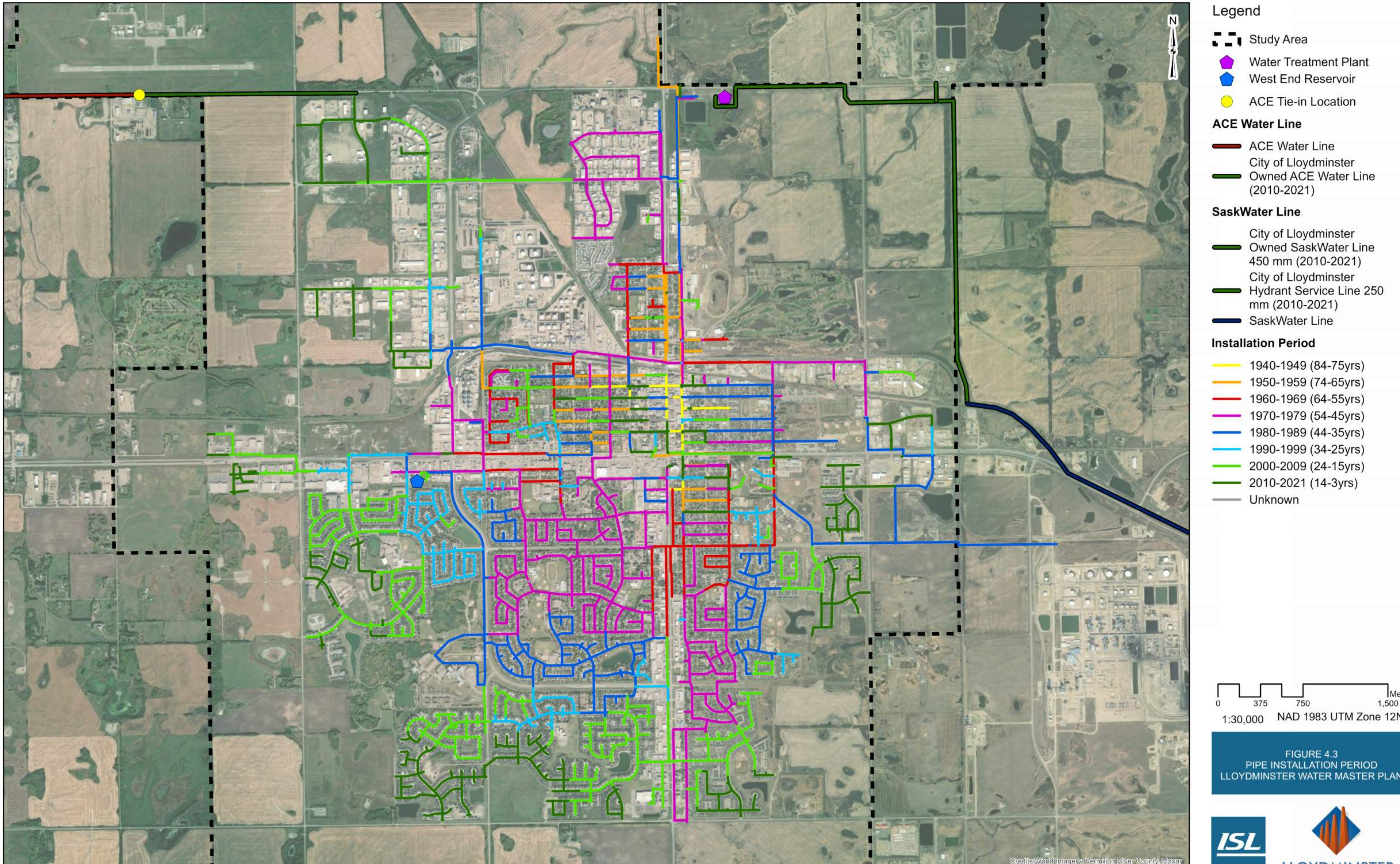

FIGURE 4.3
PIPE INSTALLATION PERIOD
LLOYDMINSTER WATER MASTER PLAN

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5.0 Hydraulic Model Development

5.1 Model Version

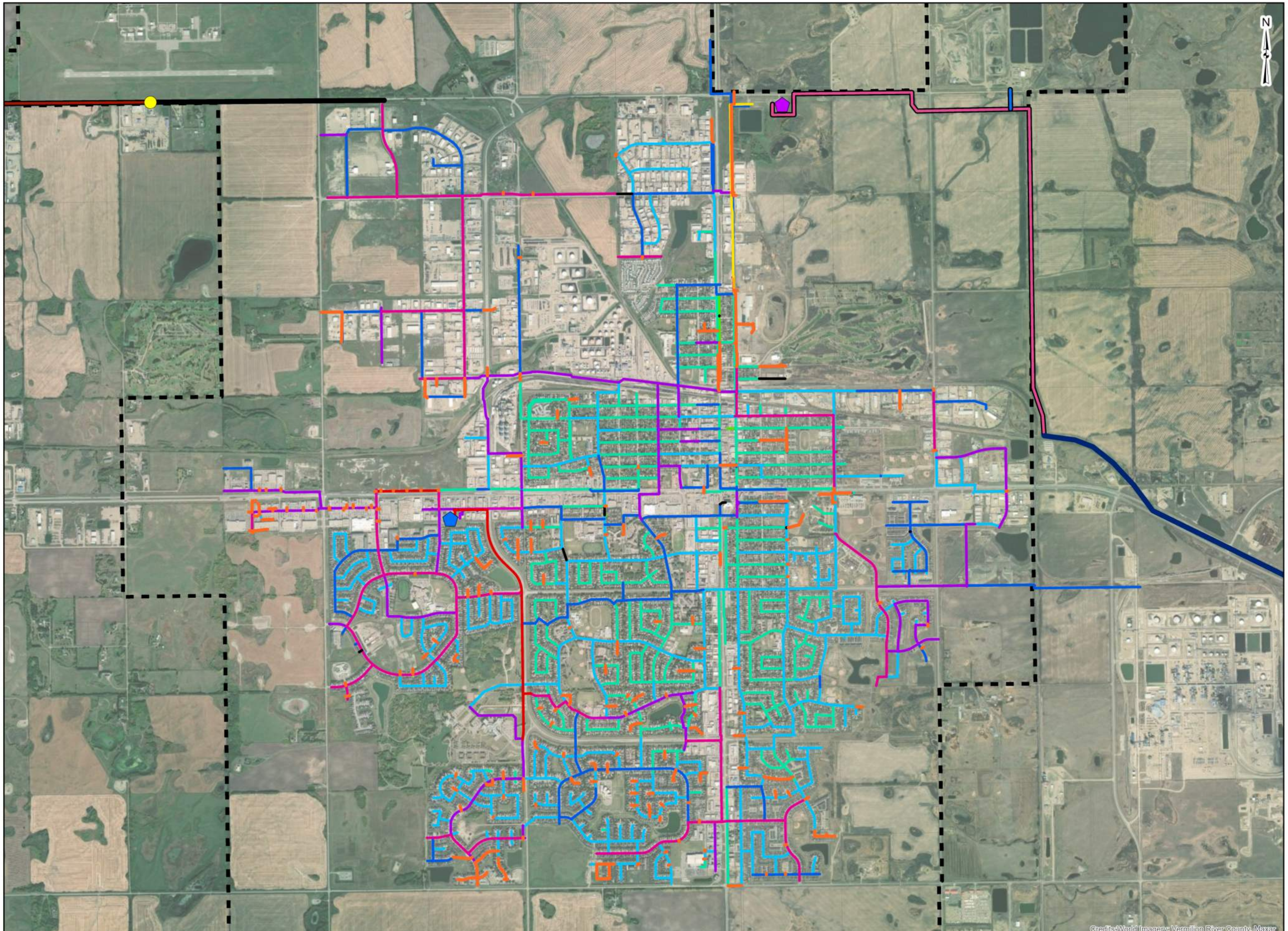
The existing water distribution model was generated in 2014 by ISL and validated through hydrant testing and a calibration exercise. Bentley OpenFlows WaterCAD Connect Edition Update 3 was used to update the existing water distribution model. WaterCAD is a powerful analysis tool that utilizes pump curve data, routes flow through the physical distribution system, and estimates available fire flow at any location in the water distribution system based on minimum system pressure. Modelling files will be appended to the final report.

All available updated GIS data relevant to the water system in the study area received from the City was reviewed in detail and used to update the WaterCAD model. The model was inspected by performing a series of quality assurance/quality control (QA/QC) tasks to ensure that all data was detailed and accurate.

5.2 Model Update

The model was updated with current GIS shapefiles and reviewed with recent as-builts. This included updating with some CI and AC pipes that were not in the previous version of the model. Model updates are shown in Figure 5.1 and some major changes are listed below:

- 250 mm CI pipe west of 50 Avenue (Highway 17) between 65 Street and 67 Street;
- 400 mm AC pipe on 49 Avenue between 54 Street and 57 Street;
- 150 mm CI pipe north of 52 Street along service road west of 50 Avenue between 52 Street and 54A Street;
- Added a 250 mm PVC pipe on 47 Avenue connecting the 150 mm watermain on 47 Street, 48 Street and 49 Street;
- Updated the 150 mm AC pipe on 48 Street between 47 Avenue and 48 Avenue to 200 mm PVC;
- 200 mm CI pipe on 46 Street between 50 Avenue (Highway 17) and 49 Avenue;
- 150 mm CI pipe on 42 Street between 47 Avenue and 48 Avenue;
- 200 mm PVC pipe on 17 Street between 61 Avenue and 59B Avenue;
- 250 mm PVC pipe connecting between cul-de-sac of 17 Street near 61 Avenue just south of the roundabout;
- Various single feed and minor looping update; and
- Private systems were removed from the model where the private watermains did not impact the overall water distribution system performance due to looping.



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown
- Model Pipe Update

0 375 750 1,500 Meters

1:30,000 NAD 1983 UTM Zone 12N

FIGURE 5.1
MODEL UPDATE SUMMARY
LLOYDMINSTER WATER MASTER PLAN

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5.3 Service Area Delineation

Following the update of the water distribution system model, it was necessary to delineate the study area into service areas for the purpose of deriving populations and system demands. The service areas were delineated based on individual lots and the development type classifications mentioned in Section 2.2, including residential, commercial, industrial, and institutional. Parks labelled as being irrigated were also included for this purpose.

Lots associated with any of the high-water users were removed from the individual lot dataset, to avoid double counting any demands at these parcels. Populations were then spatially allocated to the individual lots. Each lot was assigned to the nearest node in ArcGIS, and lots sharing the same node were merged to formulate the final service area polygons. The populations associated with each development type on a per lot basis were summated during the merging process.

5.4 Hydrant Testing

SFE Global was contracted by ISL to complete hydrant tests at 12 strategic locations throughout Lloydminster. These hydrant test locations represent multiple physical locations and elevations within Lloydminster, as well as various development types and installation periods. Two (2) residual monitoring stations (loggers) were installed to supplement the hydrant flow test locations. The overall fire flow test reports can be found in Appendix A, and a map of the flow hydrants, residual hydrants, and logger locations is illustrated in Figure 5.2.

The results of the hydrant testing are summarized in Table 5.1. Observed pressures from hydrant testing were used to calibrate the water model, subsequently obtaining more accurate scenario results.

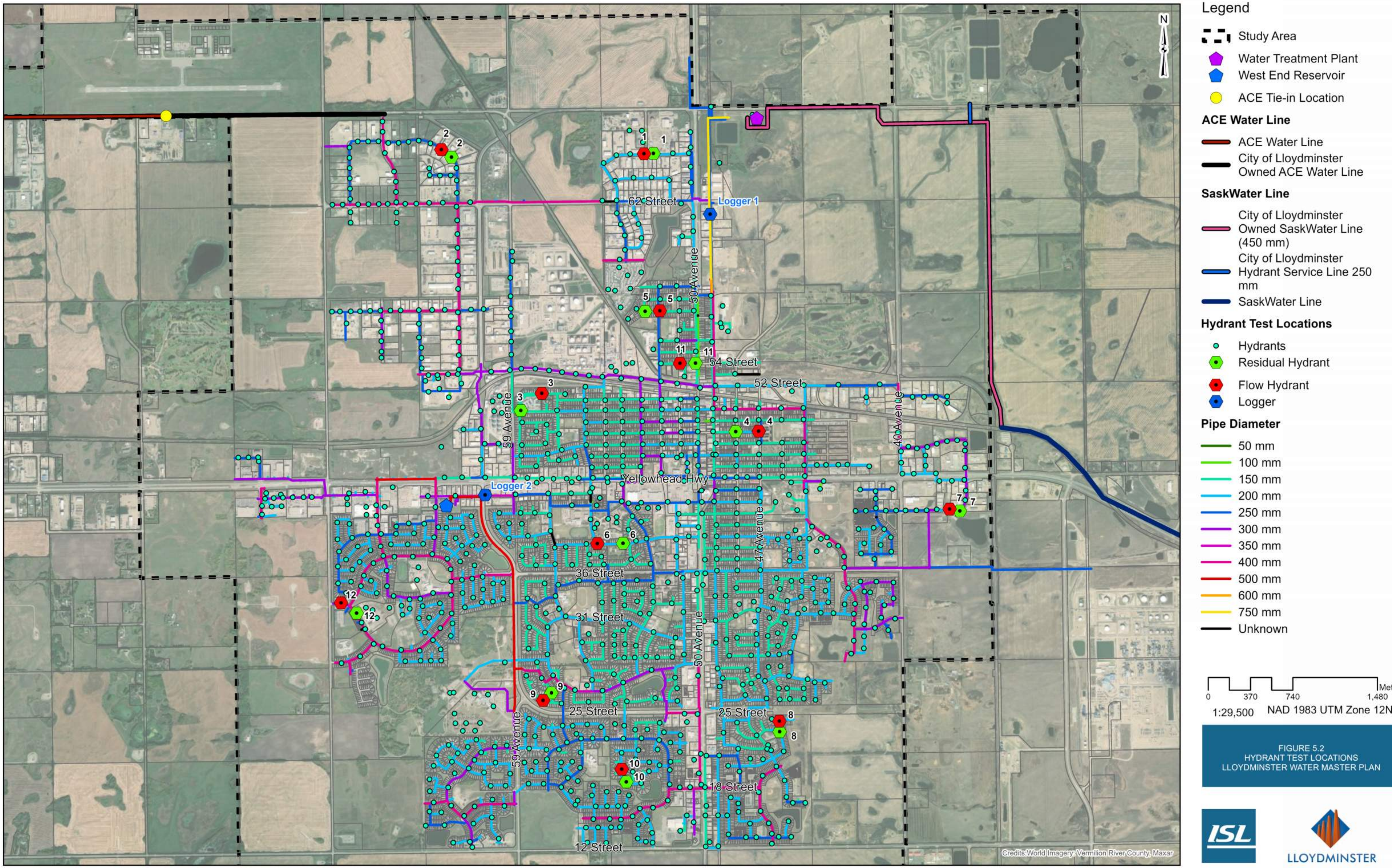

FIGURE 5.2
HYDRANT TEST LOCATIONS
LLOYDMINSTER WATER MASTER PLAN

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Table 5.1: Hydrant Flow Test Results

Hydrant Test	Time of Test	Residual Hydrant Elevation[1]	Test Type	Flow at Hydrant	Pressure					
					Residual Hydrant		Logger No. 1[2]		Logger No. 2[2]	
		m		L/s	psi	kPa	psi	kPa	psi	kPa
1			Static		91	627	87	598	48	332
	10:00	640.18	1 Port	100.74	73	503	68	472	48	329
2			Static		72	496	87	598	48	332
	10:23	649.23	1 Port	88.84	58	400	73	503	48	328
3			Static		66	455	87	598	48	332
	11:48	653.66	1 Port	88.84	54	372	88	604	45	311
4			Static		78	538	87	598	48	332
	12:11	645.4	1 Port	100.74	59	407	87	598	47	324
5			Static		84	579	87	598	48	332
	10:51	643.72	1 Port	97.86	69	476	73	502	48	331
6			Static		65	448	87	598	48	332
	13:27	655.15	1 Port	88.84	54	372	85	585	45	309
7			Static		88	607	87	598	48	332
	12:32	638.2	1 Port	94.98	77	531	85	589	45	310
8			Static		66	455	87	598	48	332
	14:57	651.29	1 Port	78.76	41	283	88	605	46	318
9			Static		52	359	87	598	48	332
	14:10	659.72	1 Port	78.76	42	290	81	560	44	301
10			Static		54	372	87	598	48	332
	14:29	660.03	1 Port	82.24	42	290	86	592	47	322
11			Static		82	565	87	598	48	332
	11:13	645.58	1 Port	68.37	29	200	89	612	48	331
12			Static		53	365	87	598	48	332
	13:52	662.66	1 Port	82.24	41	283	88	606	44	300

[1] Elevations were obtained via the DEM file provided by the City.
[2] Static pressures at each logger were calculated by taking the averages of the overall logger data.

5.5 Model Calibration

The 12 hydrant test locations were used to calibrate the WaterCAD model. Model calibration was performed by using the resultant pressures and associated flow rates obtained from the hydrant testing. This was done to ensure proper Hazen-Williams ‘C’ values were used in the WaterCAD model to simulate pipe roughness and aging. The preliminary ‘C’ values represented common practice roughness values of the various materials seen throughout Lloydminster.

The following were noted/assumed during the model calibration:

1. The WER was inactive during hydrant testing and therefore inactive during calibration.
2. During calibration, the WTP is represented by a fixed HGL that matches the pressure at the test time.
3. During hydrant testing, the valve at the corner of 40 Street and 48 Avenue and the valve at 52 Avenue between 52 Street and 54 Street were closed per correspondence with the City. The two (2) areas were therefore closed in the model during calibration. The valve on 40 Street and 48 Avenue was opened for system assessments, with the assumption that this has been corrected in the field. The valve at 52 Avenue remains closed for system assessments as it remains closed in the field due to pipe leakage, as discussed with the City.

Table 5.2 and Figures 5.3 and 5.4 show the calibration results while a summary of the calibration process and key findings is as follows:

1. **Logger 1** – Field pressure from 10:00 AM to 11:00 AM differs from the remaining pressure records, likely due to equipment error. Therefore, pressures during that time re not considered during calibration. Response from Logger 1 does not align with the response from the WTP, WER and Logger 2, as seen in Figure 5.5. Therefore, an effort to match Logger 1 pressures was not prioritized.
2. **Test 1** – Modelled residual hydrant pressure is lower than field pressure. The area could have localized lower pipe roughness coefficients, or the area could have been regraded to be lower than the model, resulting in higher field pressure.
3. **Test 2** – Modelled residual hydrant pressure is higher than field pressure. This could be due to a semi-closed or fully closed valve that is throttling flow in the field but not represented in the model.
4. **Test 7** – Modelled residual hydrant pressure is much lower than field pressure. The test hydrant was in a newly developed area where the LiDAR data could be outdated. There might have been regrading in this area, causing a discrepancy between the field and the model results.
5. **Test 8** – Modelled residual hydrant pressure is higher than field, which could be due to a semi-closed or fully closed valve in the vicinity that is not accounted for in the model. During calibration, the pipe to the west of the test hydrant was de-activated to test the potential of a closed valve, which would cause the model pressure to be higher than the field if open in the model. With the inactive west pipe, the pressure was much closer to the field; thus, a closed valve was most likely within the vicinity.
6. **Test 11** – Modelled residual hydrant pressure is much higher than field pressure, which could be due to a closed valve in the vicinity that is not accounted for. Pressure change within the area is an anomaly as the pressure drop between Logger 1 and the residual hydrant is drastic given the distance between the two (2) locations is less than 1.5 km. The City has indicated that connection to the watermain was changed from 54 Street to 50 Avenue; the change was completed in 2024 after the hydrant flow test was done.
7. Not all field conditions are represented in the model during calibration which can cause discrepancies between the model results and field results.

8. Overall, the results match consistently for most of the hydrant tests.
9. The final roughness coefficients for AC increased from the previous model value but are still within a reasonable range. The roughness coefficients of steel, small diameter cast iron pipe and unknown pipe material have decreased. The updated Hazen-Williams ‘C’ factor for various pipe materials is in Table 5.3.

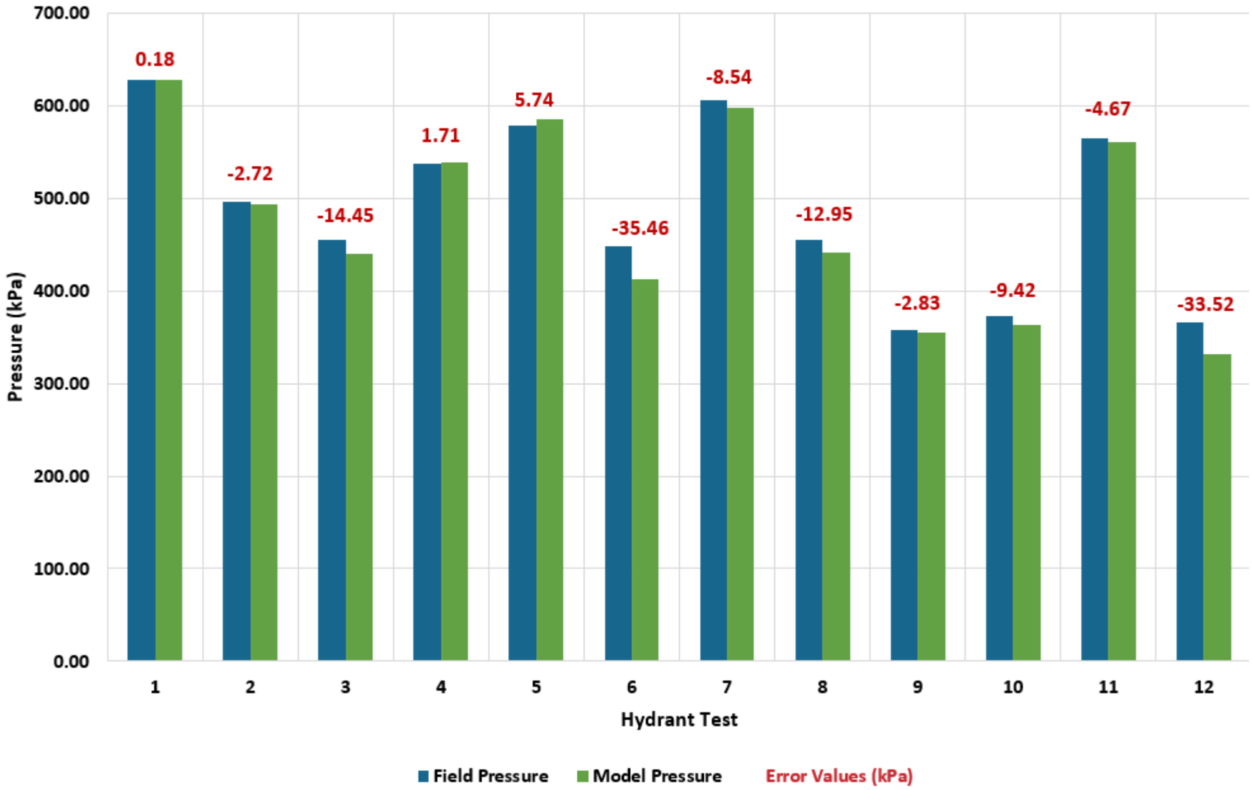

Figure 5.3: Static Calibration Results

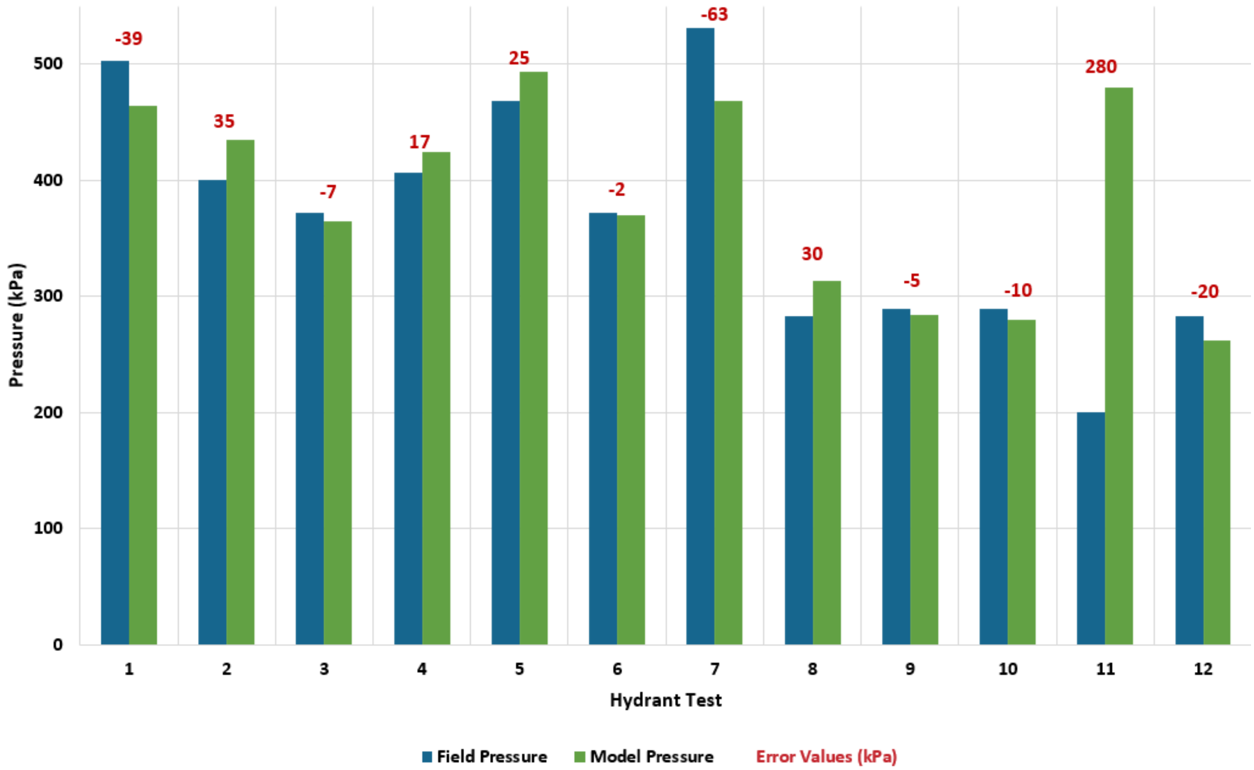

Figure 5.4: Residual Calibration Results

Table 5.2: Calibration Results

Hydrant Test	Time of Test	Test Type	Flow at Hydrant (L/s)	Water Treatment Plant					West End Reservoir				Residual Hydrant			Logger No. 1 [1]			Logger No. 2		
				Effluent Flow (L/s)	Model Pressure (kPa)	Pressure (kPa)	HGL (m)	Model Error (kPa)	Influent Flow (L/s)	Model Pressure (kPa)	Pressure (kPa)	Model Error (kPa)	Model Pressure (kPa)	Field Pressure (kPa)	Model Error (kPa)	Model Pressure (kPa)	Field Pressure (kPa)	Model Error (kPa)	Model Pressure (kPa)	Field Pressure (kPa)	Model Error (kPa)
1		Static		217.26	683	685	706.10	-2.0	84.13	322	295	26.6	628	627.4	0.2	629	600.0	28.8	354	336.0	17.7
	10:00	1 Port	100.74	246.07	633	635	701.01	-2.0	21.74	299	274	25.9	464	503.3	-39.1	578	471.6	106.4	330	328.7	1.3
2		Static		204.62	676	678	705.37	-2.0	81.47	323	295	28.3	494	496.4	-2.7	622	600.0	22.4	355	333.0	21.8
	10:23	1 Port	88.84	214.54	657	658	703.37	-1.9	53.92	312	292	20.1	435	399.9	35.0	603	503.0	99.6	343	327.8	14.9
3		Static		206.09	671	672	704.80	-2.0	76.93	317	294	23.1	441	455.1	-14.5	617	608.0	8.7	349	332.0	17.0
	11:48	1 Port	88.84	215.83	625	627	700.14	-1.9	-0.24	278	256	21.7	365	372.3	-7.4	571	603.7	-33.1	308	310.9	-3.1
4		Static		211.38	679	681	705.69	-2.0	84.59	321	295	26.1	540	537.8	1.7	625	598.0	27.1	353	328.0	25.2
	12:11	1 Port	100.74	232.28	658	659	703.48	-2.0	0.97	309	284	25.6	424	406.8	17.1	602	597.7	4.5	340	324.3	15.4
5		Static		205.44	670	672	704.75	-2.0	72.34	318	294	24.1	585	579.2	5.7	616	600.0	16.3	350	331.0	18.7
	10:51	1 Port	97.86	232.13	615	616	699.08	-1.8	44.24	290	275	14.5	494	468.8	25.0	559	502.3	56.8	320	330.7	-10.4
6		Static		215.34	668	670	704.55	-1.9	60.06	312	294	18.0	413	448.2	-35.5	614	597.0	16.7	344	329.0	14.6
	13:27	1 Port	88.84	236.41	652	653	702.87	-2.0	-0.26	284	270	14.3	370	372.3	-2.0	596	585.4	10.6	315	309.1	5.7
7		Static		210.37	675	677	705.28	-2.0	80.76	318	295	23.2	598	606.7	-8.5	621	595.0	26.2	350	332.0	18.3
	12:32	1 Port	94.98	234.03	625	627	700.19	-2.0	8.69	268	247	21.5	468	530.9	-62.8	570	589.4	-19.5	299	309.9	-11.2
8		Static		215.49	667	669	704.42	-2.0	65.01	310	294	16.1	442	455.1	-13.0	612	596.0	16.4	341	330.0	11.4
	14:57	1 Port	78.76	214.50	645	647	702.23	-1.9	-0.25	290	274	16.0	313	282.7	30.4	591	605.3	-14.2	321	317.6	3.5
9		Static		217.54	663	665	704.06	-2.0	64.31	305	294	11.3	356	358.5	-2.8	609	602.0	6.8	337	326.0	11.0
	14:10	1 Port	78.76	231.33	616	618	699.20	-1.9	-0.23	248	242	5.4	284	289.6	-5.3	560	560.3	0.1	279	300.6	-21.8
10		Static		212.82	673	675	705.08	-2.0	77.98	316	296	19.9	363	372.3	-9.4	619	590.0	29.1	348	326.0	21.6
	14:29	1 Port	82.24	222.69	659	661	703.65	-2.0	-0.26	298	281	16.2	279	289.6	-10.3	605	591.5	13.0	329	322.4	6.3
11		Static		201.55	672	674	704.95	-1.9	82.11	321	295	25.6	561	565.4	-4.7	619	611.0	7.5	353	332.0	20.5
	11:13	1 Port	68.37	226.60	636	638	701.26	-2.0	41.87	300	288	11.8	480	199.9	280.5	581	612.4	-31.6	330	331.2	-0.8
12		Static		213.98	669	671	704.68	-2.0	74.30	312	293	18.6	332	365.4	-33.5	615	606.0	9.1	343	327.0	16.3
	13:52	1 Port	82.24	255.96	634	636	701.10	-2.1	-0.26	248	271	-22.9	262	282.7	-20.5	577	605.6	-28.2	279	300.1	-20.9

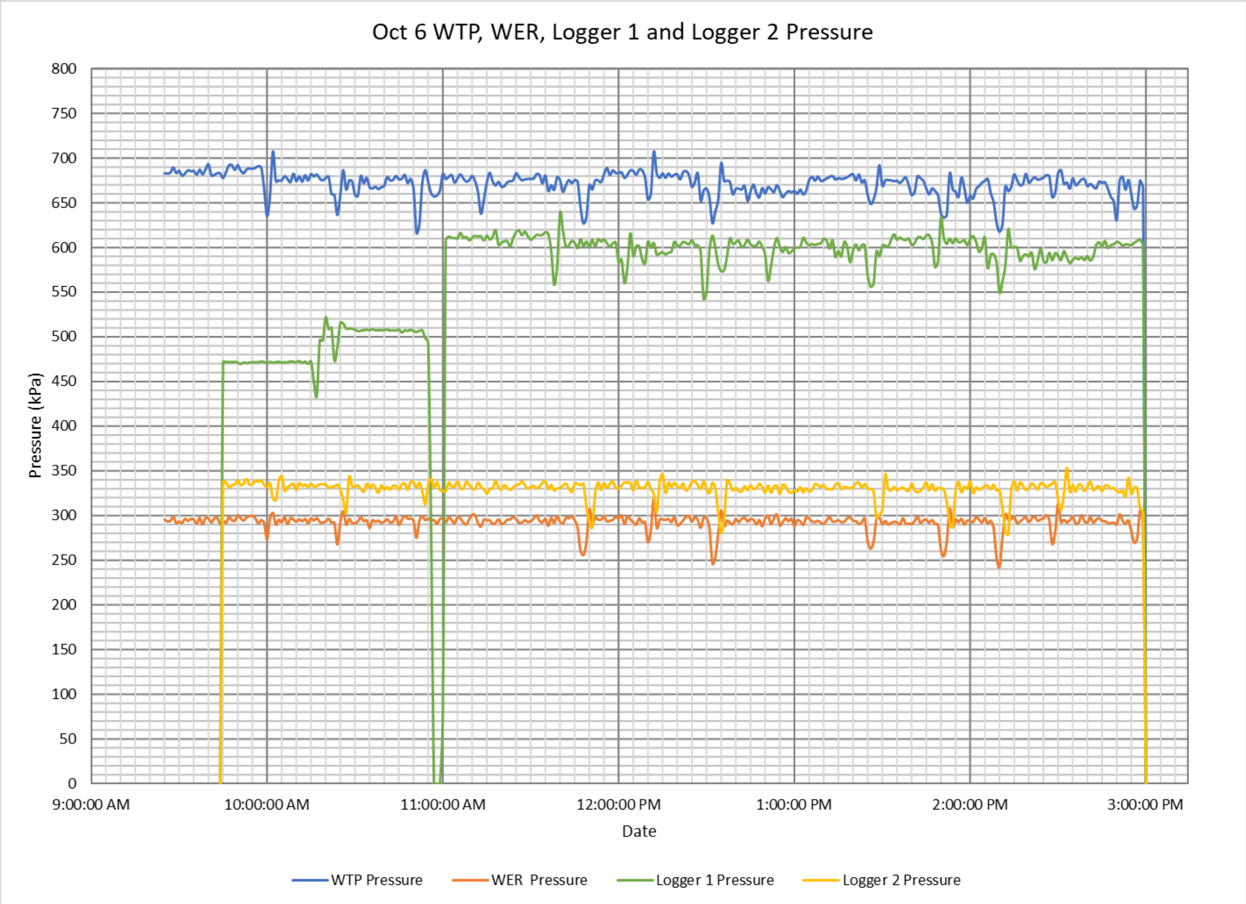

Figure 5.5: Hydrant Testing Day Pressures at the WTP, WER, Loggers 1 and 2

Table 5.3: Updated Hazen-Williams 'C' Factor

Hazen Williams C Factor	Original C Value	Final C Value
Asbestos Cement (AC)	90	105
High Density Polyethylene (HDPE)	140	140
Polyvinyl Chloride (PVC)	130	130
Steel (STL)	100	90
Cast Iron (CI) (Diameter 100 mm and smaller)	90	80
Cast Iron (CI) (Diameter 150 mm to 200 mm)	90	90
Cast Iron (CI) (Diameter 250 mm and larger)	90	90
Unknown	90	80

6.0 Existing System Assessment

The existing water distribution system was analyzed under four (4) different scenarios to determine system conditions. As mentioned in Section 3.1, these scenarios included:

- Steady State:
  - Average day demand (ADD);
  - Maximum daily demand (MDD);
  - Peak hour demand (PHD);
- Steady State with Fire Flow Analysis:
  - Maximum day demand plus fire flow (MDD + FF); and
- Reservoir filled under ADD.

Additionally, the water distribution system was assessed for reservoir storage and pumping capacity under the existing conditions. Table 6.1 summarizes the demands that were used in these assessments. The pump configuration shown in Table 6.2 was used to assess the existing system.

Table 6.1: Existing System Demands

Scenario	Demand	
	L/s	m^3/d
ADD	113.97	9,847
MDD	227.94	19,694
PHD	341.91	29,541

Table 6.2: Modelled Pump Configuration

Pump Name	Location	Pump Type	Variable Speed Set Point HGL	Existing System Model Scenario			
			m	ADD	MDD	MDD+FF	PHD
VSP 1	WER	Variable Speed	702.93	OFF	ON	ON	ON
VSP 2	WER	Variable Speed	702.93	OFF	ON	ON	ON
DP 3	WER	Constant Speed	--	OFF	OFF	OFF	OFF
DP 4	WER	Constant Speed	--	OFF	OFF	OFF	OFF
PWP 101	WTP	Constant Speed	--	ON	ON	ON	ON
PWP 102	WTP	Constant Speed	--	ON	ON	ON	ON
PWP 103	WTP	Variable Speed	703.53	OFF	OFF	OFF	OFF

6.1 Pressure Assessment

The highest and lowest pressures including the locations at which these pressures occur are shown below in Table 6.3 for each of the assessment scenarios. Results for the existing water distribution system assessments are shown in Figures 6.1 to 6.3 for the ADD, MDD, and PHD scenarios, respectively. The contours in the figures represent pressure bands, which are separated into four (4) classifications to evaluate the distribution system. Contour labels represent the pressure in kPa.

Table 6.3: Existing System Pressure Ranges

Scenario	Highest Pressure		Location	Lowest Pressure		Location
	kPa	psi		kPa	psi	
ADD	646.1	93.7	50 Avenue and 67 Street	363.3	52.7	68 Avenue and 35 Street
MDD	646.0	93.7		367.1	53.2	
PHD	645.6	93.6		362.8	52.6	

Each scenario applies the associated pump settings outlined in Table 6.2. The pressure in MDD is higher than PHD due to having the same pump setting but a lower total demand in the system.

Overall, the highest pressure observed in the distribution system is less than 700 kPa and lowest pressure is greater than 350 kPa, which indicates that the existing water distribution system is functioning optimally.

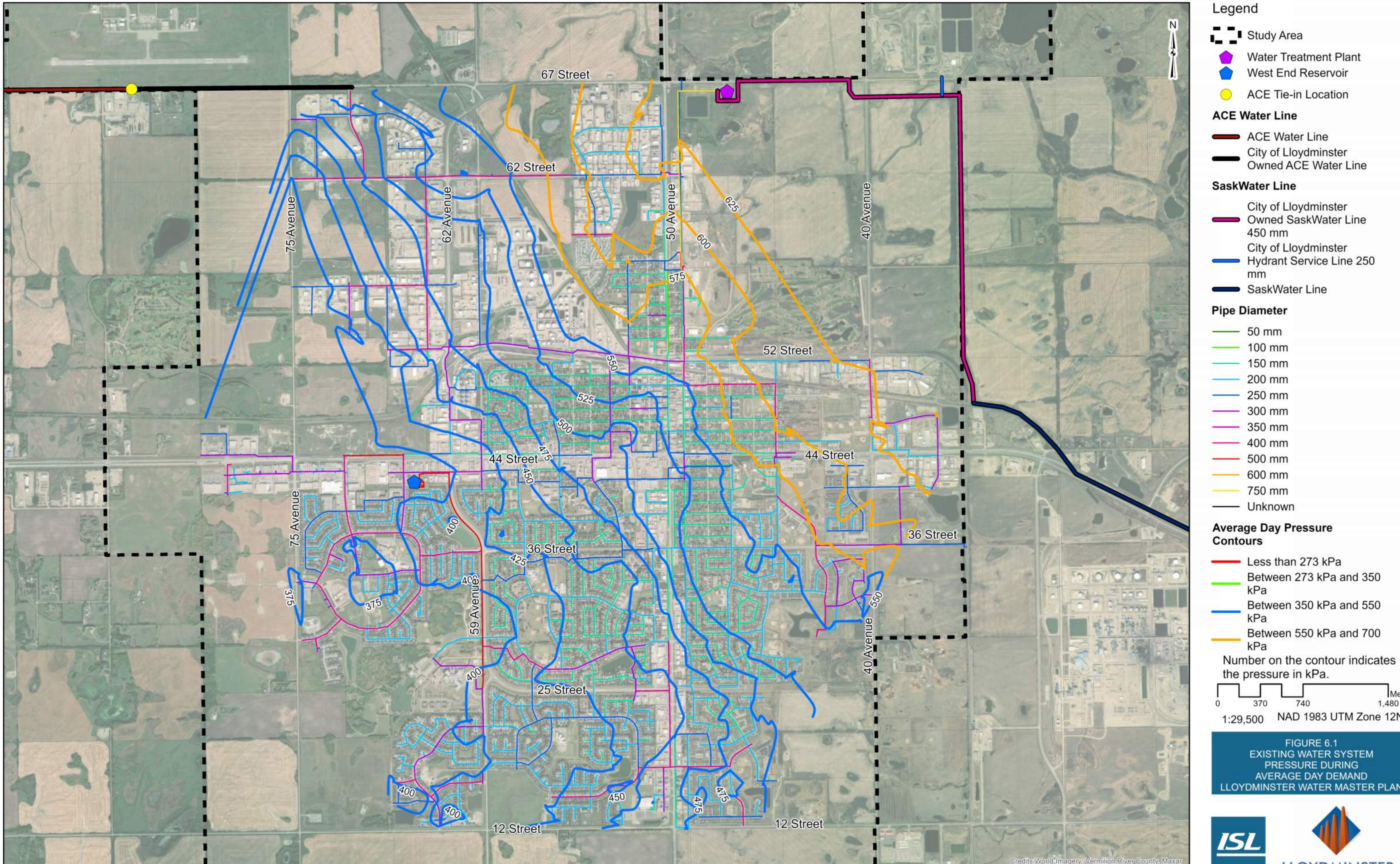

FIGURE 6.1
EXISTING WATER SYSTEM PRESSURE DURING AVERAGE DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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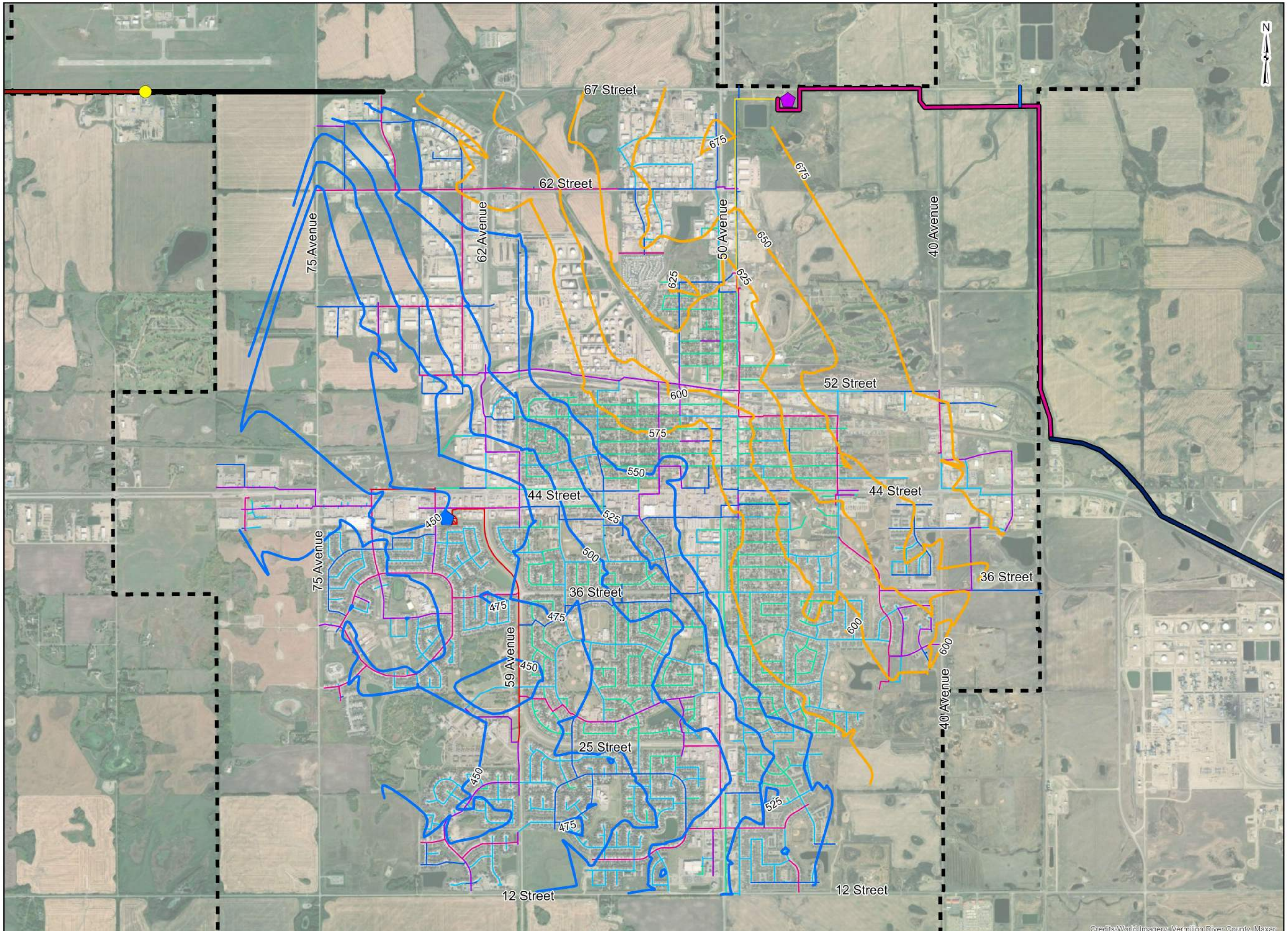

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Maximum Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 370 740 1,480 Meters

1:29,500 NAD 1983 UTM Zone 12N

FIGURE 6.2
EXISTING WATER SYSTEM PRESSURE DURING MAXIMUM DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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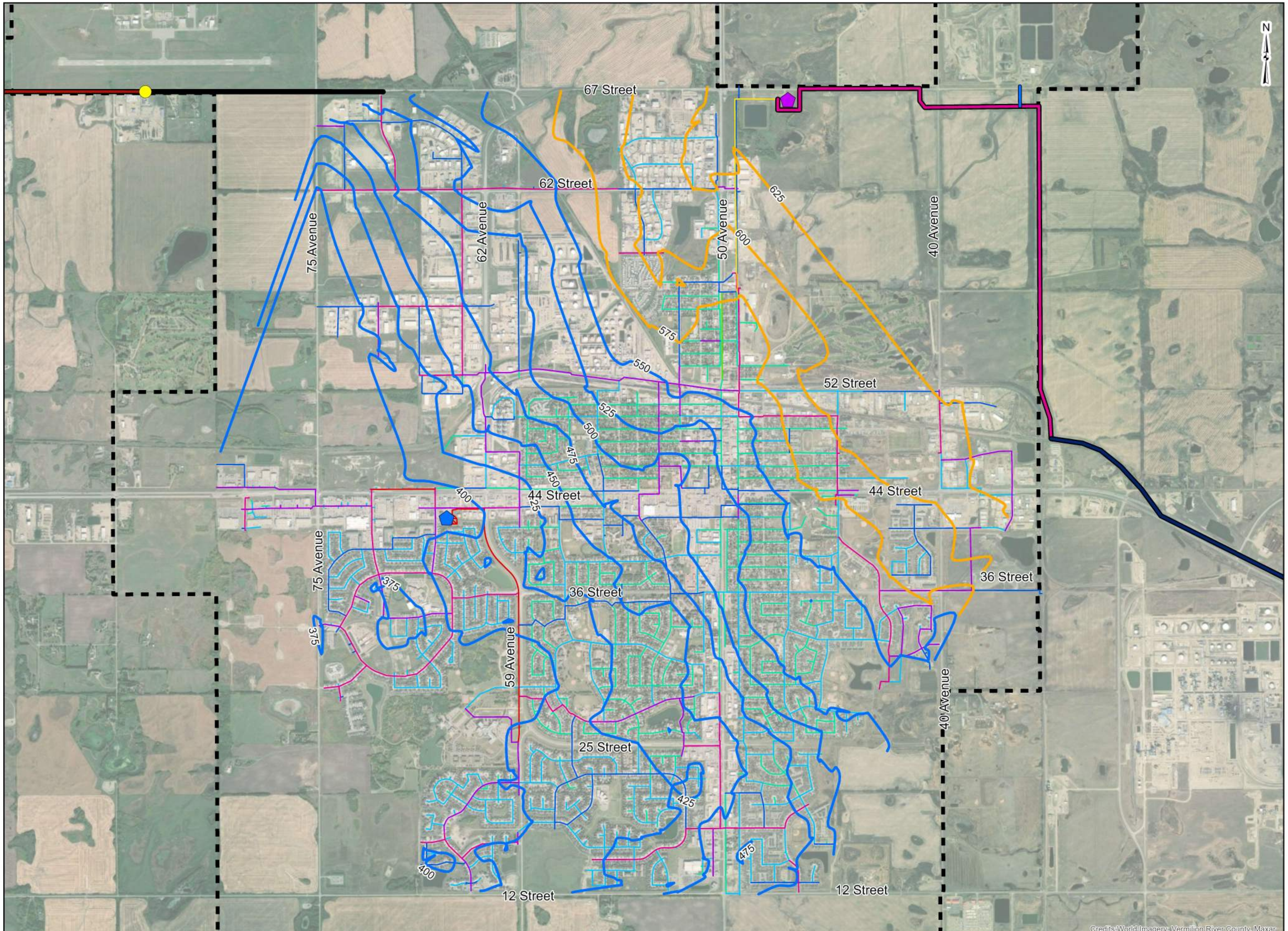

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Peak Hour Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 370 740 1,480 Meters

1:29,500 NAD 1983 UTM Zone 12N

FIGURE 6.3
EXISTING WATER SYSTEM PRESSURE DURING PEAK HOUR DEMAND
LLOYDMINSTER WATER MASTER PLAN

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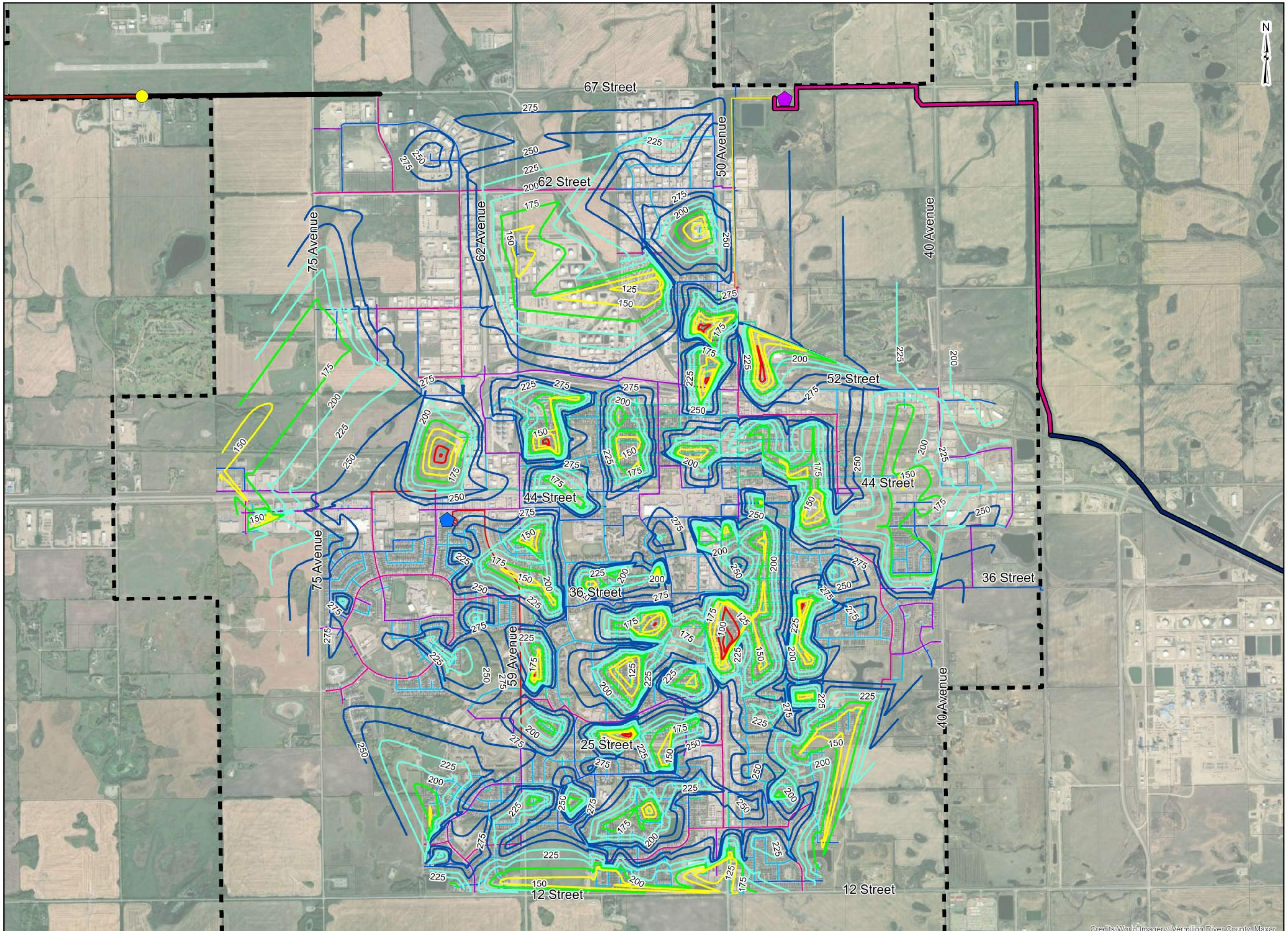
6.2 Fire Flow Assessment

Results of the MDD + FF assessment under existing conditions are shown in Figure 6.4. Available fire flow was determined only at hydrant locations (noting that the minimum pressure constraint requirement occurs at all nodes, not only the hydrants), with fire flows ranging from 100 L/s to 300 L/s.

Figure 6.5 compares the available fire flow under existing conditions to the current land use type for each parcel. The red dots show any locations that fail to meet the fire flow requirement for the given land use type. The percentage represents the fire flow that the system can reach compared to the required fire flow. There are many locations where the existing fire flow is inadequate. Some of the deficiencies are due to the hydrant being situated on a long single feed, others are due to the lack of looping, and some are due to small diameter pipes that are unable to provide the required fire flow at the minimum pressure of 150 kPa. Otherwise, the available fire flow within the existing water distribution system is generally sufficient to accommodate existing development.



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Fire Flow Contour

- Less than 100 L/s
- Between 100 and 150 L/s
- Between 150 and 185 L/s
- Between 185 and 225 L/s
- Between 225 and 300 L/s

Number on the contour indicates the available fire flow in L/s

0 370 740 1,480 Meters

1:29,500 NAD 1983 UTM Zone 12N

FIGURE 6.4
EXISTING WATER SYSTEM AVAILABLE FIRE FLOW DURING MAXIMUM DAY DEMAND
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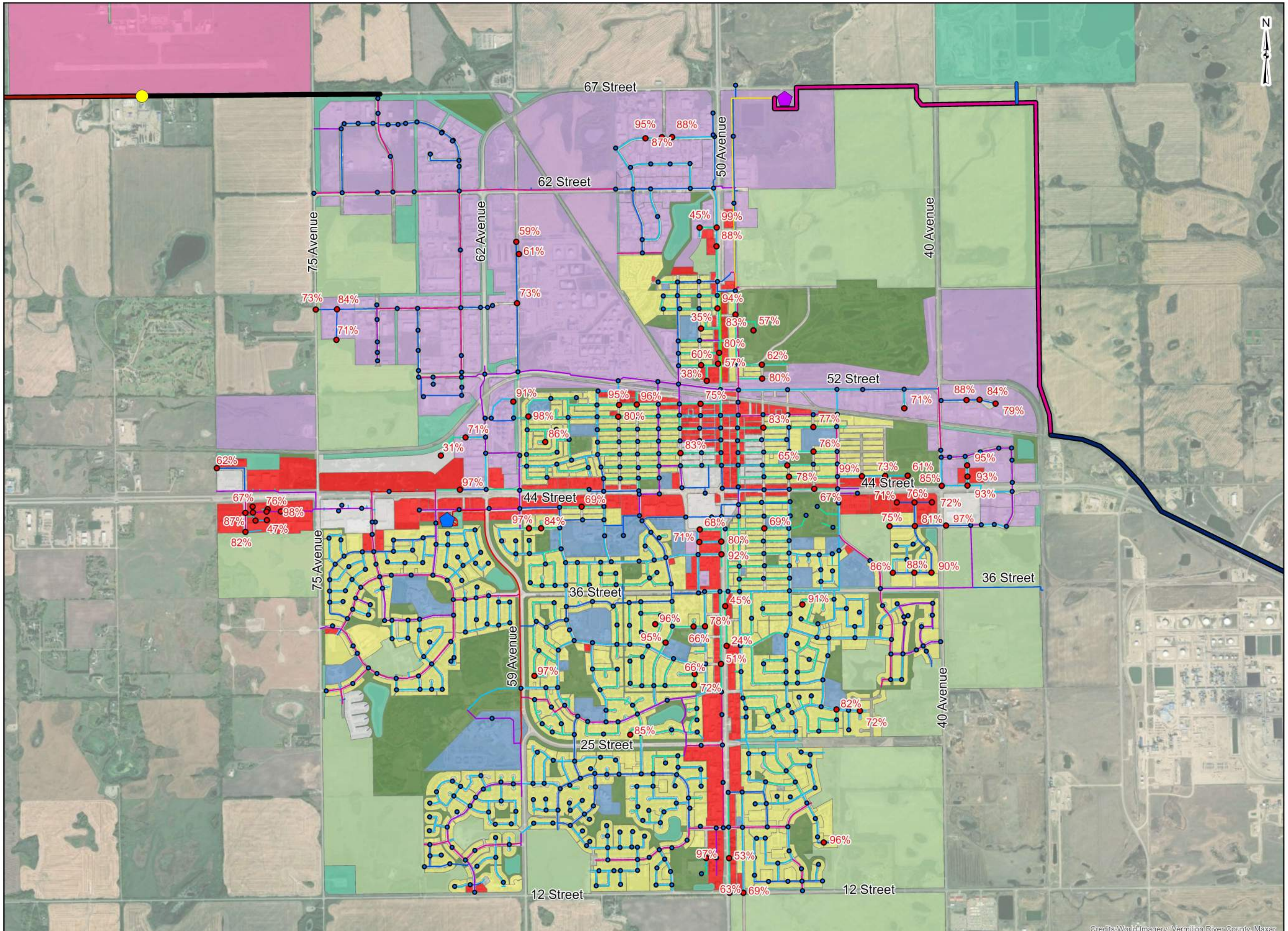

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Existing Land Use

- Residential
- Commercial
- Industrial
- PS: Public Services
- PU: Public Utility
- UP: Urban Park
- MA1: Municipal Airport Airside
- UT: Urban Transition
- Direct Control

Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm

Fire Flow Requirement

- Fail Fire Flow Requirements
- Meet Fire Flow Requirements

Percentage represent the fire flow that the system can reach in regard to the required

0 370 740 1,480 Meters

1:29,500 NAD 1983 UTM Zone 12N

FIGURE 6.5
EXISTING WATER SYSTEM
FIRE FLOW ASSESSMENT DURING
MAXIMUM DAY DEMAND LAND USE
LLOYDMINSTER WATER MASTER PLAN

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6.3 Reservoir Capacity Assessment

Water Treatment Plant

Storage capacity at the WTP has not been assessed because the WTP clearwell holds treated water primarily used as a source of filter backwash water; therefore, it does not contribute to the treated water storage capacity of the water distribution system.

West End Reservoir

The WER stores treated water from the WTP and supports the water distribution system during high demand scenarios, such as during fire flow events or non-operational times at the WTP. The WER has a total storage capacity of 24,796 m^3. The above-ground concrete tank constructed in 1974 provides 4,545 m^3 of storage, and two (2) underground reservoirs installed in 2006 provide an additional 20,250 m^3 of storage.

Table 6.4 shows the Saskatchewan Ministry of Environment total storage required. Table 6.5 shows the Alberta Environment and Protected Areas total storage required. Table 6.6 shows the storage analysis based on the required storage and the current available storage.

Table 6.4: Saskatchewan Ministry of Environment Storage Requirement

SME Parameters	Volume
ADD, m^3	9,847
Total Storage, m^3	**19,694**

Table 6.5: Alberta Environment and Protected Areas Storage Requirement

AEPA Parameters	Volume
A (Fire Storage), m^3	2,430
B (Equalization Storage), m^3	4,924
C (Emergency Storage), m^3	1,477
D[1] (T10 to meet CT requirements), m^3	188
Total Storage, m^3	**8,831**

[1] D represents the chlorine tank storage.

Table 6.6: Storage Analysis

Parameter	Unit	Volume
ADD	m^3	9,847
MDD	m^3	19,694
Available Storage	m^3	24,796
Required Storage (AEPA)	m^3	8,831
Meets Requirements?		Yes
Required Storage (SME)	m^3	19,694
Meets Requirements?		Yes

The WER has sufficient storage for the existing water distribution system needs and no further upgrades to storage are required to accommodate the existing water distribution system.

6.4 Reservoir Filling Assessment

A reservoir filling scenario was completed under ADD conditions to simulate the WER being filled. This assessment assumes that the reservoir is filled over a seventeen-hour period. This assumption considers that WTP shuts down at 11 PM and the WER operates from 11 PM to 6 AM, allowing the reservoir to fill during the day. This scenario was completed to ensure that the water distribution system can meet reservoir filling requirements, without depleting pressures throughout the remainder of the water distribution system. Three (3) scenarios were assessed and documented as follows in Table 6.7.

Table 6.7: Reservoir Filling Requirements and Results

Scenario	Storage	Flow	Pressure at Delivery Point
	m^3	L/s	kPa
Full Reservoir Storage Capacity	24,796	405	-388
Storage Requirements under SME	19,694	322	-121
Storage Requirements under AEPA	8,831	144	280

Negative pressures in Table 6.7 suggest depletion throughout the distribution system, as well. Contrarily, at a maximum fill rate of 144 L/s, positive pressures are maintained throughout. The minimum pressure under this fill scenario (144 L/s) is 276 kPa, near the intersection of 35 Street and 67 Avenue.

This presents a conservative approach to reservoir filling of the WER, given this reservoir generally only operates at night while the WTP is shut down or during high flow events, such as fire flows. It is unlikely that the reservoir would become completely depleted under night-time demands, and a typical fire flow event only requires 2,430 m^3 using the criteria established in Section 3.0. Additionally, the WTP is currently rated at 838.5 m^3/hr (232.3 L/s), meaning that notwithstanding distribution pressure deficiencies, the maximum volume that can be filled within a seventeen-hour period is 14,223 m^3. Two (2) days would be needed to fill the WER to 100% of its storage if the reservoir was completely empty, at this limiting capacity.

It is not expected that the reservoir would require filling to 100% of its storage regularly. Therefore, it is recommended that the City monitor the rate at which this reservoir is filled and the frequency of it dropping to less than 20% full to determine if further redundancy to the reservoir fill approach (i.e., consideration of a dedicated supply main) is warranted. Historically, the City has not observed the reservoir dropping below 20% capacity since its startup in 2006. As the City continues to grow, night-time demands will increase, resulting in a greater fluctuation of reservoir volume and likely requiring consistently larger flow rates during the day to fill the reservoir in a seventeen-hour period. An extended period simulation is recommended to further pinpoint when a new fill line is needed.

A dedicated supply main that can convey a flow of 232 L/s (i.e., limiting rate based on the current WTP capacity) for approximately 6 km, assuming a conservative roughness coefficient of 130, could range from 400 mm to 600 mm, depending on the degree of headloss tolerated and the pump characteristics. The following graphic (Figure 6.6) illustrates the amount of headloss per pipe size with the parameters noted above to indicate the sensitivity of pipe sizes.

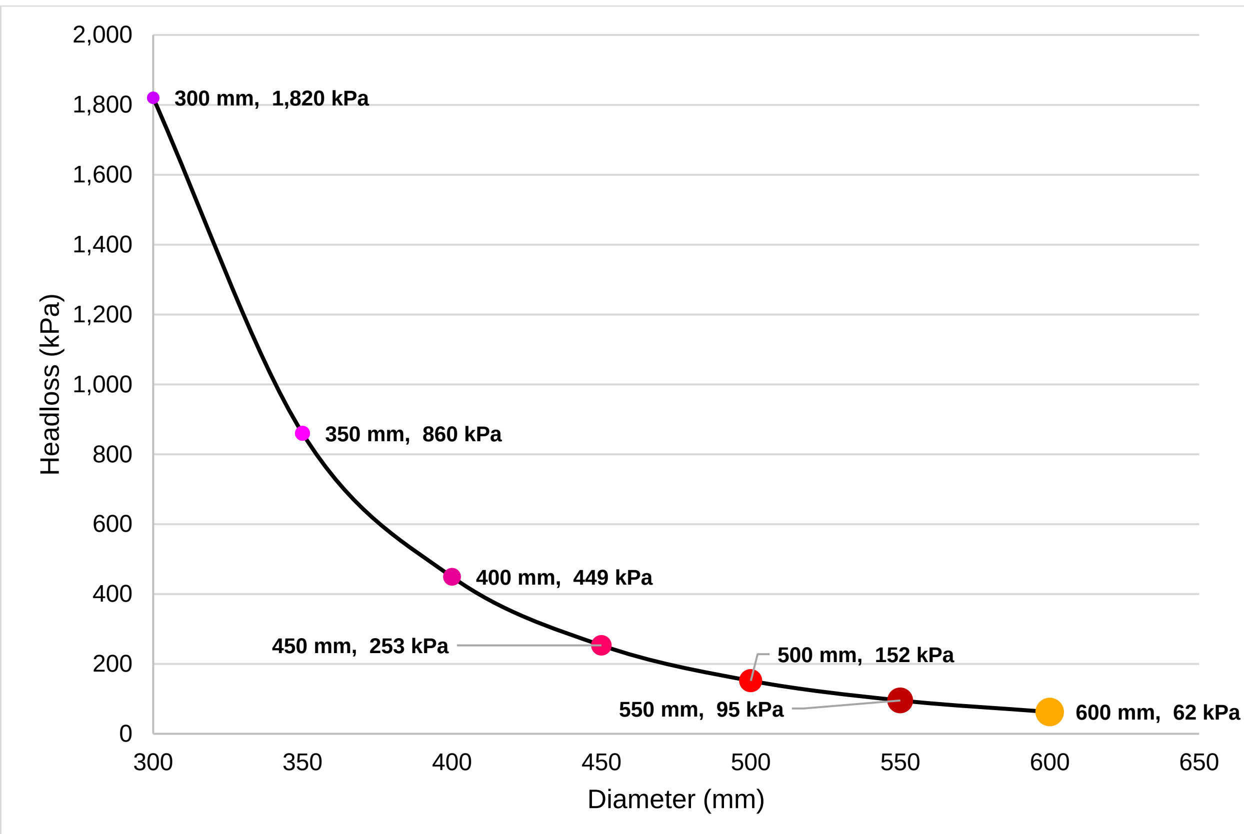

Figure 6.6: Dedicated Supply Main Headloss per Pipe Diameter (6 km, 232 L/s, 130 Roughness Coefficient)

6.5 Pumping Capacity Assessment

The WTP supplies most of the average day demand flow to the water distribution system while the WER assists in the delivery of flow during periods of high usage or non-operational times at the WTP. The existing combined pumping capacity of the WTP and WER is 654 L/s. Table 6.8 shows the required pumping capacity and the available pumping capacity.

Table 6.8: Existing Pumping Requirements and Capacity

Parameter	Flow	
	L/s	m^3/hr
ADD	114	410
MDD	228	821
MDD + FF	453	1,631
PHD	342	1,231
Governing Pumping Capacity[1]	453	1,631
Current Pumping Capacity[2]	552	1,987
Pumping Deficiency[3]	99	356

[1] Governing pumping capacity was determined using the greater of the PHD and MDD + FF (MDD + 225 L/s).
[2] Based on the current pumps' cumulative firm capacity.
[3] Calculated by subtracting current pumping capacity with governing pump capacity; a positive value indicates no pumping deficiency.

The WTP and WER have sufficient pumping capacity to support the existing water distribution system; therefore, no additional pumping capacity is required.

6.6 Unaccounted for Water Assessment

As noted in Section 3.2, UFW is assumed to be leakage losses throughout the existing water distribution system. An average leakage of 8% of the total volume of water produced was calculated, which is common due to natural deterioration of water distribution system facilities. An average leakage below 10% is considered to perform very well. Generally, leakage averages about 20-30%, according to the National Research Council of Canada Construction Technology Update Article No. 40 (2000). Though the average leakage is low, it is still loss in revenue and an inefficient use of operation cost so continual pipe condition monitoring and addressing high risk pipe locations is required to help maintain and improve system resiliency.

A desktop exercise was undertaken to identify areas of the water distribution system that are likely more susceptible to leakage. The critical factors that were considered in this exercise were watermain age, watermain material, and pressure under ADD conditions. These factors are shown in Figures 4.1, 4.2, and 6.1, respectively. Cast iron watermains generally experience the most main breaks.

Based on the factors identified above, an assessment identifying the leakage potential for each section of watermain was performed. Watermains were ranked based on priority to consider further investigation and/or replacements. Three (3) criteria were identified as follows:

- Watermains built before 1974 received a score of 1;
- Watermains comprising of cast iron, steel, or AC received a score of 1; and
- Watermains with a pressure greater than 550 kPa under ADD conditions received a score of 1.

The total scores were summated and used to prioritize leakage investigation, noting that the GIS data identified very limited sections of cast iron or steel watermains but a large number of asbestos cement watermains. This analysis is shown in Figure 6.7, where higher risk watermains are shown as red and lower risk watermains are green. Areas of note include the North Lloydminster residential neighbourhood and East Lloydminster. Moderate risk areas are generally made up of a combination of either cast iron, steel, or asbestos cement watermains that are more than 50 years old, or the water distribution system pressure is greater than 550 kPa, making it more susceptible to leakage. This is generally in the core of Lloydminster, where the water distribution system is older compared to the peripheral neighbourhoods.

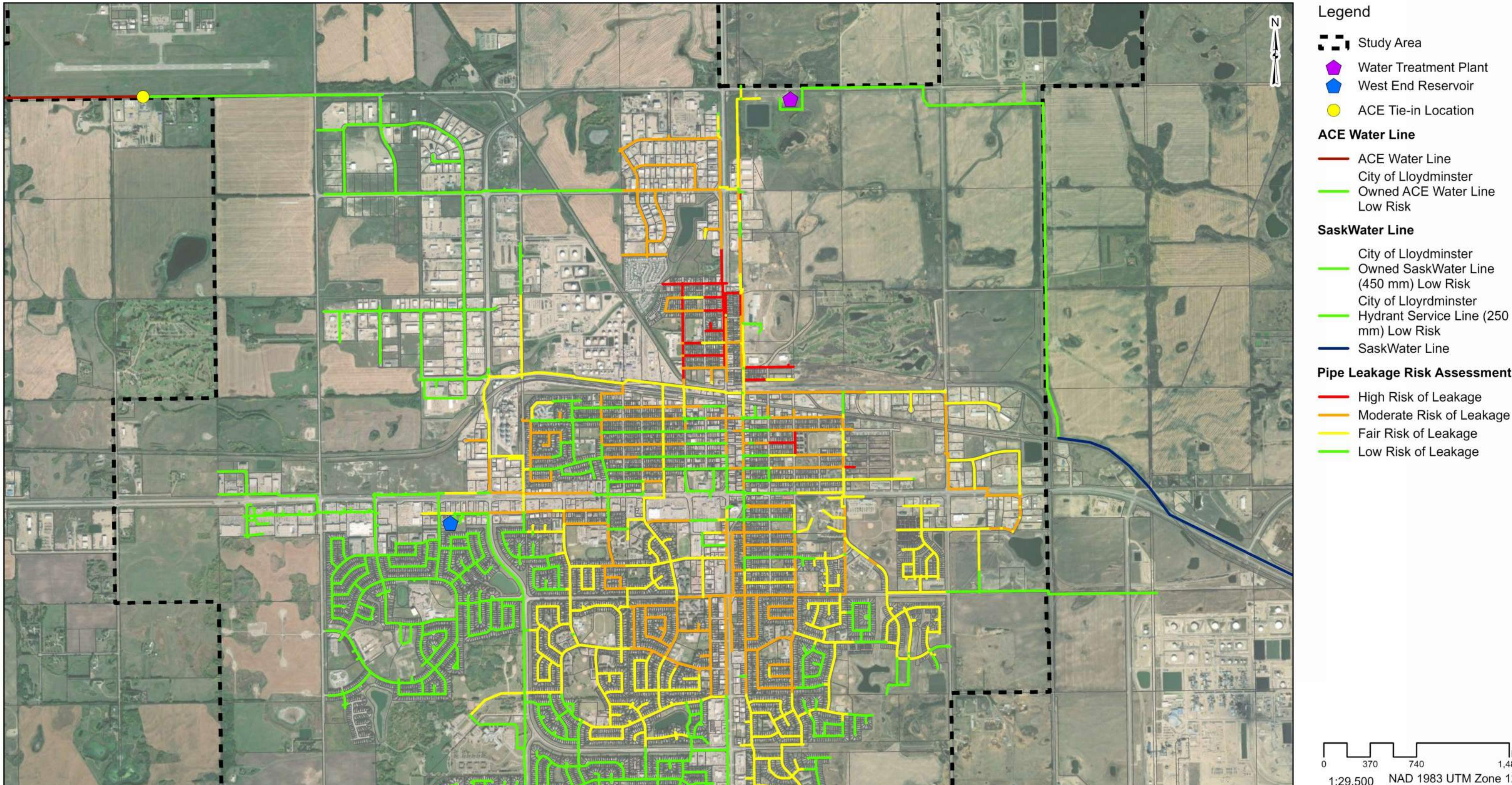

FIGURE 6.7
PIPE LEAKAGE RISK ASSESSMENT
LLOYDMINSTER WATER MASTER PLAN

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6.7 Existing System Recommendations

Existing water distribution system upgrades are proposed to meet fire flow standards and increase system redundancy through upsizing and looping. A summary of the proposed upgrades to the existing water distribution system is shown in Table 6.9 and in Figure 6.8. Any watermain improvements that cross private property will have additional cost implications regarding procurement costs of land and/or easements.

Table 6.9: Proposed Existing System Upgrades

Upgrade No.	Diameter	Location	Pipe Upgrade	Length
	mm			m
Ex UPG 1	250	59 Avenue between the dead-end of the watermain and 62 Street	Loop with 250 mm	419
Ex UPG 2	250	50 Avenue between 62 Street and 60 Street, and 60 Street between 50 Avenue Service Road and 51 Avenue	Upsize to 250 mm	457
Ex UPG 3	250	51 Avenue between 55 Street and 55A Street	Loop with 250 mm (Note this is to supplement fire flow to Queen Elizabeth School)	93
Ex UPG 4	250	54 Street between 51 Avenue and 52 Avenue	Upsize to 250 mm	225
Ex UPG 5	250	51 Avenue between 52 Street and 54 Street, Crossing CP Rail	Upsize to 250 mm	181
Ex UPG 6	300	54 Street between 50 Avenue and 49 Avenue	Twinning with 300 mm	150
Ex UPG 7	150	53 Street between 48 Avenue and 49 Avenue	Upsize to 200 mm	192
Ex UPG 8	250	52 Street between 4409 52 Street and 42 Avenue	Upsize to 250 mm	542
Ex UPG 9	250	42 Avenue from 52 Street to the dead-end of the watermain	Upsize to 250 mm	153
Ex UPG 10	250	47 Avenue between 45 Street and 47 Street	Loop with 250 mm (Note this is to supplement fire flow to Lloydminster Gospel Fellowship)	205
Ex UPG 11	200	45 Street between 40 Avenue and 41 Avenue	Loop with 200 mm	355
Ex UPG 12	300	41 Street between 3804 41 Street and 37 Avenue	Upsize to 300 mm	201
Ex UPG 13	300	39 Avenue between 36 Street 41 Street	Twinning with 300 mm	511
Ex UPG 14	250	41 Street between 50 Avenue and 51 Avenue	Upsize to 250 mm	173
Ex UPG 15	250	50 Avenue between 41 Street and 42 Street	Upsize to 250 mm	104
Ex UPG 16	250	50 Avenue between 32 Street and 36 Street	Upsize to 250 mm	442
Ex UPG 17	250	32 Street Between 49 Avenue and 50 Avenue	Loop with 250 mm	110
Ex UPG 18	250	50 Avenue between 27 Street and 31 Street	Upsize to 250 mm	226
Ex UPG 19	400	99 Street between 52 Street and 62 Street	Loop with 400 mm	1,176
Ex UPG 20	250	44 Street between 63 Avenue and 66 Avenue	Upsize to 250 mm	201
Ex UPG 21	500	44 Street between 70 Avenue and 75 Avenue	Loop with 500 mm	451
Ex UPG 22	400	80 Avenue crossing 44 Street	Loop with 400 mm	85

Ex UPG 1 and 19 will be triggered by development. Ex UPG 1 improves existing fire flow deficiencies in an industrial area where the water distribution system can only currently provide approximately 56% of the required fire flow. Deferring Ex UP 1 could risk disrupting the firefighting capability, so the City may wish to consider upgrades sooner. Ex UPG 19 is intended to provide system redundancy for the industrial area, therefore can be deferred until development occurs. The results for the upgraded existing water distribution system can be found in Figures 6.9 to 6.12.

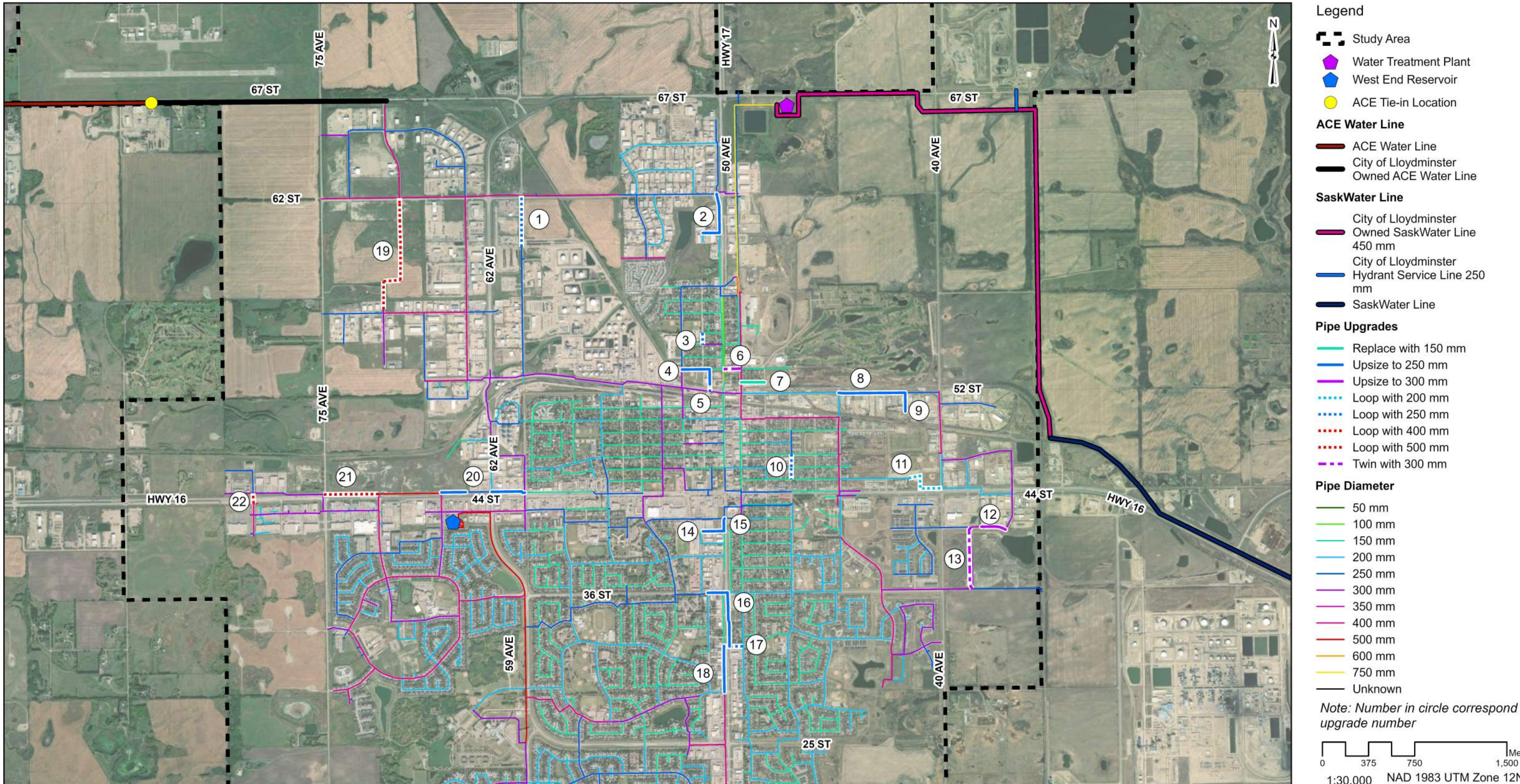

FIGURE 6.8
EXISTING WATER SYSTEM
PROPOSED PIPE UPGRADE
LLOYDMINSTER WATER MASTER PLAN

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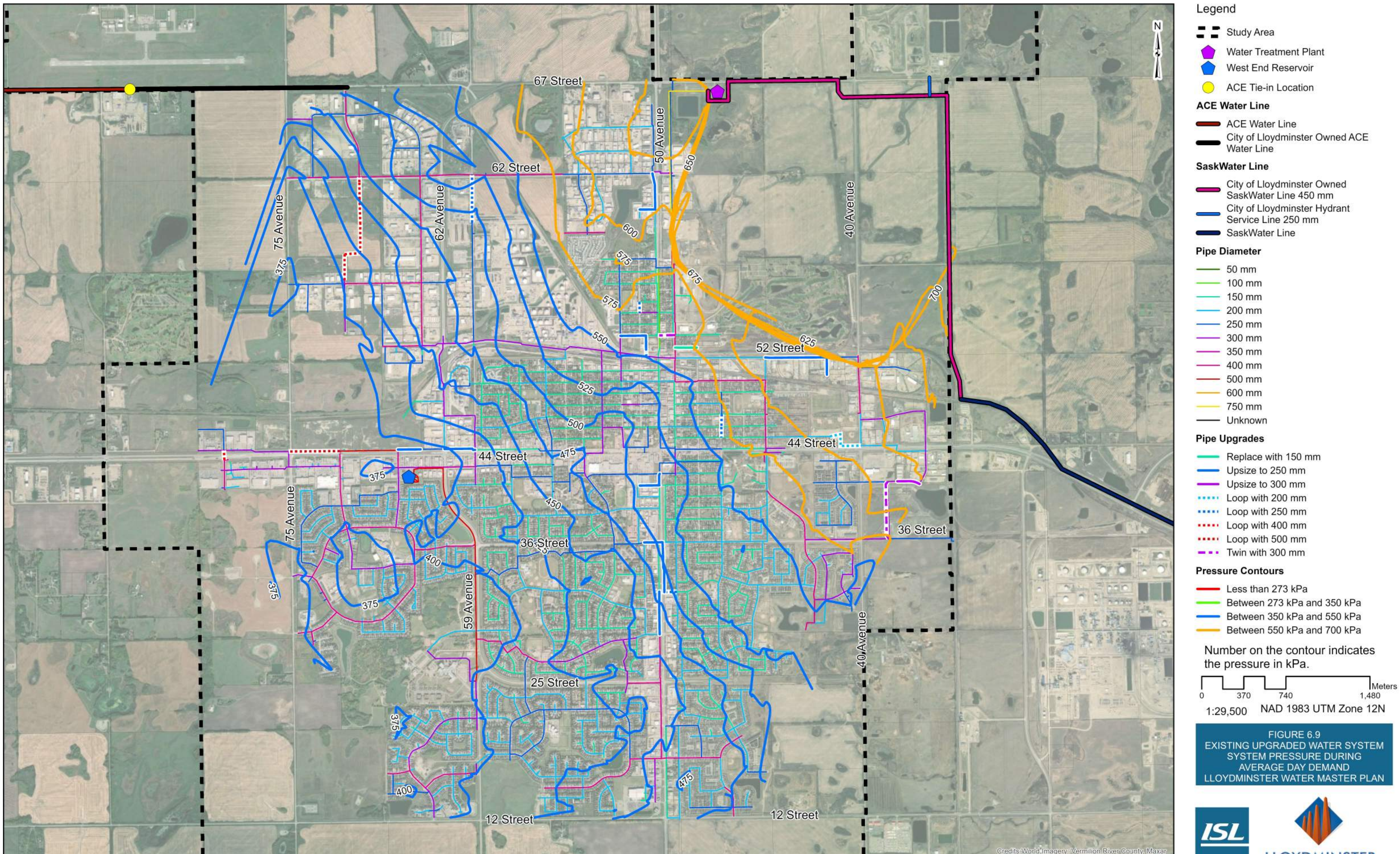

FIGURE 6.9
EXISTING UPGRADED WATER SYSTEM
SYSTEM PRESSURE DURING
AVERAGE DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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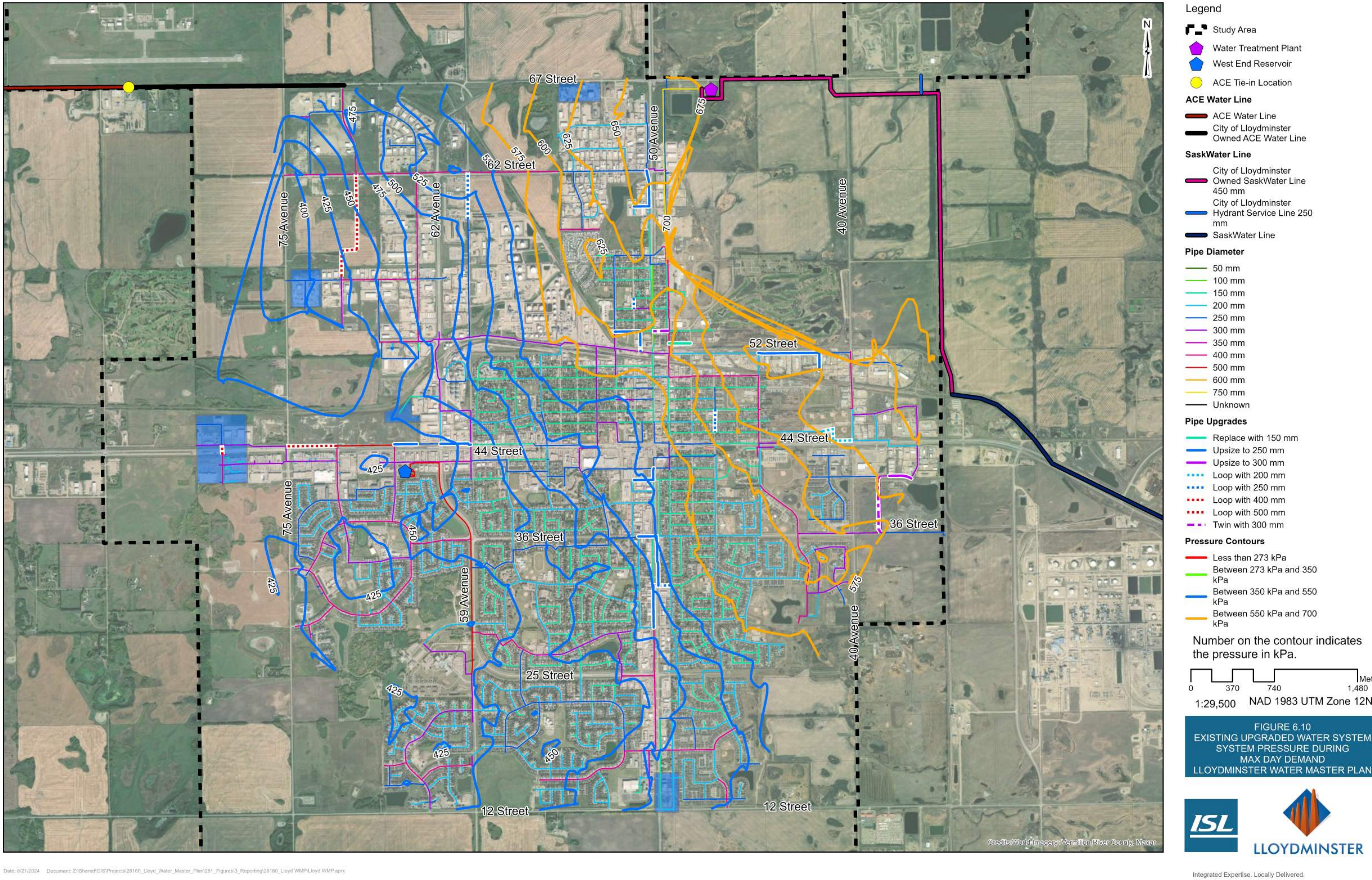
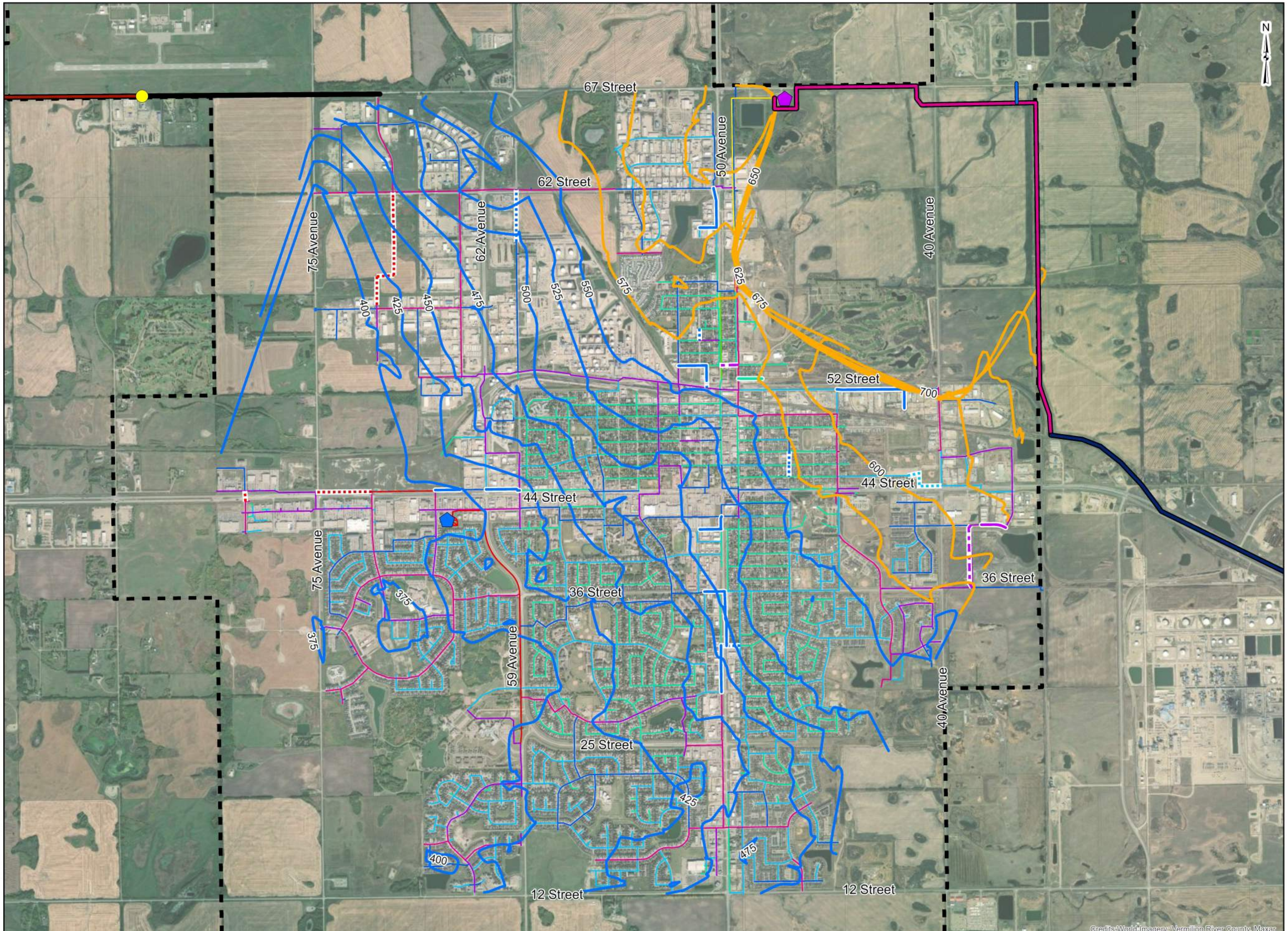


FIGURE 6.10
EXISTING UPGRADED WATER SYSTEM SYSTEM PRESSURE DURING MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Pipe Upgrades

- Replace with 150 mm
- Upsize to 250 mm
- Upsize to 300 mm
- Loop with 200 mm
- Loop with 250 mm
- Loop with 400 mm
- Loop with 500 mm
- Twin with 300 mm

Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 370 740 1,480 Meters

1:29,500 NAD 1983 UTM Zone 12N

FIGURE 6.11
EXISTING UPGRADED WATER SYSTEM
SYSTEM PRESSURE DURING
PEAK HOUR DEMAND
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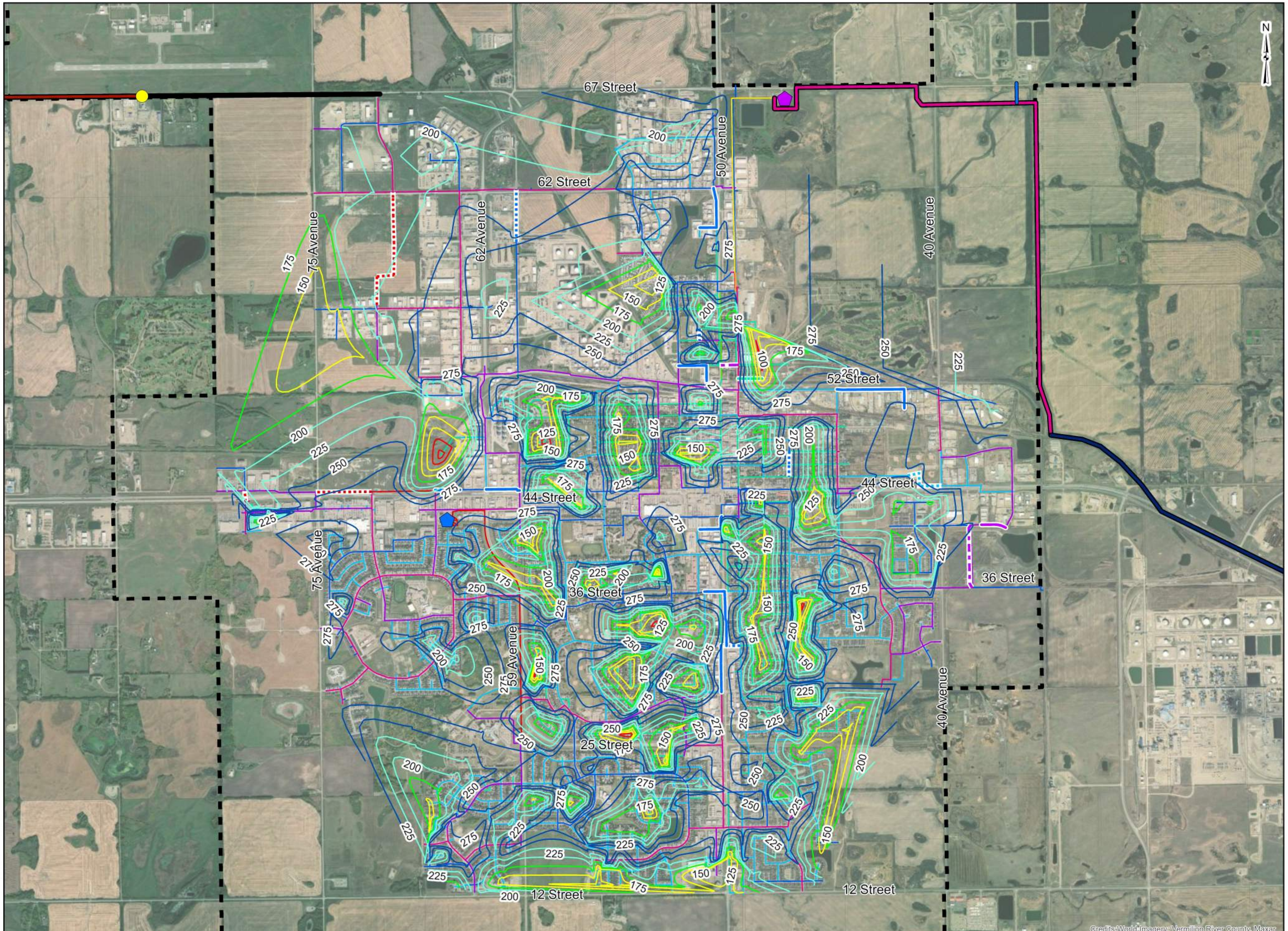

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Pipe Upgrades

- Replace with 150 mm
- Upsize to 250 mm
- Upsize to 300 mm
- Loop with 200 mm
- Loop with 250 mm
- Loop with 300 mm
- Loop with 400 mm
- Loop with 500 mm
- Twin with 300 mm

Fire Flow Contour

- Less than 100 L/s
- Between 100 and 150 L/s
- Between 150 and 185 L/s
- Between 185 and 225 L/s
- Between 225 and 300 L/s

Number on the contour indicates the available fire flow in L/s

0 370 740 1,480 Meters

1:29,500 NAD 1983 UTM Zone 12N

FIGURE 6.12
EXISTING UPGRADED WATER SYSTEM AVAILABLE FIRE FLOW DURING MAXIMUM DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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6.8 Risk Assessment

Proposed upgrades are ranked based on the pipe conditions, land use, and road conditions. The rating summaries are shown in Tables 6.10 to 6.13. The pipe conditions rating summary is outlined in Table 6.10. The rating for improved fire flow based on the upgrade is outlined in Table 6.11. The rating for the impacted area is outlined in Table 6.12. Finally, the road condition rating is outlined in Table 6.13. Rating for each proposed upgrade based on the following rating criteria is shown in Appendix C.

Table 6.10: Pipe Condition Rating Summary

Rating	Condition	Description
1	Excellent	No further action required.
2	Good	This category was applied to pipe sections that is PVC and the service age is less than 50 years or proposed new pipes.
3	Fair	This category was applied to pipe sections that is not PVC and the service age is approximately 40 to 50 years.
4	Poor	This category was applied to pipe sections that is not PVC and the service age is between 50 to 60 years old.
5	Failing	This category was applied to pipe sections that is not PVC and the service age is greater than 60 years.

Table 6.11: Available Fire Flow Improvement Rating Summary

Rating	Condition	Description
5	> 50%	The upgrade improved the available fire flow by more than 50%.
4	40% - 50%	The upgrade improved the available fire flow by more than 40% but less than 50%.
3	30% - 40%	The upgrade improved the available fire flow by more than 30% but less than 40%.
2	20% - 30%	The upgrade improved the available fire flow by more than 20% but less than 30%.
1	<10%	The upgrade improved the available fire flow by less than 10%.

Table 6.12: Impacted Area Rating Summary

Rating	Condition	Description
5	Very High	The upgrade improved a high-density residential area.
4	High	The upgrade improved a large area with multiple parcels that is densely populated or higher value.
3	Moderate	The upgrade improved a large area with multiple parcels or at key locations such as highway commercial.
2	Low	The upgrade improved a specific location only.
1	Negligible	The upgrade improved the overall system redundancy but does not directly impact a specific area.

Table 6.13: Road Condition Rating Summary

Rating	Condition	Description
5	Excellent	The upgrade to the pipe can improve the existing road condition during construction.
4	Good	The upgrade is likely to improve the existing road condition during construction.
3	Fair	The upgrade can improve the existing road condition during construction.
2	Poor	The upgrade is unlikely to improve the existing road condition during construction.
1	Negligible	The upgrade will not improve the existing road condition or the upgrade is within the ROW, where there will be no road rehabilitation during construction.

Tables 6.14 to 6.16 show the risk weight of each factor, the scores of each upgrade location and priority upgrade summary, respectively. The available fire flow impact is weighted the highest where the possibility of combining a road upgrade project with the water pipe upgrade is weighted the lowest. The overall score of each upgrade is found in Table 6.15 and the scores are arranged from highest to lowest to represent the upgrade priority as shown in Table 6.16. Upgrade 1 and 19 will be triggered by development. Though, Upgrade 1 is more critical since it improves existing fire flow deficiencies in an industrial area where the water distribution system can only currently provide approximately 56% of the required fire flow. Upgrade 19 is intended to provide system redundancy for the industrial area, therefore can be deferred until development occurs.

Table 6.14: Existing System Upgrades Risk Assessment – Criteria Ranking

Risk Criteria - Pairwise Comparison					Count	Weighting	Criteria Ranking		
	C.1	C.2	C.3	C.4			Rank	ID	Description
C.1	C.1	C.1	C.1	C.1	4	40.0%	1	C.1	Available Fire Flow Impact
C.2		C.2	C.2	C.2	3	30.0%	2	C.2	Existing Impact
C.3			C.3	C.3	2	20.0%	3	C.3	Generalized Pipe Condition
C.4				C.4	1	10.0%	4	C.4	Road Condition Upgrade Potential
Total					10	100.0%			

Table 6.15: Existing System Upgrades Risk Assessment – Risk Score

Upgrade No.	Name	Category	Length	Category Weighted Score: Existing Fire Flow Available Percentage	Existing Impact	Generalized Pipe Condition	Road Condition Upgrade Potential	Combined Weighted Score
1	59 Avenue and 62 Street	Fire Flow	419	1.60	1.20	0.20	0.50	3.50
2	60 Street between 50 and 51 Avenue	Fire Flow	138	2.00	0.30	0.60	0.30	3.20
3	51 Avenue between 55 and 55A Street	Fire Flow	93	2.00	0.90	0.20	0.40	3.50
4	54 Street between 51 and 52 Avenue	Fire Flow	225	2.00	0.90	0.80	0.30	4.00
5	51 Avenue W between 52 and 54 Street	Fire Flow	181	2.00	1.20	0.60	0.50	4.30
6	54 Street between 50 Avenue and 49 Avenue	Fire Flow	1377	1.60	0.60	0.20	0.20	2.60
7	53 Street between 48 and 49 Avenue	Fire Flow	192	2.00	0.30	1.00	0.30	3.60
8	52 Street between Dana's Door Service and 42 Avenue	Fire Flow	542	1.20	0.60	0.60	0.10	2.50
9	42 Avenue from 52 Street	Fire Flow	153	1.20	0.30	0.60	0.40	2.50
10	47 Avenue between 45 and 47 Street	Fire Flow	205	2.00	1.20	0.20	0.30	3.70
11	45 Street between 40 and 45 Avenue	Fire Flow	272	1.60	0.60	0.40	0.50	3.10
12	41 Street between Right Move Property Rentals & Storage and 37 Avenue	Fire Flow	201	0.40	0.30	0.40	0.50	1.60
13	39 Avenue ROW between 41 Street and Cenovus Energy Hub	Fire Flow	511	0.40	0.30	0.20	0.10	1.00
14	41 Street between 50 and 51 Avenue	Fire Flow	173	1.20	1.20	0.60	0.40	3.40
15	50 Avenue between 41 and 42 Street	Fire Flow	104	1.60	1.20	0.60	0.20	3.60
16	50 Avenue between 32 and 36 Street	Fire Flow	442	2.00	1.20	0.80	0.30	4.30
17	32 Street Between 49 and 50 Avenue	Fire Flow	110	2.00	1.50	0.20	0.50	4.20
18	50 Avenue between 27 and 31 Street	Fire Flow	226	2.00	1.20	0.80	0.30	4.30
19	99 Street between 52 Street and 62 Street	Fire Flow	1176	1.20	0.30	0.20	0.20	1.90
20	44 Street between 63 and 66 Avenue	Fire Flow	201	1.60	0.90	0.60	0.30	3.40
21	44 Street between 70 and 75 Avenue	Fire Flow	451	0.40	0.30	0.20	0.30	1.20
22	80 Avenue crossing 44 Street	Fire Flow	85	0.80	0.90	0.20	0.10	2.00

Table 6.16: Existing System Proposed Upgrades Priority

Priority	Upgrade No.	Name	Category	Length	Category Weighted Score				Combined Weighted Score
					Existing Fire Flow Available Percentage	Existing Impact	Generalized Pipe Condition	Road Condition Upgrade Potential	
1	5	51 Avenue W between 52 and 54 Street	Fire Flow	181	2.00	1.20	0.60	0.50	4.30
2	4	54 Street between 51 and 52 Avenue	Fire Flow	225	2.00	0.90	0.80	0.30	4.00
3	16	50 Avenue between 32 and 36 Street	Fire Flow	442	2.00	1.20	0.80	0.30	4.30
4	17	32 Street Between 49 and 50 Avenue	Fire Flow	110	2.00	1.50	0.20	0.50	4.20
5	18	50 Avenue between 27 and 31 Street	Fire Flow	226	2.00	1.20	0.80	0.30	4.30
6	10	47 Avenue between 45 and 47 Street	Fire Flow	205	2.00	1.20	0.20	0.30	3.70
7	7	53 Street between 48 and 49 Avenue	Fire Flow	192	2.00	0.30	1.00	0.30	3.60
8	15	50 Avenue between 41 and 42 Street	Fire Flow	104	1.60	1.20	0.60	0.20	3.60
9	1	59 Avenue and 62 Street	Fire Flow	419	1.60	1.20	0.20	0.50	3.50
10	3	51 Avenue between 55 and 55a Street	Fire Flow	93	2.00	0.90	0.20	0.40	3.50
11	14	41 Street between 50 and 51 Avenue	Fire Flow	173	1.20	1.20	0.60	0.40	3.40
12	20	44 Street between 63 and 66 Avenue	Fire Flow	201	1.60	0.90	0.60	0.30	3.40
13	2	60 Street between 50 and 51 Avenue	Fire Flow	138	2.00	0.30	0.60	0.30	3.20
14	11	45 Street between 40 and 45 Avenue	Fire Flow	272	1.60	0.60	0.40	0.50	3.10
15	6	54 Street between 50 Avenue and 49 Avenue	Fire Flow	1377	1.60	0.60	0.20	0.20	2.60
16	9	42 Avenue from 52 Street	Fire Flow	153	1.20	0.30	0.60	0.40	2.50
17	8	52 Street between Dana's Door Service and 42 Avenue	Fire Flow	542	1.20	0.60	0.60	0.10	2.50
18	22	80 Avenue crossing 44 Street	Fire Flow	85	0.80	0.90	0.20	0.10	2.00
19	19	99 Street between 52 Street and 62 Street	Fire Flow	1176	1.20	0.30	0.20	0.20	1.90
20	12	41 Street between Right Move Property Rentals & Storage and 37 Avenue	Fire Flow	201	0.40	0.30	0.40	0.50	1.60
21	21	44 Street between 70 and 75 Avenue	Fire Flow	451	0.40	0.30	0.20	0.30	1.20
22	13	39 Avenue ROW between 41 Street and Cenovus Energy Hub	Fire Flow	511	0.40	0.30	0.20	0.10	1.00

Note: Upgrade locations that are connected indicated by the green cells are shifted up.

6.9 Existing Water Distribution System Upgrades Cost Estimates

A summary of the costs associated with the recommended existing water distribution system upgrades are detailed below in Table 6.17. The list is ordered based on upgrade IDs, while priorities are included for reference. A full breakdown of the costs has been provided in Appendix B.

Table 6.17: Cost Estimates for Recommended Existing System Upgrades

Upgrade No.	Priority	Total Cost[1]
1	9	$900,000
2	13	$1,140,000
3	10	$240,000
4	2	$560,000
5	1	$460,000
6	15	$400,000
7	7	$480,000
8	17	$1,340,000
9	16	$380,000
10	6	$510,000
11	14	$580,000
12	20	$530,000
13	22	$1,150,000
14	11	$430,000
15	8	$270,000
16	3	$1,100,000
17	4	$280,000
18	5	$560,000
19	19	$1,620,000
20	12	$1,190,000
21	21	$1,400,000
22	18	$250,000
	Total	**$16,540,000**

1 The total cost has been rounded to the nearest $10,000 and includes a 30% contingency, as well as 15% for engineering.

7.0 Future Water System

7.1 Future System Concept Development

The proposed water distribution system is shown in Figure 7.1. A standard 300 mm grid network was generally assumed along or within the center of quarter section boundaries, supplemented with 400 mm and 500 mm watermains as needed to meet servicing requirements. The grid network is a baseline requirement, noting that the actual water distribution alignment can be tailored to each subdivision to follow the subdivision layout. The actual water distribution system alignment should be designed to avoid dead-end mains, following the general concept proposed in this WMP. The selected concept must be approved by the City prior to implementation.

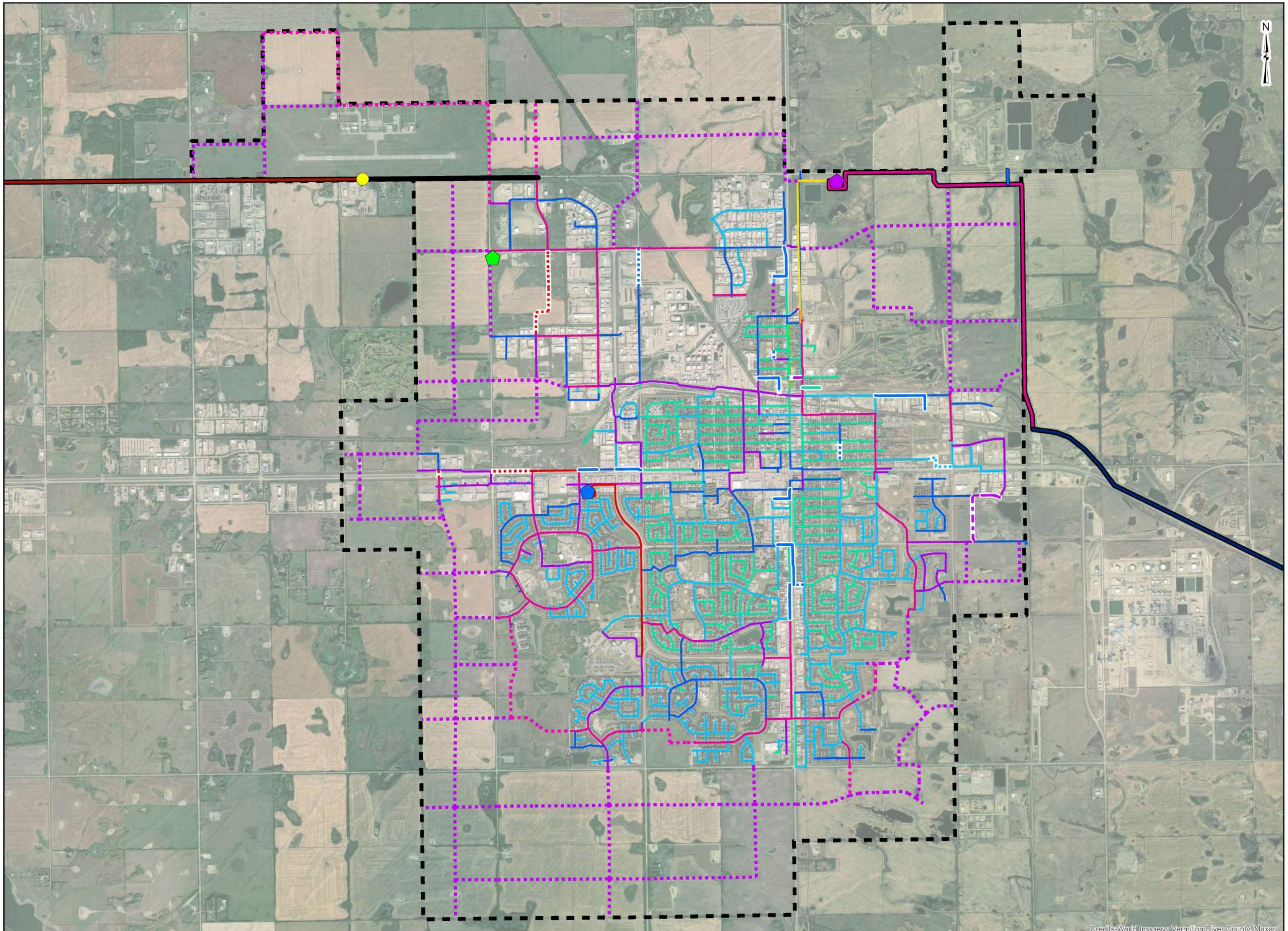
The servicing concept assumes that all existing water distribution system upgrades are implemented. Thus, it is recommended that these upgrades are completed prior to any substantial densification or future development.

The proposed watermains were connected to the City's existing water distribution network at key junctions. The looped water distribution system was only considered in quarter sections with residential or employment populations in the given growth scenario. That said, the Ultimate Boundary scenario provides a full overview of the distribution watermains necessary under all horizons, while the interim growth looping was limited to only specific quarter sections with those horizons. All proposed watermains have been assumed to be PVC, with a 'C' value of 140 to be reasonably conservative.

Each quarter section was further divided into smaller service areas to improve the spatial allocation of the demands in the model scenarios. Populations were evenly distributed between the service areas. Junctions were added at all corners and intersections of the service areas and at changes in ground slope to detail low and high points. Service areas were connected to the nearest junction in the model.

It is noted that Figure 7.1 shows the location of a new reservoir. This is an alternative to upgrades to the existing WER reservoir, if there are any space restrictions for new pumps or storage. That said, the existing WER was initially designed with provisions for Cell #3 and 4 to be installed on the north side. Piping is already installed within the pumphouse for the future cells and there is additional room for a fifth distribution pump. The new reservoir location would also help to increase redundancy throughout the system in the event of a failure at the WER or WTP. That said, assessments completed below assume upgrades to the WER, rather than implementation of a new reservoir.

Based on the current proposed system of only upgrading at the WER, servicing to the airport land located northwest of the City might not have the highest economic benefits due to the extensive amount of large diameter pipes needed so that the system meets standard requirements for fire flow for relatively small serviceable land. However, if the City ever considers building a new reservoir as an alternative to upgrading the WER reservoir, then the pipe system to service the airport land could be more economical.



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Existing Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Existing Pipe Upgrades

- Replace with 150 mm
- Upsize to 250 mm
- Upsize to 300 mm
- Loop with 200 mm
- Loop with 250 mm
- Loop with 400 mm
- Loop with 500 mm
- Twin with 300 mm

Proposed Future Pipe

- Proposed 300 mm
- Proposed 400 mm

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 7.1
FUTURE WATER SYSTEM CONCEPT
PIPE DIAMETER
LLOYDMINSTER WATER MASTER PLAN

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7.2 Future System Assessment

The future water distribution system was analyzed under four (4) different scenarios to determine system conditions. As mentioned in Section 3.1, these scenarios included:

- Steady State:
  - Average day demand (ADD);
  - Maximum daily demand (MDD); and
  - Peak hour demand (PHD);
- Steady State with Fire Flow Analysis:
  - Maximum day demand plus fire flow (MDD + FF); and
- Reservoir filled under ADD.

The system was also assessed for reservoir storage and pumping capacity under future demands.

Future water distribution system assessments generally analyze the full buildout of the water distribution system and determines the ultimate upgrades needed before considering the staging of the growth. The four (4) interim growth horizons discussed in Section 2.3 were analyzed in terms of infrastructure staging. All considered growth horizons are as follows:

- 3-Year Growth (2025) – Population of 34,651;
- 5-Year Growth (2027) – Population of 36,132;
- 10-Year Growth (2032) – Population of 41,148;
- 20-Year Growth (2042) – Population of 57,271; and
- Ultimate Boundary (2051) – Population of 67,149.

Table 7.1 summarizes the demands used for input in the ultimate and interim future water distribution system assessments.

Table 7.1: Future Water Distribution System Demands (Total)

Horizon	ADD			MDD			PHD		
	L/s	m^3	m^3/hr	L/s	m^3	m^3/hr	L/s	m^3	m^3/hr
Existing	114	9,847	410	228	19,694	821	342	29,541	1,231
3-Year	124	10,738	447	249	21,476	895	373	32,215	1,342
5-Year	133	11,452	477	265	22,905	954	398	34,357	1,432
10-Year	154	13,344	556	309	26,687	1,112	463	40,031	1,668
20-Year	214	18,477	770	428	36,954	1,540	642	55,430	2,310
Ultimate	262	22,625	943	524	45,250	1,885	786	67,875	2,828

7.2.1 Pressure Assessment

The highest and lowest pressures and locations at which these pressures occur are shown below in Table 7.2 for each of the assessment scenarios. Results for the ultimate future water distribution system assessments are shown in Figures 7.2 to 7.4 for the ADD, MDD, and PHD scenarios, respectively.

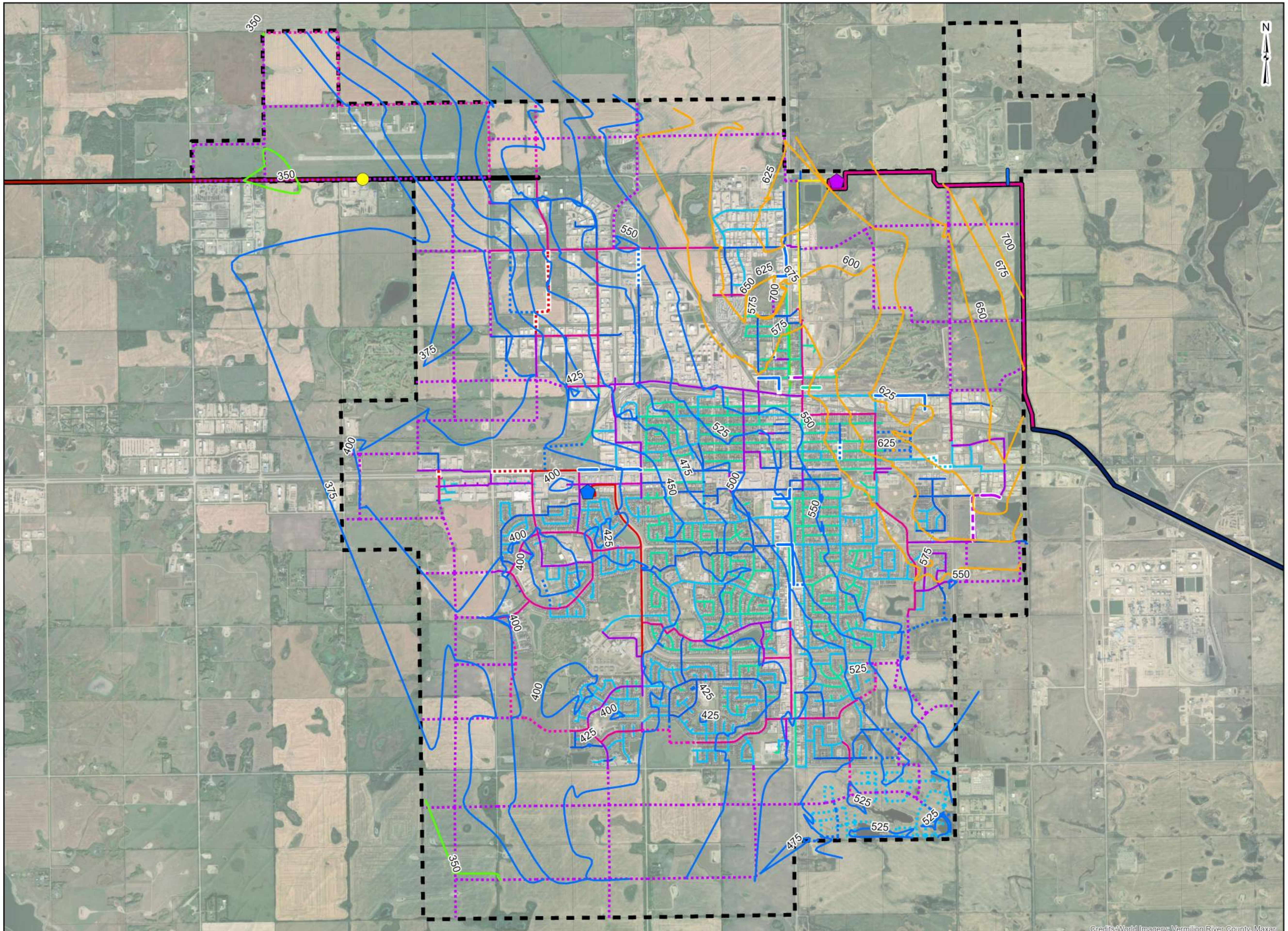
Table 7.2: Future System Pressure Ranges

Scenario	Highest Pressure		Location	Lowest Pressure		Location
	kPa	psi		kPa	psi	
3-Year Growth (2025)						
ADD	747.2	108	East of 40 Avenue along City owned SaskWater line	389.3	56	75 Avenue and 56 Street
MDD	744.6	108		326.9	47	
PHD	722.6	105		320.6	46	
5-Year Growth (2027)						
ADD	749.6	109	East of 40 Avenue along City owned SaskWater line	389.3	56	75 Avenue and 56 Street
MDD	742.6	108		327.8	48	
PHD	730.3	106		312.2	45	
10-Year Growth (2032)						
ADD	750.0	109	East of 40 Avenue along City owned SaskWater line	380.0	55	75 Avenue and 52 Street
MDD	742.8	108		323.5	47	
PHD	728.4	106		300.7	44	
20-Year Growth (2042)						
ADD	749.7	109	East of 40 Avenue along City owned SaskWater line	339.9	49	West of 75 Avenue and north of Township Road 494
MDD	743.1	108		326.6	47	
PHD	729.1	106		306.9	45	
Ultimate Boundary (2051)						
ADD	749.9	109	East of 40 Avenue along City owned SaskWater line	337.6	49	West of 75 Avenue and north of Township Road 494
MDD	750.3	109		307.6	45	
PHD	743.5	108		280.7	41	

There is a risk of high pressures along the SaskWater line, as it is fed directly by the WTP. The existing SaskWater line is a 450 mm C900 PVC DR25 pipe that can withstand the high system pressure; therefore, no upgrades are recommended at the SaskWater line. There is no concern with the low pressure within the system, as it is generally above 273 kPa in the PHD scenario. Pumping capacity will need to be increased during the 20-Year Growth Horizon to keep up with the growing demands. The above table assumes additional pumping capacity will be implemented before the 20-Year Growth Horizon.

7.2.2 Fire Flow Assessment

The fire flow assessment results are shown in Figure 7.5 for the Ultimate Boundary horizon. Fire flow contours are generally consistent in comparison to the existing system upgrades results. Apart from pumping upgrades, no additional upgrades are needed to meet the required fire flow.



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Existing Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Pipe Upgrades

- Replace with 150 mm
- Upsize to 250 mm
- Upsize to 300 mm
- Loop with 200 mm
- Loop with 250 mm
- Loop with 400 mm
- Loop with 500 mm
- Twin with 300 mm

Proposed Future Pipe

- Proposed 200 mm
- Proposed 250 mm
- Proposed 300 mm
- Proposed 400 mm
- Proposed 500 mm

Average Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 7.2
FUTURE PIPE SYSTEM
AVERAGE DAY DEMAND PRESSURE
LLOYDMINSTER WATER MASTER PLAN

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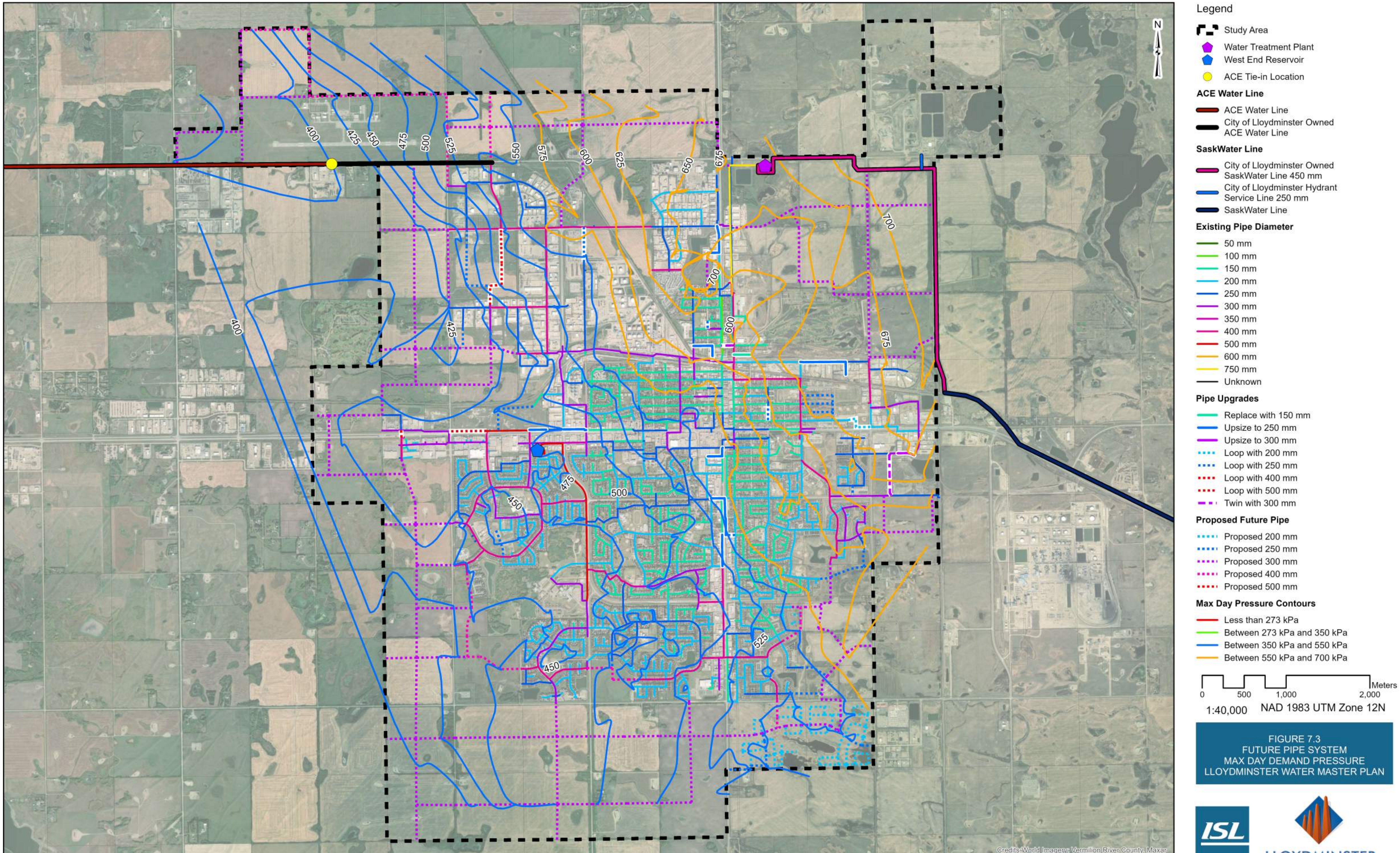

FIGURE 7.3
FUTURE PIPE SYSTEM
MAX DAY DEMAND PRESSURE
LLOYDMINSTER WATER MASTER PLAN

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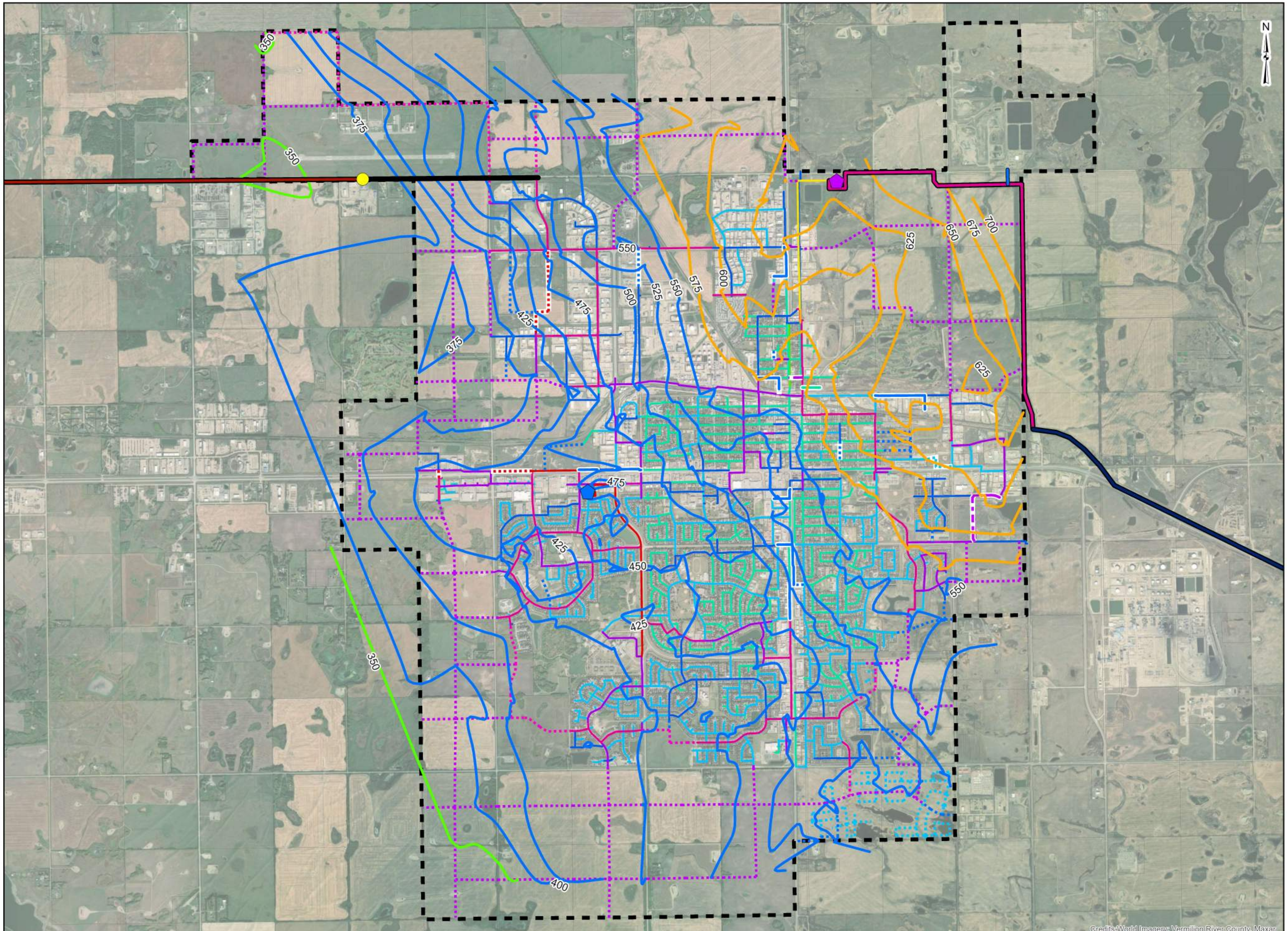

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Existing Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Pipe Upgrades

- Replace with 150 mm
- Upsize to 250 mm
- Upsize to 300 mm
- Loop with 200 mm
- Loop with 250 mm
- Loop with 400 mm
- Loop with 500 mm
- Twin with 300 mm

Proposed Future Pipe

- Proposed 200 mm
- Proposed 250 mm
- Proposed 300 mm
- Proposed 400 mm
- Proposed 500 mm

Peak Hour Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 7.4
FUTURE PIPE SYSTEM
PEAK HOUR DEMAND PRESSURE
LLOYDMINSTER WATER MASTER PLAN

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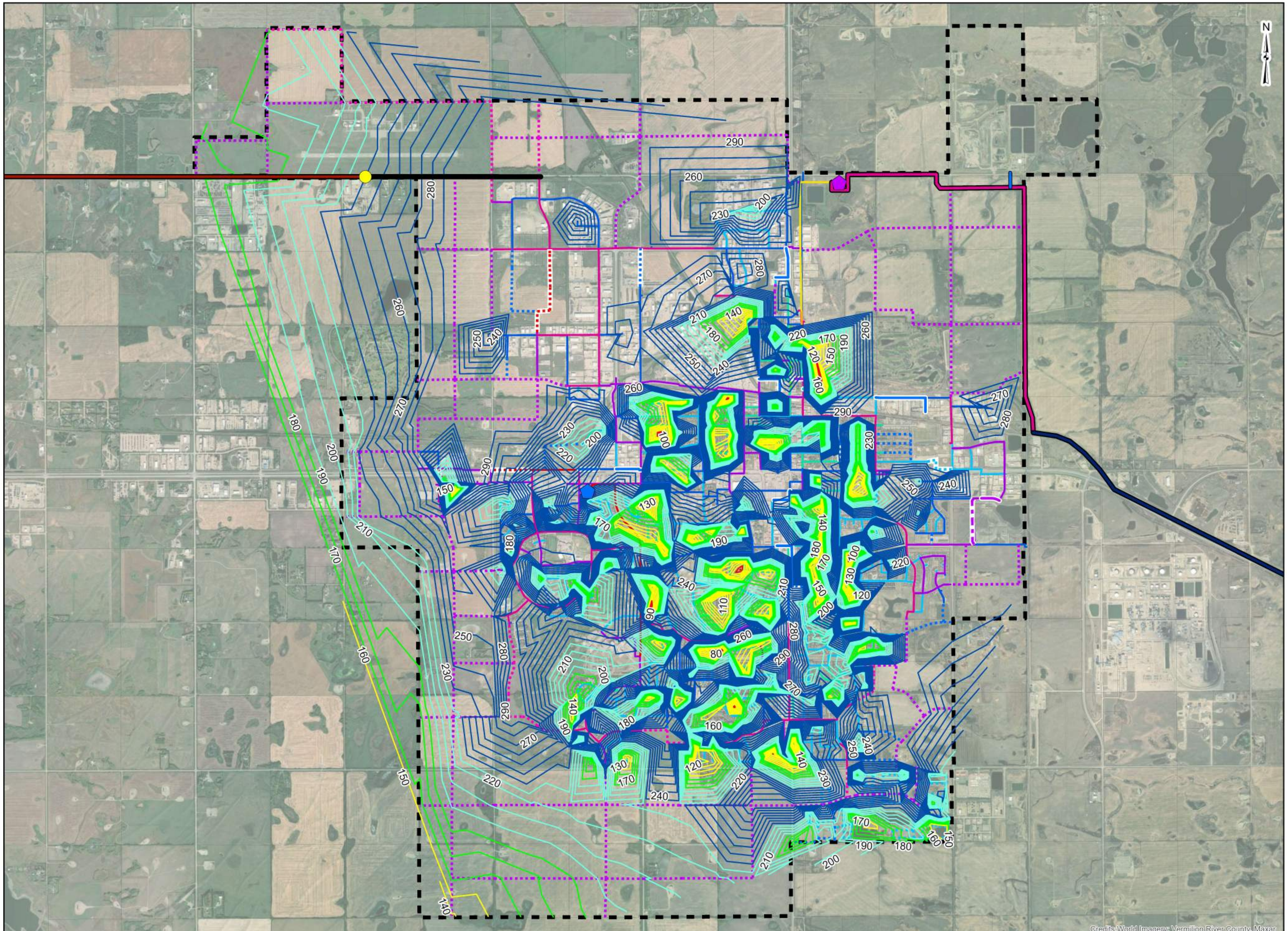

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Existing Pipe Diameter

- 50 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 350 mm
- 400 mm
- 500 mm
- 600 mm
- 750 mm
- Unknown

Pipe Upgrades

- Replace with 150 mm
- Upsize to 250 mm
- Upsize to 300 mm
- Loop with 200 mm
- Loop with 250 mm
- Loop with 400 mm
- Loop with 500 mm
- Twin with 300 mm

Proposed Future Pipe

- Proposed 200 mm
- Proposed 250 mm
- Proposed 300 mm
- Proposed 400 mm
- Proposed 500 mm

Fire Flow Contour

- Less than 100 L/s
- Between 100 and 150 L/s
- Between 150 and 185 L/s
- Between 185 and 225 L/s
- Between 225 and 300 L/s

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 7.5
FUTURE PIPE SYSTEM
MAX DAY DEMAND WITH FIRE FLOW
LLOYDMINSTER WATER MASTER PLAN

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7.2.3 Reservoir Capacity Assessment

The future reservoir capacity requirements per growth scenario are shown in Table 7.3. According to the AEPA standard, the existing storage capacity is sufficient for the Ultimate Boundary scenario. However, according to the SME standard, extra storage capacity will be required at and beyond the 10-year scenario.

Table 7.3: Future Storage Capacity Assessment

Parameter	Unit	Existing	3 Year	5 Year	10 Year	20 Year	Ultimate
ADD	m^3	9,847	10,738	11,452	13,344	18,477	22,625
MDD	m^3	19,694	21,476	22,905	26,687	36,954	45,250
Available Storage	m^3	24,796	24,796	24,796	24,796	24,796	24,796
Required Storage (AEPA)[2]	m^3	8,831	9,410	9,874	11,103	14,440	17,136
Meets Requirements?		Yes	Yes	Yes	Yes	Yes	Yes
Required Storage (SME)	m^3	19,694	21,476	22,905	26,687	36,954	45,250
Meets Requirements?		Yes	Yes	Yes	No	No	No
Additional Storage Needed	m^3	N/A	N/A	N/A	1,891	12,158	20,454

7.2.4 Pumping Capacity Assessment

The pumping requirements per growth scenario are shown in Table 7.4. The current pump capacity is sufficient for the development horizon up to the 20-year scenario. After the 20-year scenario, pumping capacity will need to be upgraded for the Ultimate Boundary scenario. Please note that the current pumping capacity represents the firm capacity of both the WTP and WER.

Table 7.4: Future Pumping Capacity Assessment

Parameter	Unit	Existing	3 Year	5 Year	10 Year	20 Year	Ultimate
ADD	L/s	114	124	133	154	214	262
	m^3/hr	410	448	477	556	770	943
MDD	L/s	228	249	265	309	428	524
	m^3/hr	821	895	955	1112	1540	1886
MDD + FF	L/s	453	474	490	534	653	749
	m^3/hr	1631	1705	1765	1922	2350	2696
PHD	L/s	342	373	398	463	642	738
	m^3/hr	1231	1343	1432	1668	2310	2656
Governing Pumping Capacity[1]	L/s	453	474	490	534	653	749
	m^3/hr	1631	1705	1765	1922	2350	2696
	L/s	552	552	552	552	552	552

Parameter	Unit	Existing	3 Year	5 Year	10 Year	20 Year	Ultimate
Current Pumping Capacity[2]	m^3/hr	1987	1987	1987	1987	1987	1987
Pumping Deficiency[3]	L/s	99	78	62	18	-101	-197
	m^3/hr	356	282	223	65	-363	-708

1 Governing pumping capacity was determined using the greater of the PHD and MDD + FF (MDD + 225 L/s).
2 Based on the current pumps' cumulative firm capacity.
3 Calculated by subtracting current pumping capacity with governing pump capacity, a positive value indicates no pumping deficiency.

7.2.5 Recommended Upgrades to Existing Infrastructure

The results from the model simulations indicate that the proposed concept performs well under average day demand, peak hour demand, and maximum day demand plus fire flow. Some pockets of higher pressure exist in the northeast due to the lower topography and proximity to the WTP. That said, pressures are mostly below 700 kPa except for a single modelled junction south of the City's WWTP where elevations are the lowest. High pressures in this area could be mitigated with localized PRVs or potential regrading of the area (in the order of 5 m).

Upgrades to the existing water distribution system in response to future growth are therefore limited to additional reservoir storage and pumping capacity required in the 10-Year and Ultimate Boundary Growth Horizons, respectively. As mentioned in Section 7.1, these upgrades can be completed at the WER since the existing WER was initially designed with provisions for Cell #3 and 4 to be installed on the north side. Piping is already installed within the pumphouse for the future cells and there is additional room for a fifth distribution pump. Proposed upgrades can also be in the form of a new reservoir and pump station as shown in Figure 7.1. The location of the new reservoir was identified by the City as the preferred location for a new reservoir, if needed. By ultimate build-out, an additional storage volume of roughly 20,500 m^3 and an additional pumping capacity of 200 L/s are required.

Based on the footprint that would be needed to accommodate the additional storage and the benefits for redundancy, it is recommended that the new reservoir and pump station facility is built. This could be phased into three (3) cells based on the additional storage requirements of 2,000 m^3, 12,000 m^3, and 20,500 m^3 in the 10-Year, 20-Year, and Ultimate Boundary Growth Horizons.

7.3 Future System Cost Estimates

The cost estimate summary for the servicing concept is summarized below in Table 7.5. For a detailed cost breakdown, please refer to Appendix B. The costs are stipulated for the pipes necessary for the proposed concept only. This also includes any additional pumping or reservoir capacity required to meet requirements of the Ultimate Boundary.

Table 7.5: Cost Estimates for Recommended Upgrades under Growth Conditions

Item	Total Cost[1, 2]
300 mm Watermain	$63,550,000
400 mm Watermain	$11,730,000
Reservoir Storage Capacity	$32,700,000
Pumping Capacity	$5,800,000
Total	**$113,780,000**

[1] Costs herein are comparable to other municipalities. Costs are representative of 2024 dollars.
[2] The total cost has been rounded to the nearest $10,000.

7.4 Staging of Servicing Concept

Staging of the servicing concept for the 3-, 5-, 10-, and 20-Year Growth Horizons are shown in Figures 7.6 to 7.9, respectively. Model servicing concept results for the 3-, 5-, 10-, and 20-Year Growth Horizons are shown in Appendix D.

The proposed servicing concept staging has been oversized to account for future development up to the Ultimate Boundary based on an approximate watermain service life of 60 years. Oversizing watermain upgrades for future scenarios is seen as more cost-effective, since the difference in pipe cost will be marginal compared to the costs of excavating and rehabilitating roadways multiple times. Oversizing watermains to account for the Ultimate Boundary may introduce operational and maintenance concerns, such as water stagnation due to lower velocities. It is worth noting that detailed design of watermain upgrades may wish to consider additional flushing programs or alternative upgrading concepts, such as staged infrastructure or interim smaller diameter watermains that would ultimately be twinned.

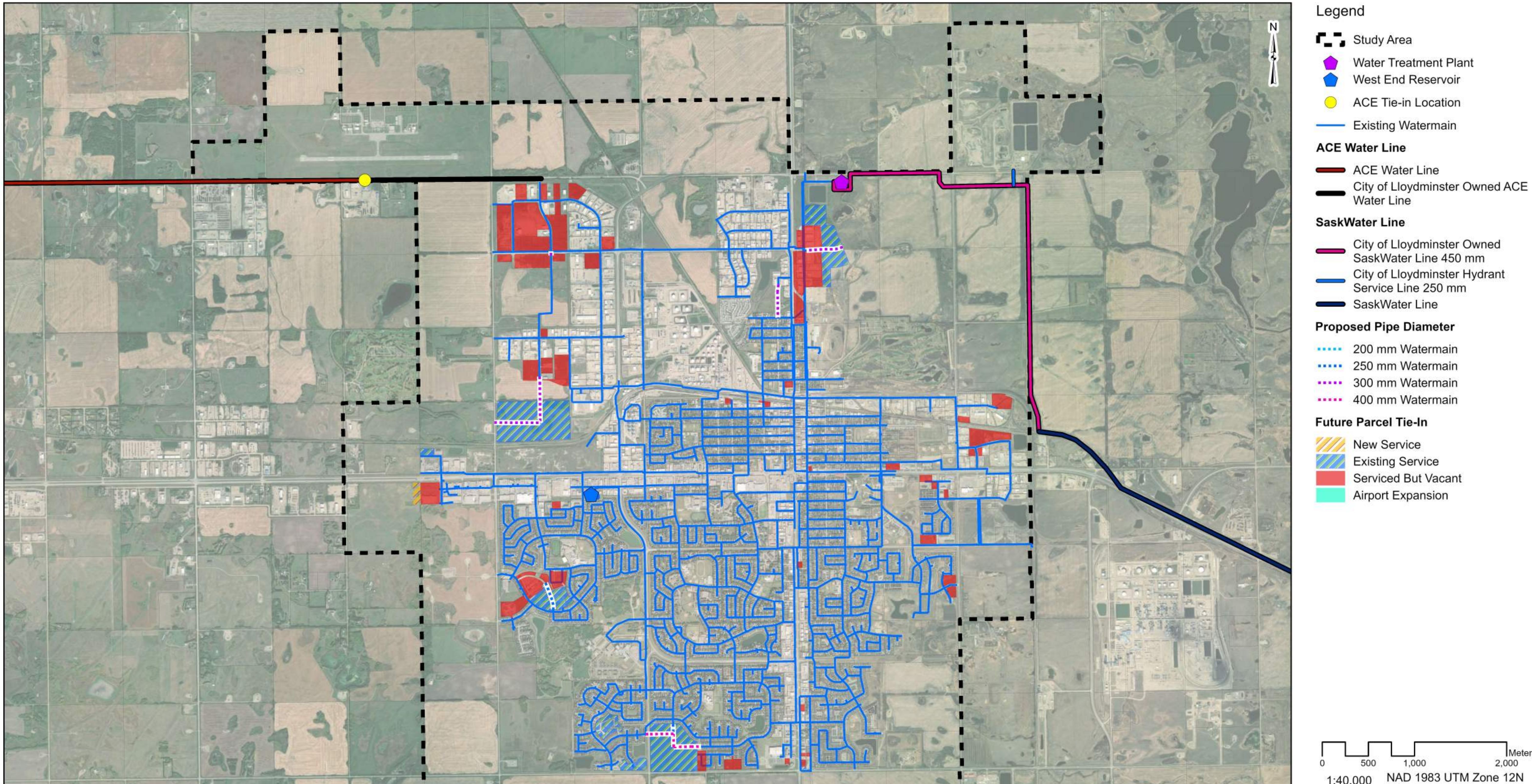

FIGURE 7.6
FUTURE SERVICING CONCEPT
3 YEAR STAGING PLAN
LLOYDMINSTER WATER MASTER PLAN

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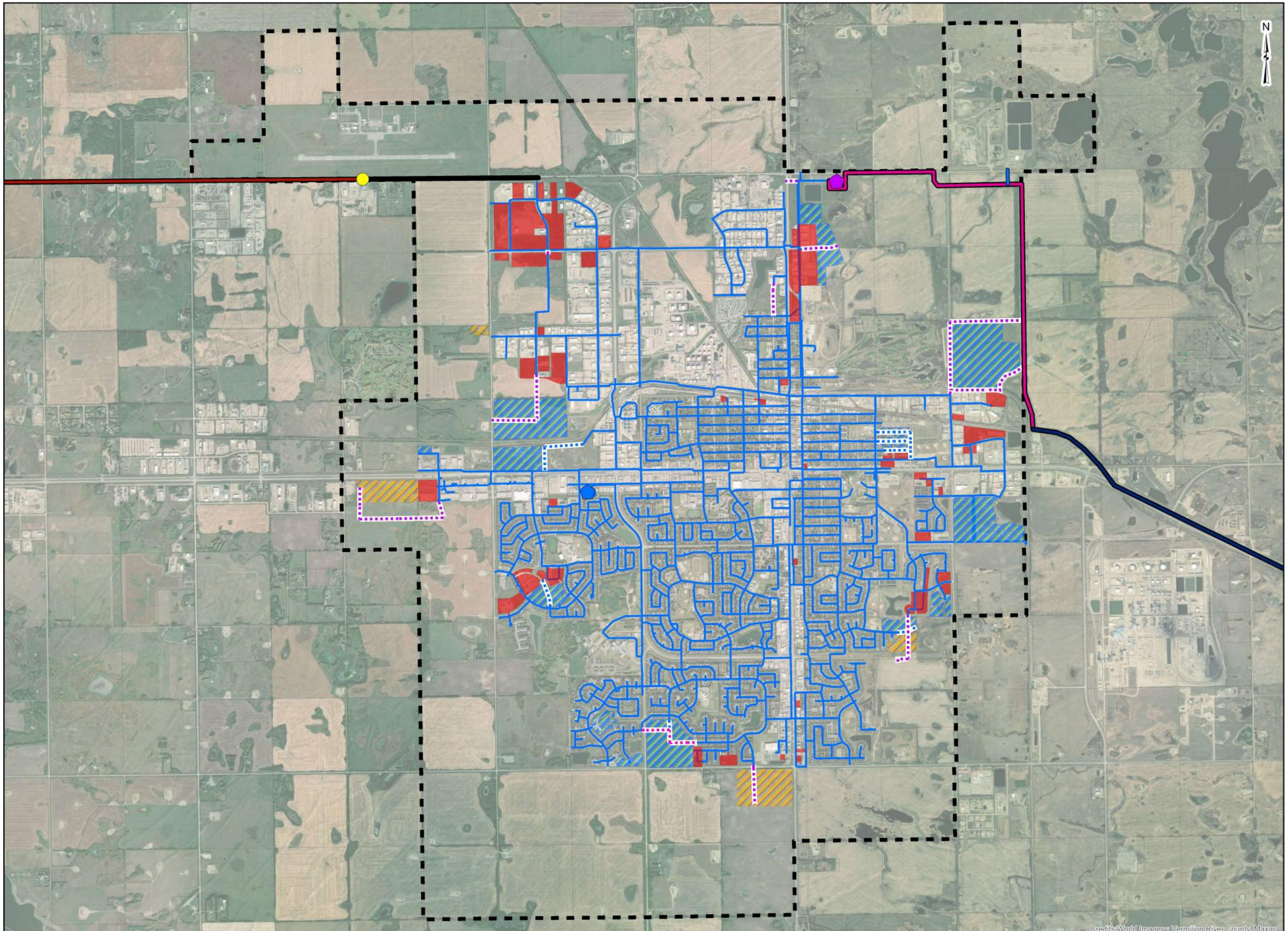

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 7.7
FUTURE SERVICING CONCEPT
5 YEAR STAGING PLAN
LLOYDMINSTER WATER MASTER PLAN

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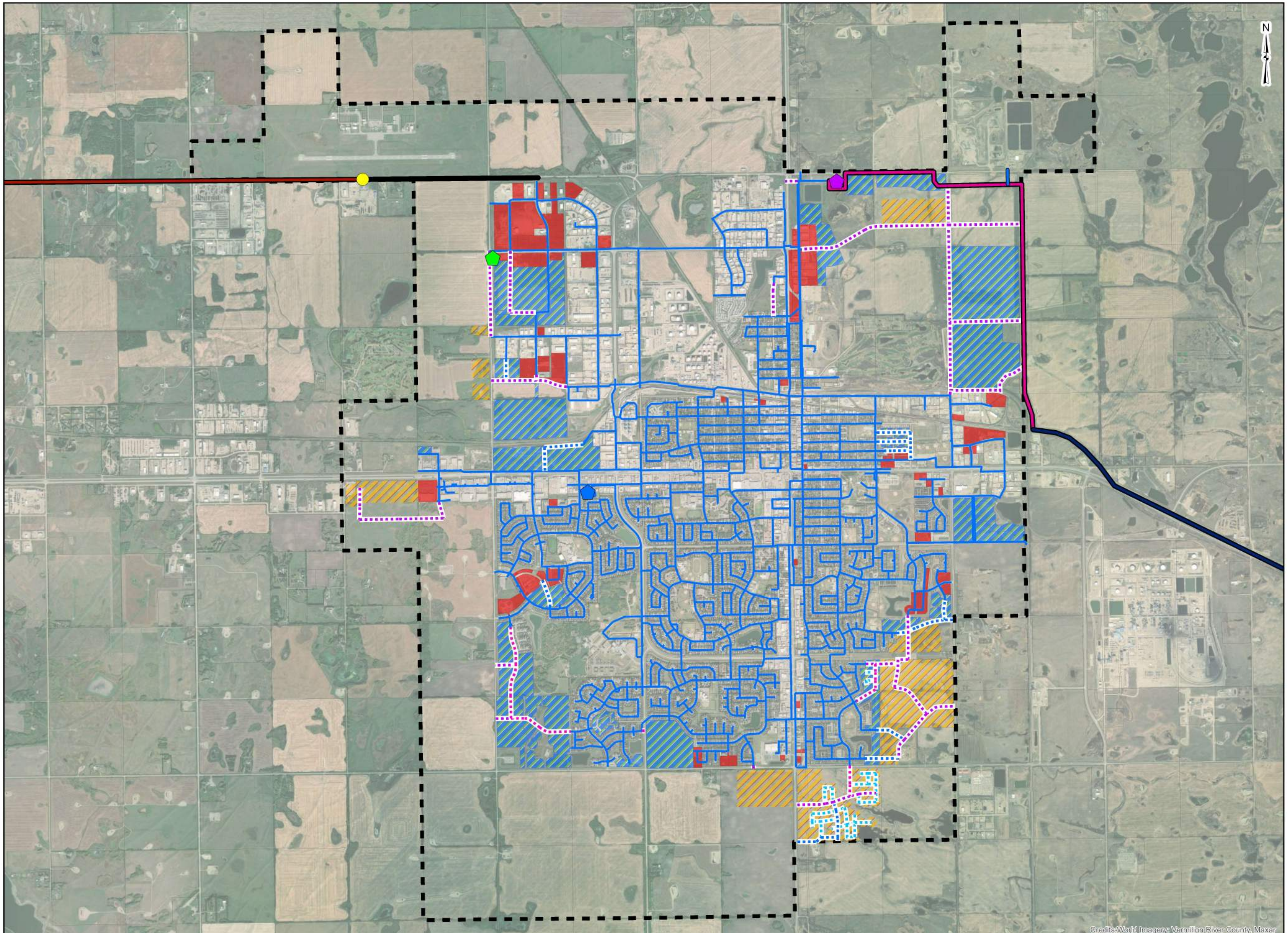

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 7.8
FUTURE SERVICING CONCEPT
10 YEAR STAGING PLAN
LLOYDMINSTER WATER MASTER PLAN

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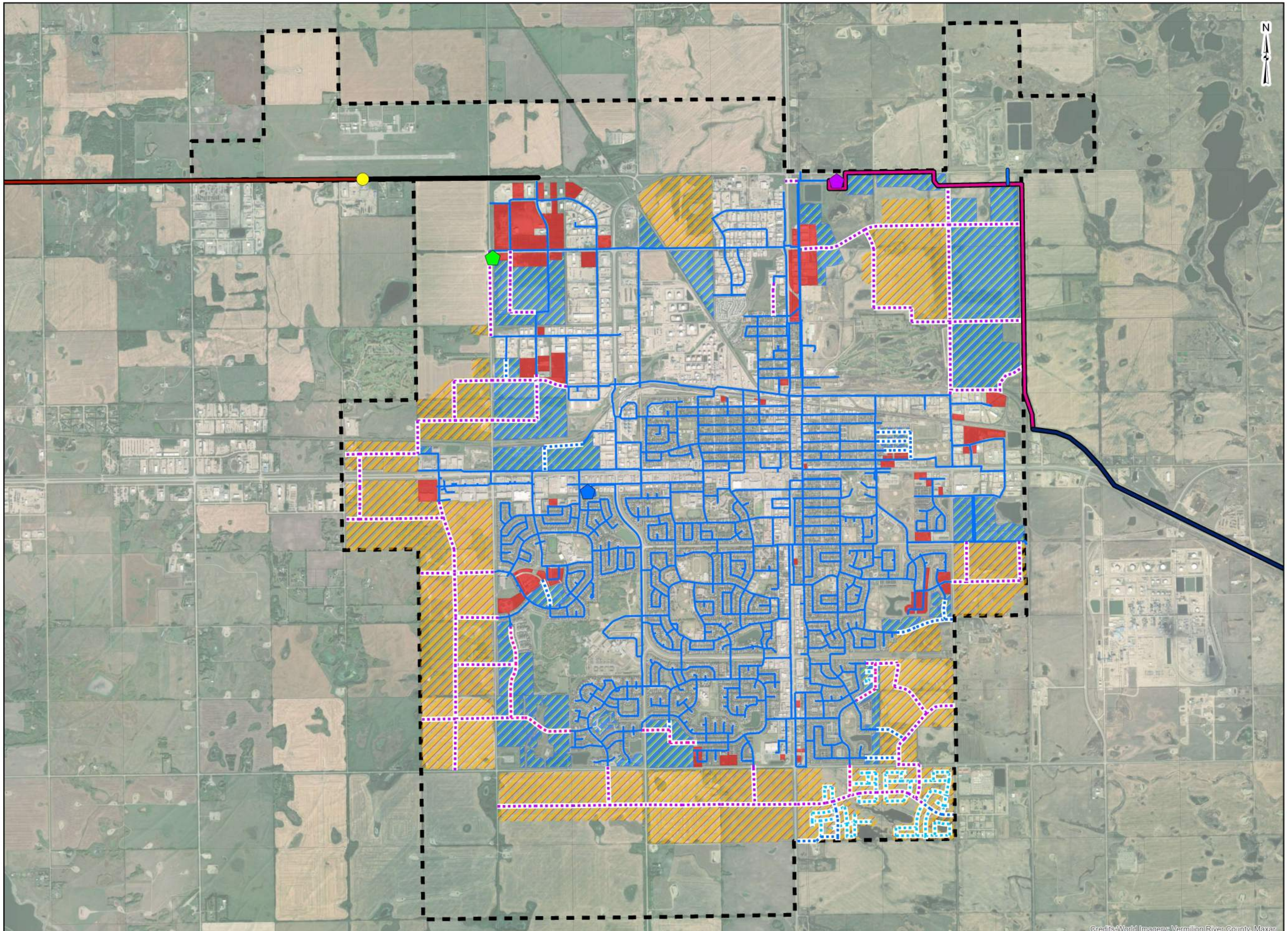

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 7.9
FUTURE SERVICING CONCEPT
20 YEAR STAGING PLAN
LLOYDMINSTER WATER MASTER PLAN

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8.0 Capital Plan

A Capital Plan staged to the Ultimate Boundary has been developed from the recommendations made by this WMP. An overview of the capital plan, including all upgrades required to the system by full build-out, the servicing scheme proposed, and the projected development horizon, are illustrated in Figure 8.1. The following should be considered when reviewing this information:

- A 2.0% inflation increase per year should be considered to the base costs;
- The annual capital budget allowance is meant to hold funding each year for maintenance and "one off" instances where repairs are required;
- The horizon in which the upgrade is suggested is based on discussion between the City and ISL on when development could occur based on a full build-out scenario; and
- High level cost estimates provided are a Class 4 with an accuracy of +75% to -40%.

To provide interim measures to ensure that areas of the City are growth ready, the following staging plan is recommended to align with the capital plan.

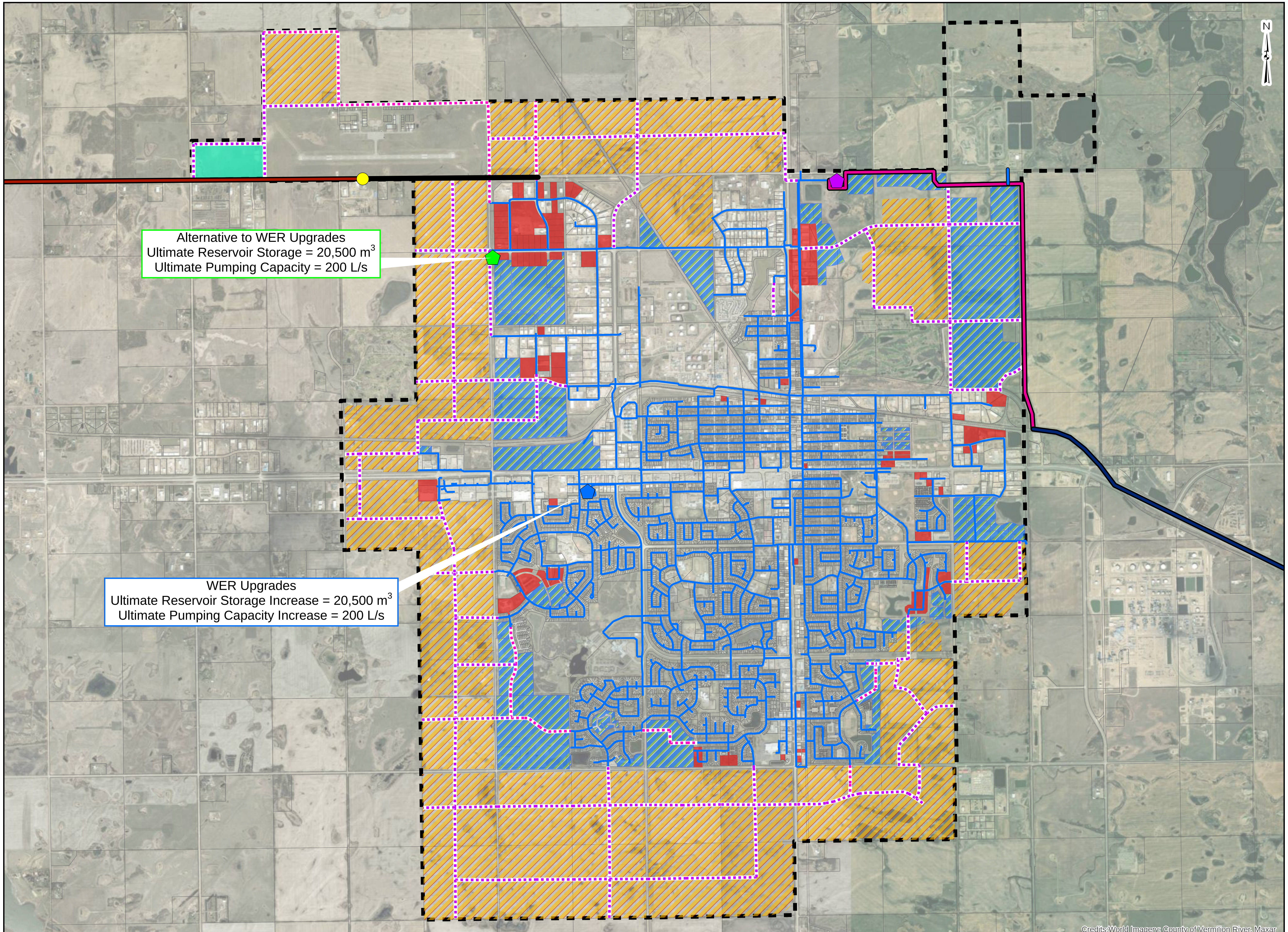
- Complete the capacity upgrades recommended to the existing system based on the priority noted in Table 6.16.
- Complete the condition upgrades recommended to the existing system based on the priority noted in Table 6.16. It is noted that upgrades to this infrastructure could also be completed in conjunction with the City's roadworks program to minimize costs.
- Conduct periodic hydrant testing programs to monitor system performance within certain neighbourhoods.
- Progress the future servicing concept as development proceeds, prioritizing infrastructure required to service development in the short-term.
- Begin implementation of the proposed reservoir storage in a three (3)-stage approach (10-Year, 20-Year, Ultimate Boundary).

This generalized staging plan is shown in relation to the triggered growth horizon in Figure 8.2 and in Table 8.1 below. Cost breakdowns per growth horizon are included in Appendix B. These recommended upgrades are being provided as a staging plan with the intent that the WMP will be integrated into an overall capital plan and budget. These upgrades are meant to align with the City's roadworks program; thus, they would be implemented in conjunction with the road upgrades to reduce capital costs.

Table 8.1: Capital Planning Horizons

ID	Type	Description	Cost
3 Years (2024 to 2027)			
EX UPG 1	Existing Fire Flow Upgrade	Loop with 250 mm on 59 Avenue between the dead-end of the watermain and 62 Street.	$900,000
EX UPG 2	Existing Fire Flow Upgrade	Upsize to 250 mm on 50 Avenue between 62 Street and 60 Street, and 60 Street between 50 Avenue Service Road and 51 Avenue.	$1,140,000
EX UPG 3	Existing Fire Flow Upgrade	Loop with 250 mm on 51 Avenue between 55 Street and 55A Street.	$240,000
EX UPG 4	Existing Fire Flow Upgrade	Upsize to 250 mm on 54 Street between 51 Avenue and 52 Avenue.	$560,000
EX UPG 5	Existing Fire Flow Upgrade	Upsize to 250 mm on 51 Avenue between 52 Street and 54 Street, crossing CP Rail.	$460,000
EX UPG 6	Existing Fire Flow Upgrade	Twin with 300 mm on 54 Street between 50 Avenue and 49 Avenue.	$400,000
EX UPG 7	Existing Fire Flow Upgrade	Upsize to 200 mm on 53 Street between 48 Avenue and 49 Avenue.	$480,000
EX UPG 8	Existing Fire Flow Upgrade	Upsize to 250 mm on 52 Street between 4409 52 Street and 42 Avenue.	$1,340,000
EX UPG 9	Existing Fire Flow Upgrade	Upsize to 250 mm on 42 Avenue from 52 Street to the dead-end of the watermain.	$380,000
EX UPG 10	Existing Fire Flow Upgrade	Loop with 250 mm on 47 Avenue between 45 Street and 47 Street.	$510,000
EX UPG 11	Existing Fire Flow Upgrade	Loop with 200 mm on 45 Street between 40 Avenue and 41 Avenue.	$580,000
EX UPG 12	Existing Fire Flow Upgrade	Upsize to 300 mm on 41 Street between 3804 41 Street and 37 Avenue.	$530,000
EX UPG 13	Existing Fire Flow Upgrade	Twin with 300 mm on 39 Avenue between 36 Street 41 Street.	$1,150,000
EX UPG 14	Existing Fire Flow Upgrade	Upsize to 250 mm on 41 Street between 50 Avenue and 51 Avenue.	$430,000
EX UPG 15	Existing Fire Flow Upgrade	Upsize to 250 mm on 50 Avenue between 41 Street and 42 Street.	$270,000
EX UPG 16	Existing Fire Flow Upgrade	Upsize to 250 mm on 50 Avenue between 32 Street and 36 Street	$1,100,000
EX UPG 17	Existing Fire Flow Upgrade	Loop with 250 mm on 32 Street Between 49 Avenue and 50 Avenue.	$280,000
EX UPG 18	Existing Fire Flow Upgrade	Upsize to 250 mm on 50 Avenue between 27 Street and 31 Street.	$560,000
EX UPG 19	Existing Fire Flow Upgrade	Loop with 400 mm on 75 Avenue between 57 Street and 62 Street.	$2,390,000
EX UPG 20	Existing Fire Flow Upgrade	Upsize to 250 mm on 44 Street between 63 Avenue and 66 Avenue.	$1,190,000
EX UPG 21	Existing Fire Flow Upgrade	Loop with 500 mm on 44 Street between 70 Avenue and 75 Avenue.	$1,400,000
EX UPG 22	Existing Fire Flow Upgrade	Loop with 400 mm on 80 Avenue crossing 44 Street.	$250,000
FUT SER 1	Future Servicing	Loop with 400 mm watermains in College Park.	$1,030,000
FUT SER 2	Future Servicing	Extend 300 mm watermains through Hill Industrial.	$1,130,000
FUT SER 3	Future Servicing	Loop with 300 mm watermains through Glenn E. Neilson Industrial Park.	$390,000
FUT SER 4	Future Servicing	Extend 300 mm watermains through North Industrial.	$430,000

ID	Type	Description	Cost
5 Years (2027 to 2029)			
FUT SER 5	Future Servicing	Extend 300 mm watermains through Sask Industrial.	$2,260,000
FUT SER 6	Future Servicing	Extend 300 mm watermains through the recently annexed area west of the West Commercial neighbourhood.	$1,550,000
FUT SER 7	Future Servicing	Extend 300 mm watermains through quarter section west of The Willows and south of College Park.	$470,000
FUT SER 8	Future Servicing	Extend 300 mm watermains south through Aurora and crossing into Wallacefield.	$690,000
FUT SER 9	Future Servicing	Extend 300 mm watermains west of the WTP into Glenn E. Neilson Industrial Park.	$150,000
10 Years (2029 to 2034)			
FUT SER 10	Future Servicing	Complete looping and extensions of 300 mm watermains through North Industrial and connecting into Sask Industrial.	$7,990,000
FUT SER 11	Future Servicing	Complete looping and extensions of 300 mm watermains in Hill Industrial.	$2,990,000
FUT SER 12	Future Servicing	Complete looping and extensions of 300 mm and 400 mm watermains in Lakeside, up north connecting into Parkview Estates.	$2,780,000
FUT SER 13	Future Servicing	Complete looping and extensions of 300 mm and 400 mm watermains in Wallacefield.	$2,910,000
FUT SER 14	Future Servicing	Extend 300 mm and 400 mm watermains in The Willows.	$1,420,000
FUT SER 15	Storage Capacity	Add ~1,900 m^3 of storage either at the WER or a new reservoir.	$3,040,000
20 Years (2034 to 2044)			
FUT SER 16	Future Servicing	Complete additional looping of 300 mm watermains through North Industrial.	$2,000,000
FUT SER 17	Future Servicing	Complete looping of 300 mm watermains through Wigfield Industrial.	$1,740,000
FUT SER 18	Future Servicing	Complete looping of 300 mm watermains in The Willows.	$1,310,000
FUT SER 19	Future Servicing	Complete looping and extensions of 300 mm watermains in the recently annexed area in the south.	$3,930,000
FUT SER 20	Future Servicing	Complete looping and extensions of 300 mm watermains in the recently annexed area in the west.	$5,610,000
FUT SER 21	Future Servicing	Complete looping and extensions of 300 mm watermains in the recently annexed area in the far west, west of West Commercial.	$3,560,000
FUT SER 22	Storage Capacity	Add ~10,300 m^3 of storage either at the WER or a new reservoir.	$16,430,000
FUT SER 23	Pumping Capacity	Add ~101 L/s (360 m^3/hr) of pumping capacity either at the WER or a new pump station.	$2,930,000
Ultimate (2044 to Full Build-out)			
FUT SER 24	Future Servicing	Complete looping of 300 mm and 400 mm watermains in the recently annexed areas in the north and west, near the airport.	$22,770,000
FUT SER 25	Future Servicing	Complete looping and extensions of 300 mm watermains in the recently annexed lands in the south.	$8,300,000
FUT SER 26	Storage Capacity	Add ~8,300 m^3 of storage either at the WER or a new reservoir.	$13,240,000
FUT SER 27	Pumping Capacity	Add ~99 L/s (360 m^3/hr) of pumping capacity either at the WER or a new pump station.	$2,880,000



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Future Pipe

- Proposed 300 mm
- Proposed 400 mm

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 8.1
CAPITAL PLAN OVERVIEW
LLOYDMINSTER WATER MASTER PLAN

ISL

LLOYDMINSTER

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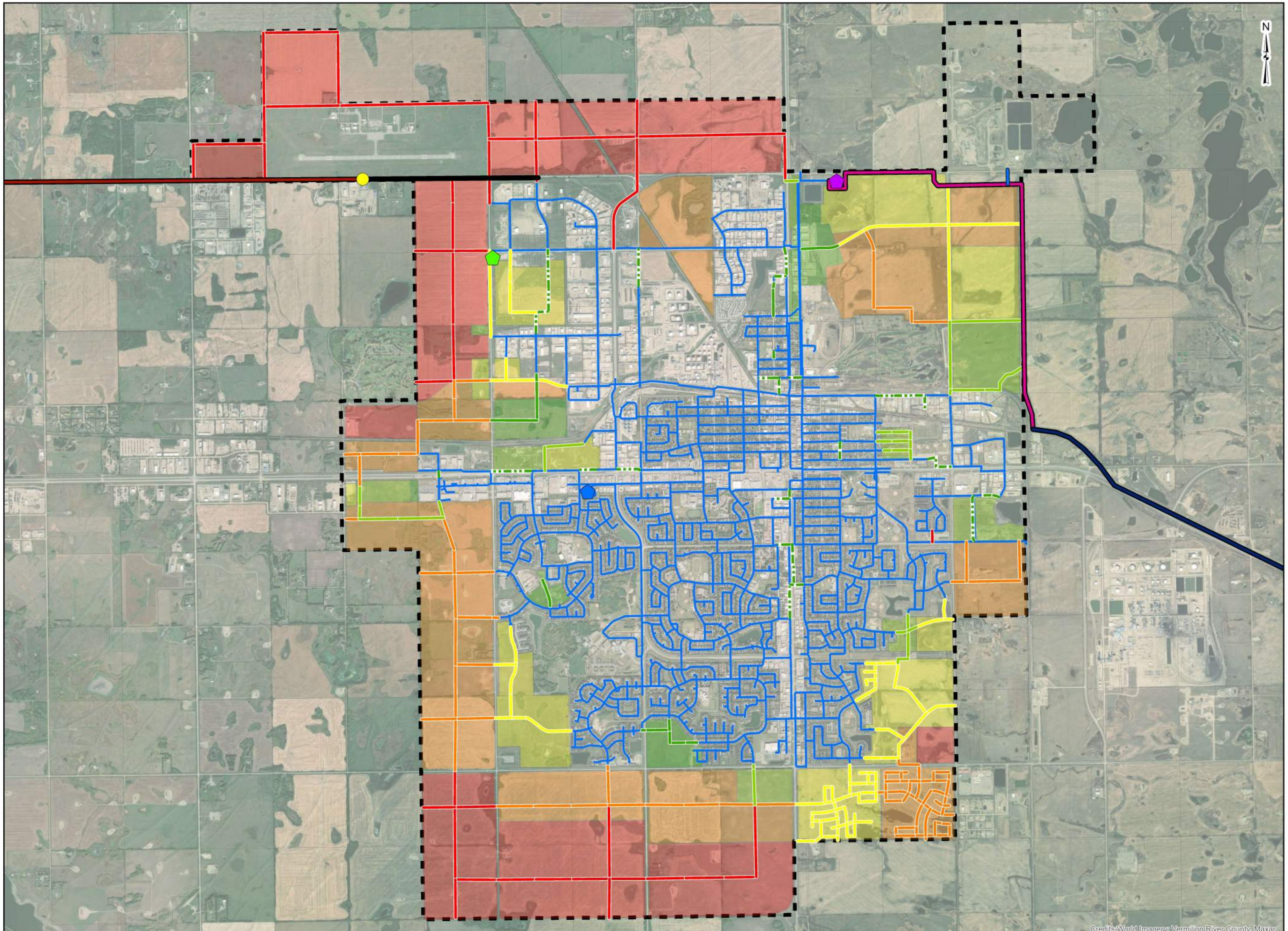

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Staging

- Existing Upgrades
- 3-Year Growth
- 5-Year Growth
- 10-Year Growth
- 20-Year Growth
- Ultimate Boundary

Development Timing

- 3-Years
- 5-Years
- 10-Years
- 20-Years
- Ultimate Boundary

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE 8.2
CAPITAL PLANNING HORIZONS
LLOYDMINSTER WATER MASTER PLAN

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Date: 7/25/2024 Document: C:\Users\nlai\OneDrive - ISL Engineering and Land Services\Desktop\28160_Lloyd WMP\Lloyd WMP.aprx

9.0 Conclusions and Recommendations

ISL was retained by the City to provide engineering services to generate an updated WMP. The WMP evaluated the current and future performance and capacity of the water infrastructure in the city, and assessed any additional servicing required to meet the needs of future populations.

Since the last update to the WMP in 2016, the City has undergone significant changes, including expansion through the 2022 Annexation Lands and various water system upgrades. These changes, along with the anticipated increase in water demands from annexation and population growth and the ongoing deterioration of the system, necessitate an updated WMP. This updated plan will help the City understand and manage the servicing implications of new developments, ensuring effective infrastructure improvements and future expansion while maintaining service levels for residents and businesses.

The purpose of the WMP is generally summarized below:

- Inventory and analyze existing infrastructure under current conditions;
- Calibrate the hydraulic model based on hydrant tests;
- Prepare capacity assessments of the current water distribution system using the calibrated model;
- Develop servicing plans for future growth considering servicing needs, annexed land locations, and community planning;
- Identify and recommend necessary upgrades based on condition and capacity assessments; and
- Provide a framework for future capital planning, including cost estimates and infrastructure staging.

Conclusions and recommendations from the updated WMP are provided in Sections 9.1 and 9.2 below for the water system.

9.1 Conclusions

Conclusions for the water distribution system are as follows:

- Locations with insufficient fire flow were identified and flagged in the existing water distribution system assessment, mainly due to aging infrastructures and long sections of single feed pipes;
- A risk assessment was undertaken to prioritize the capacity and condition upgrades recommended under existing water distribution system conditions; and
- Under Ultimate Boundary Growth conditions, the existing water distribution system was generally found to perform adequately:
  - Pumping capacity will need to be upgraded before the 20-Year Growth Horizon, storage capacity will need to be upgraded starting at the 10-Year Horizon;
  - There are areas that are experiencing high pressure and will need to be addressed;
  - The future network assumes all the recommended existing water upgrades are implemented; therefore, these upgrades should be completed prior to any substantial densification or future development; and
  - Hydraulic assessment of the proposed water distribution system is sufficient in managing demand generated from the future development areas given that all proposed upgrades are implemented.

9.2 Recommendations

Recommendations for the water distribution system are as follows:

- Prioritize upgrades to the existing water distribution system based on the order documented in Table 6.16;
- Continue condition assessments and flow monitoring and aligning infrastructure upgrades with development and roadworks programs to minimize costs;
- Proceed with staging of future developments based on the plan developed herein:
  - The future water distribution system should be designed based on the City's Municipal Development Standards (City of Lloydminster, 2020); and
  - The WMP should be reviewed and updated every five (5) years or after significant periods of growth. This ensures that the hydrodynamic model and analysis reflect any recent capital upgrades completed by the City and incorporate the latest growth plans. This could provide clarity on the planned location of development, the density of the proposed development, and the potential corresponding upgrades. This will ensure capacity is maintained and staging upgrades are advancing as needed.

10.0 References

Alberta Environment. 2012. Standards and Guidelines for Municipal Waterworks, Wastewater, and Storm Drainage Systems.

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National Research Council of Canada. 200. Detecting Leaks in Water-Distribution Pipes. Construction Technology Update No. 40.

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Saskatchewan Ministry of Environment Water Security Agency. 2013. Guidelines for Sewage Works Design EPB 203. Regina, Saskatchewan.

APPENDIX
Hydrant Test Report

A

Final Report for
ISL Engineering

Attn: **Sarah Barbosa, P.Eng., ENV SP**

Lloydminster, Alberta
Fire Hydrant Flow Testing
October 2022

Prepared and submitted by:

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October 14th, 2022

Sarah Barbosa, P. Eng., ENV SP
Lead, Municipal Infrastructure Planning

ISL Engineering
4015 – 7 St SE
Calgary, Alberta
T2G 2Y9

FINAL REPORT: A22-143 - Fire Hydrant Flow Testing, Llyodminster, Alberta

Dear Sarah Barbosa,

Please find enclosed SFE's Final Report for the above-mentioned project. If you have any questions, comments, or concerns, please do not hesitate to contact us at your earliest convenience.

Thank you for having SFE conduct this work on your behalf. We are appreciative of the opportunity to work with you and your team on this project. We look forward to working together again soon.

Sincerely,
SFE Global

Nick Schellenberg
Director of Operations
(780) 461-0171
Nick.Schellenberg@sfeglobal.com
www.sfeglobal.com

1. Executive Summary

This report provides details of the hydrant fire flow testing conducted in Llyodminster, Alberta. SFE Global was retained by ISL Engineering under the direction of Sarah Barbosa, P.Eng., ENV SP. Nick Schellenberg represented SFE Global as Project Manager during this project.

As requested, SFE conducted twelve (12) fire hydrant flow tests on October 6th, 2022. The flow hydrants and test hydrants were indicated to SFE by maps supplied by the client. The fire flow tests were conducted according to National Fire Protection Association (NFPA) 291 standards.

2. Summary of Testing

SFE Technicians met representatives of Lloydminster on-site to perform testing. The testing plan was discussed, and location maps reviewed by all participants.

Testing Equipment

Testing was performed on flow hydrants utilizing a Hydro Flow Product Hose Monster system with integral de-chlorinator. These are fixed pitot devices to measure flow, de-chlorinate and diffuse in one process. The benefit of this system is the ability to provide repeatable results and manage discharge water conditions.

The configuration for the Hose Monster System consisted of a four inch hose monster device. To digitally log system pressure SFE Technicians installed two (2) Telog HPR hydrant pressure loggers. The devices were set to ten second logging intervals and one second sampling intervals. Each interval logs the minimum, maximum and average pressure for that time stamp.

Testing Procedure

The client selected all flow and residual hydrants for each test. SFE Technicians installed flow testing equipment on each flow hydrant and residual pressure measurement equipment on the residual hydrant.

The tests were performed by recording system static pressure then flowing the hydrant until flow and pressure stabilized. Residual and pitot (flow) pressures were then obtained. Upon closure of the flow hydrant, static pressure was obtained. Total flow and extrapolated flow to 20 psi residual pressure are calculated with system under normal conditions and using system static pressure.

Flow testing summary sheets are included in Appendix I.

3. Data

The testing reports included in Appendix I contain all test results and photos. All pressure readings are in psi and all flow values are reported in IGPM. All hydrants were returned to as found condition upon completion of testing.

4. Safety

A pre-job safety inspection and meeting was conducted by SFE personnel, and the following potential hazards were identified:

- Need for Personal Protective Equipment
- Working with water under pressure
- Pedestrian and vehicular traffic conditions
- Safe operation and shut down of fire hydrants
- COVID-19 Precautions

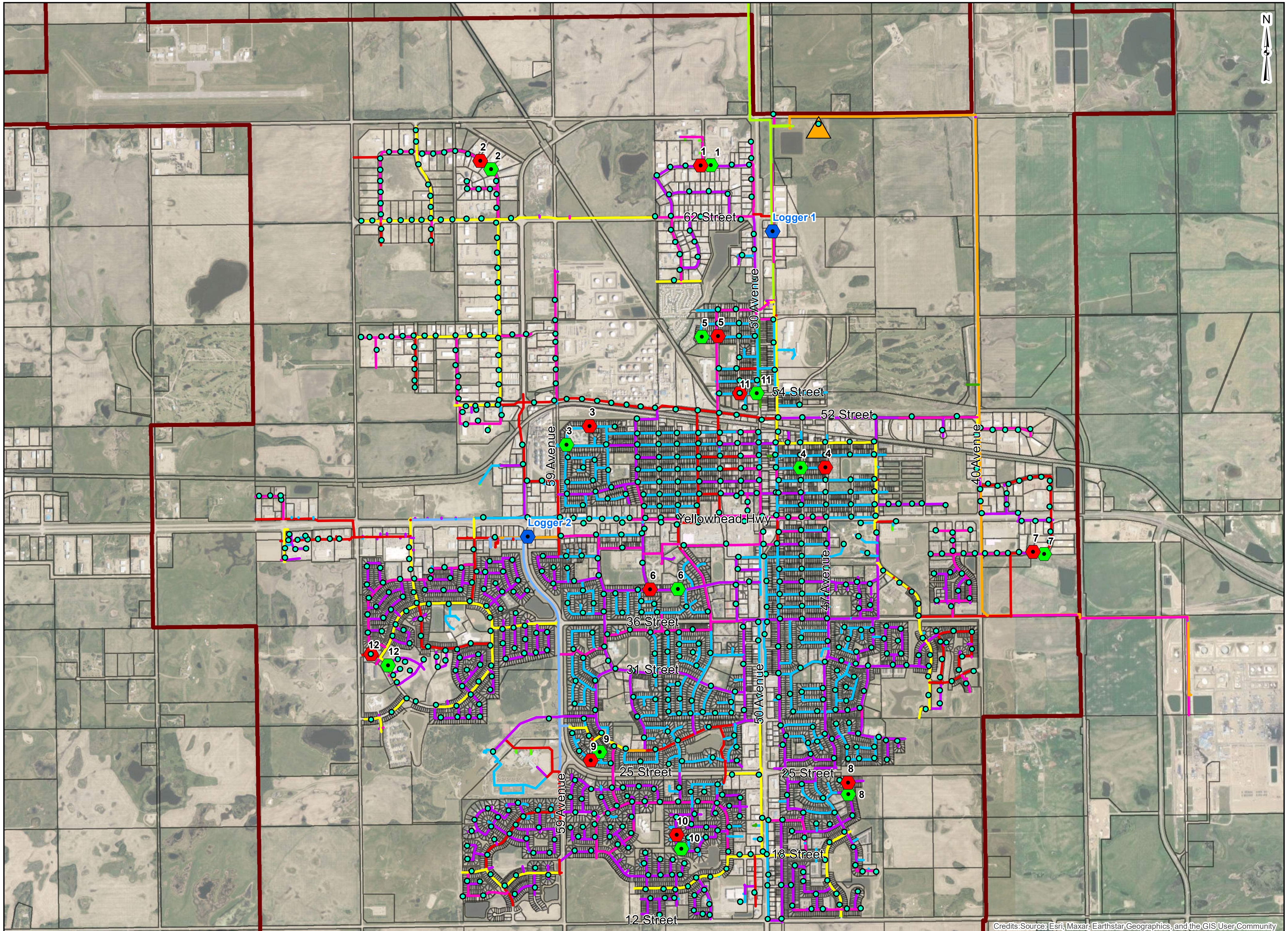
This project was conducted in accordance with the WCB and OSHA safety standards as documented in SFE's Safety Procedures Manual. The SFE crew reviewed the work to be completed and safety requirements at a tail-gate safety meeting held prior to commencing work.

Report End
October 2022

SFE Global
Project A22-143

Appendix I

Testing Map and Test Results



Legend

City Limit

Water Treatment Plant

Hydrant Test Locations

Hydrants

Residual Hydrant

Flow Hydrant

Logger

Watermain Diameter

100mm

150mm

200mm

250mm

300mm

350mm

400mm

500mm

750mm

0 375 750 1,500 Meters

1:29,500 NAD 1983 UTM Zone 12N

FIGURE 1
PROPOSED HYDRANT TEST LOCATIONS
CITY OF LLOYDMINSTER WATER
SYSTEM ASSESSMENT STUDY AND
MASTER PLAN

ISL

LLOYDMINSTER

Date: 2022-09-27 Document: Q:\Projects\28160_Lloyd_Water_Master_Plan\251_Figures\28114_Tests.mxd

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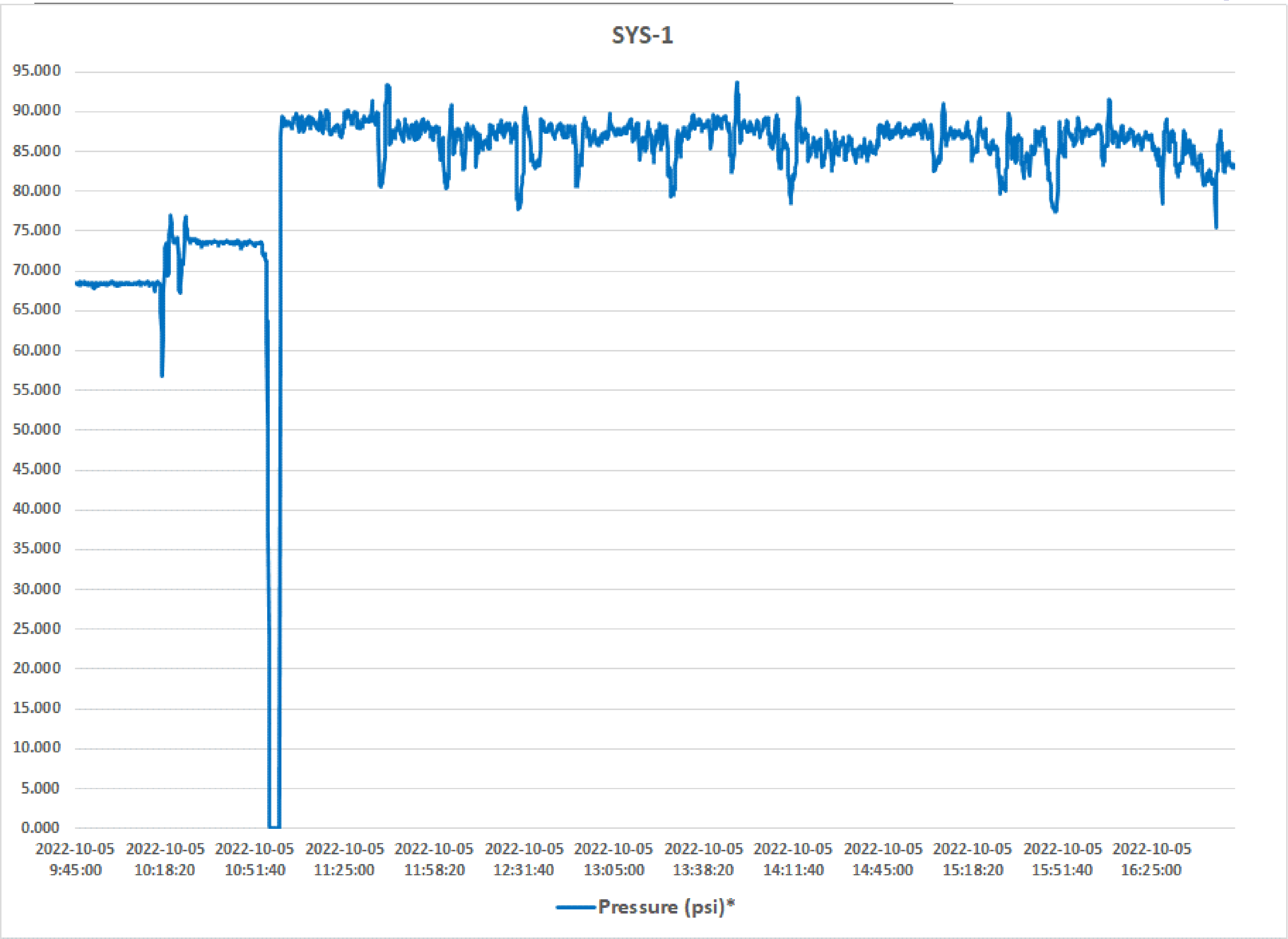
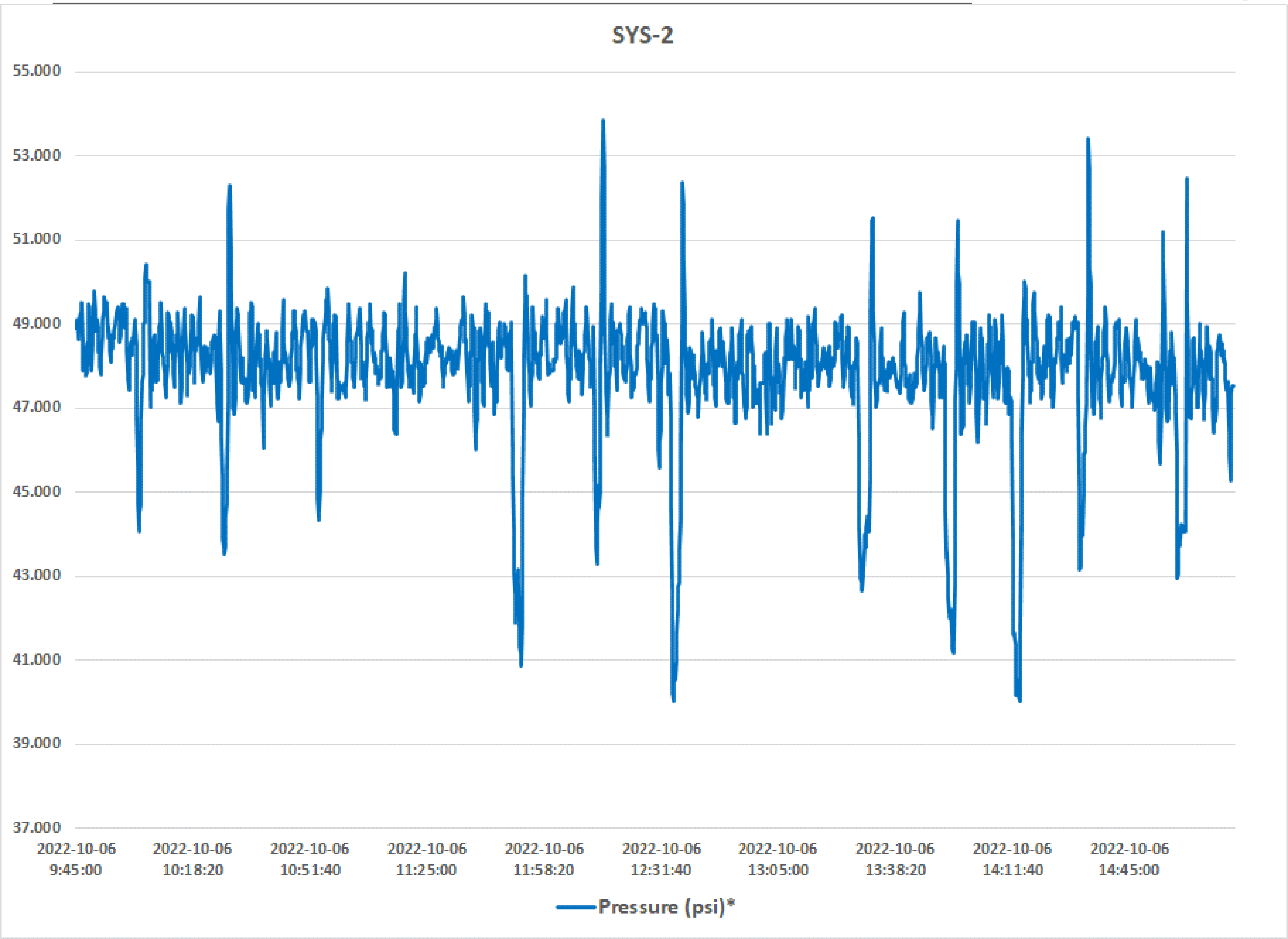
Final Report



Final Report



Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	N/A	Logger Address	49 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	N/A	Resid Hyd Addr.	N/A
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: System Logger 1 Test : N/A of N/A Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
9:25	15:20	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Flow Summary (igpm)	
Flow 1-1	0
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	0
Flow @ 20 psi	N/A

Notes:

System Logger Hydrant 1

GPS N53.2988 W-110.0036

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	N/A	Logger Address	43 St and 62 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	N/A	Resid Hyd Addr.	N/A
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: System Logger 2 Test : N/A of N/A Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
9:43	15:14	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Flow Summary (igpm)	
Flow 1-1	0
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	0
Flow @ 20 psi	N/A

Notes: Hydrant has loose operating nut

System Logger Hydrant 2

GPS N53.2769 W-110.0336

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	65 St and 52 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	65 St
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 1 | Test : 1 of 12 | Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
10:00	10:05	18	N/A	N/A	N/A	91	73	94

Flow Summary (igpm)	
Flow 1-1	1329
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1329
Flow @ 20 psi	2788

Notes: Flow hydrant: dark turbid flow on startup

Flow Hydrant

GPS N53.3036 W-110.0121

Residual Hydrant

GPS N53.3036 W-110.0109

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	63 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	63 Ave
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 2 | Test : 2 of 12 | Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
10:23	10:30	14	N/A	N/A	N/A	72	58	70

Flow Summary (igpm)	
Flow 1-1	1172
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1172
Flow @ 20 psi	2380

Notes: Flow hydrant: dark turbid flow on startup

Flow Hydrant

GPS N53.30422 W-110.0388

Residual Hydrant

GPS N53.30365 W-110.0375

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	52 Ave 56a St
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	56a St
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 5 Test : 3 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
10:51	10:57	17	N/A	N/A	N/A	84	68	85

Flow Summary (igpm)	
Flow 1-1	1291
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1291
Flow @ 20 psi	2729

Notes: Flow Hydrant: clean flow on startup, pumper port requires new gasket

Flow Hydrant

GPS N53.29126 W-110.0103

Residual Hydrant

GPS N53.29125 W-110.0123

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	54 St 51 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	54 S 50 Ave
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 11 Test : 4 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
11:13	11:19	8	N/A	N/A	N/A	82	29	81

Flow Summary (igpm)	
Flow 1-1	902
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	902
Flow @ 20 psi	982

Notes: Flow Hydrant: clean flow on startup

Flow Hydrant

GPS N53.28712 W-110.0078

Residual Hydrant

GPS N52.28712 W-110.0057

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	51 St
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	50 St
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 3   Test : 5 of 12   Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
11:48	11:53	14	N/A	N/A	N/A	66	54	66

Flow Summary (igpm)	
Flow 1-1	1172
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1172
Flow @ 20 psi	2421

Notes: Flow hydrant: clean flow on startup
First initial test with 2-1/2" pito start at 11:38, end at 11:42. Sized up to 4" pito

Flow Hydrant
GPS N53.28358 W-110.0288

Residual Hydrant
GPS N53.28491 W-110.0260

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	48 St and 47 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	48 St and 48 Ave
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 4 Test : 6 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
12:11	12:15	18	N/A	N/A	N/A	78	59	76

Flow Summary (igpm)	
Flow 1-1	1329
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1329
Flow @ 20 psi	2428

Notes: Flow hydrant: clean flow on startup

Flow Hydrant

GPS N53.28168 W-110.9976

Residual Hydrant

GPS N53.28169 W-110.0005

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	41 St
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	41 St and 37 Ave
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 7 | Test : 7 of 12 | Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
12:32	12:37	16	N/A	N/A	N/A	88	77	92

Flow Summary (igpm)	
Flow 1-1	1253
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1253
Flow @ 20 psi	3351

Notes: Flow Hydrant: clean flow on startup

Flow Hydrant

GPS N53.27534 W-110.9727

Residual Hydrant

GPS N53.27518 W-110.9714

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	39 St and 56 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	39 St
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 6 Test : 8 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
13:27	13:31	14	N/A	N/A	N/A	65	54	66

Flow Summary (igpm)	
Flow 1-1	1172
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1172
Flow @ 20 psi	2508

Notes: Flow hydrant: clean flow on startup

Flow Hydrant

GPS N53.27300 W-110.0190

Residual Hydrant

GPS N53.27300 W-110.0155

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	34 St		
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A		
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	72 Ave		
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**		
		Test Procedure	NFPA 291	(circle one)	Force On		

Test ID: Test 12 Test : 9 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
13:52	13:55	12	N/A	N/A	N/A	53	41	53

Flow Summary (igpm)	
Flow 1-1	1085
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1085
Flow @ 20 psi	1874

Notes: Flow hydrant: clean flow on startup

Flow Hydrant

GPS N53.26860 W-110.0527

Residual Hydrant

GPS N53.26807 W-110.0510

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	58 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	57b Ave
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 9 Test : 10 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
14:10	14:14	11	N/A	N/A	N/A	52	42	54

Flow Summary (igpm)	
Flow 1-1	1039
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1039
Flow @ 20 psi	1947

Notes: Flow hydrant: clean flow on startup

Flow Hydrant

GPS N53.26071 W-110.0264

Residual Hydrant

GPS N53.2613 W-110.0253

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	53 Ave
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	53 Ave
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	**Auto**
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 10 Test : 11 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
14:29	14:33	12	N/A	N/A	N/A	54	42	55

Flow Summary (igpm)	
Flow 1-1	1085
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1085
Flow @ 20 psi	1904

Notes: Flow hydrant: turbid light brown flow on startup

Flow Hydrant

GPS 53.25549 W-110.0162

Residual Hydrant

GPS N53.25421 W-110.0156

Fire Flow Test Report

Client Name:	ISL	Hyd 1 - #/Port Size	1-4"	Flow Hyd 1 Addr.	24 St
Project Location:	Lloydminster	Hyd 2 - #/Port Size	N/A	Flow Hyd 2 Addr.	N/A
SFE Project #:	A22-143	Hyd 1 - Pito Types	HM - 4"	Resid Hyd Addr.	23 St and 46 Ave
SFE Technicians:	NS/JS	Hyd 2 - Pito Types	N/A	Fire Pump Status	Auto
		Test Procedure	NFPA 291	(circle one)	Force On

Test ID: Test 8 Test : 12 of 12 Date: 6-Oct-22

		Flow Hyd 1		Flow Hyd 2		Residual Hydrant		
Start Time	End Time	Port 1-1 psi	Port 1-2 psi	Port 2-1 psi	Port 2-2 psi	Static psi	Residual psi	Static psi
14:57	15:02	11	N/A	N/A	N/A	66	41	66

Flow Summary (igpm)	
Flow 1-1	1039
Flow 1-2	0
Flow 2-1	0
Flow 2-2	0
Total Flow	1039
Flow @ 20 psi	1444

Notes: Flow hydrant: had to relocate, bushes/tress in front and around selected flow hydrant
Alternate flow hydrant: light brown turbid flow on startup

Flow Hydrant

GPS N53.25901 W-109.9964

Residual Hydrant

GPS N53.25800 W-109.9954

APPENDIX B
Detailed Cost Estimates

Table B.1: Existing System Fire Flow Upgrades Cost Estimates

Upgrade Number	Items	Location	Material	Quantity	Units	Unit Cost[1]	Sub-Total	Contingency (30%)	Engineering (15%)	Total Cost[2]
1	250mm Watermain	59 Avenue and 62 Street	PVC	419	Metres	$670	$280,730	$84,219	$42,110	$410,000
	Gravel Road Rehabilitation		N/A	419	Metres	$800	$335,200	$100,560	$50,280	$490,000
						EX Upgrade 1 Sub-Total:	**$615,930**	**$184,779**	**$92,390**	**$900,000**
2	250mm Watermain	60 Street between 50 and 51 Avenue	PVC	457	Metres	$670	$306,190	$91,857	$45,929	$450,000
	Pavement Rehabilitation		N/A	457	Metres	$1,030	$470,710	$141,213	$70,607	$690,000
						EX Upgrade 2 Sub-Total:	**$776,900**	**$233,070**	**$116,535**	**$1,140,000**
3	250mm Watermain	51 Avenue between 55 and 55a Street	PVC	93	Metres	$670	$62,310	$18,693	$9,347	$100,000
	Pavement Rehabilitation		N/A	93	Metres	$1,030	$95,790	$28,737	$14,369	$140,000
						EX Upgrade 3 Sub-Total:	**$158,100**	**$47,430**	**$23,715**	**$240,000**
4	250mm Watermain	54 Street between 51 and 52 Avenue	PVC	225	Metres	$670	$150,750	$45,225	$22,613	$220,000
	Pavement Rehabilitation		N/A	225	Metres	$1,030	$231,750	$69,525	$34,763	$340,000
						EX Upgrade 4 Sub-Total:	**$382,500**	**$114,750**	**$57,375**	**$560,000**
5	250mm Watermain	51 Avenue W between 52 and 54 Street	PVC	181	Metres	$670	$121,270	$36,381	$18,191	$180,000
	Pavement Rehabilitation		N/A	181	Metres	$1,030	$186,430	$55,929	$27,965	$280,000
						EX Upgrade 5 Sub-Total:	**$307,700**	**$92,310**	**$46,155**	**$460,000**
6	300mm Watermain	54 Street between 50 Avenue and 49 Avenue	PVC	150	Metres	$740	$111,000	$33,300	$16,650	$170,000
	Pavement Rehabilitation		N/A	150	Metres	$1,030	$154,500	$46,350	$23,175	$230,000
						EX Upgrade 6 Sub-Total:	**$265,500**	**$79,650**	**$39,825**	**$400,000**
7	200mm Watermain	53 Street between 48 and 49 Avenue	PVC	192	Metres	$650	$124,800	$37,440	$18,720	$190,000
	Pavement Rehabilitation		N/A	192	Metres	$1,030	$197,760	$59,328	$29,664	$290,000
						EX Upgrade 7 Sub-Total:	**$322,560**	**$96,768**	**$48,384**	**$480,000**
8	250mm Watermain	52 Street between 4409 525 Street and 42 Avenue	PVC	542	Metres	$670	$363,140	$108,942	$54,471	$530,000
	Pavement Rehabilitation		N/A	542	Metres	$1,030	$558,260	$167,478	$83,739	$810,000
						EX Upgrade 8 Sub-Total:	**$921,400**	**$276,420**	**$138,210**	**$1,340,000**
9	250mm Watermain	42 Avenue from 52 Street	PVC	153	Metres	$670	$102,510	$30,753	$15,377	$150,000
	Pavement Rehabilitation		N/A	153	Metres	$1,030	$157,590	$47,277	$23,639	$230,000
						EX Upgrade 9 Sub-Total:	**$260,100**	**$78,030**	**$39,015**	**$380,000**
10	250mm Watermain	47 Avenue between 45 and 47 Street	PVC	205	Metres	$670	$137,350	$41,205	$20,603	$200,000
	Pavement Rehabilitation		N/A	205	Metres	$1,030	$211,150	$63,345	$31,673	$310,000
						EX Upgrade 10 Sub-Total:	**$348,500**	**$104,550**	**$52,275**	**$510,000**
11	200mm Watermain	45 Street between 40 and 45 Avenue	PVC	272	Metres	$650	$176,800	$53,040	$26,520	$260,000
	Gravel Road Rehabilitation		N/A	272	Metres	$800	$217,600	$65,280	$32,640	$320,000
						EX Upgrade 11 Sub-Total:	**$394,400**	**$118,320**	**$59,160**	**$580,000**
12	300mm Watermain	41 Street between 3804 41 Street and 37 Avenue	PVC	201	Metres	$740	$148,740	$44,622	$22,311	$220,000
	Pavement Rehabilitation		N/A	201	Metres	$1,030	$207,030	$62,109	$31,055	$310,000
						EX Upgrade 12 Sub-Total:	**$355,770**	**$106,731**	**$53,366**	**$530,000**
13	300mm Watermain	39 Avenue ROW between 41 Street and Cenovus Energy Hub	PVC	511	Metres	$740	$378,140	$113,442	$56,721	$550,000
	Gravel Road Rehabilitation		N/A	511	Metres	$800	$408,800	$122,640	$61,320	$600,000
						EX Upgrade 13 Sub-Total:	**$786,940**	**$236,082**	**$118,041**	**$1,150,000**
14	250mm Watermain	41 Street between 50 and 51 Avenue	PVC	173	Metres	$670	$115,910	$34,773	$17,387	$170,000
	Pavement Rehabilitation		N/A	173	Metres	$1,030	$178,190	$53,457	$26,729	$260,000
						EX Upgrade 14 Sub-Total:	**$294,100**	**$88,230**	**$44,115**	**$430,000**
15	250mm Watermain	50 Avenue between 41 and 42 Street	PVC	104	Metres	$670	$69,680	$20,904	$10,452	$110,000
	Pavement Rehabilitation		N/A	104	Metres	$1,030	$107,120	$32,136	$16,068	$160,000
						EX Upgrade 15 Sub-Total:	**$176,800**	**$53,040**	**$26,520**	**$270,000**
16	250mm Watermain	50 Avenue between 32 and 36 Street	PVC	442	Metres	$670	$296,140	$88,842	$44,421	$430,000
	Pavement Rehabilitation		N/A	442	Metres	$1,030	$455,260	$136,578	$68,289	$670,000
						EX Upgrade 16 Sub-Total:	**$751,400**	**$225,420**	**$112,710**	**$1,100,000**
17	250mm Watermain	32 Street Between 49 and 50 Avenue	PVC	110	Metres	$670	$73,700	$22,110	$11,055	$110,000
	Pavement Rehabilitation		N/A	110	Metres	$1,030	$113,300	$33,990	$16,995	$170,000
						EX Upgrade 17 Sub-Total:	**$187,000**	**$56,100**	**$28,050**	**$280,000**
18	250mm Watermain	50 Avenue between 27 and 31 Street	PVC	226	Metres	$670	$151,420	$45,426	$22,713	$220,000
	Pavement Rehabilitation		N/A	226	Metres	$1,030	$232,780	$69,834	$34,917	$340,000
						EX Upgrade 18 Sub-Total:	**$384,200**	**$115,260**	**$57,630**	**$560,000**
19	400mm Watermain	99 Street between 52 Street and 62 Street	PVC	1,176	Metres	$950	$1,117,200	$335,160	$167,580	$1,620,000
	Asphalt Pavement Rehabilitation		N/A	0	Metres	$800	$0	$0	$0	$0
						EX Upgrade 19 Sub-Total:	**$1,117,200**	**$335,160**	**$167,580**	**$1,620,000**
20	250mm Watermain	44 Street between 63 and 66 Avenue	PVC	476	Metres	$670	$318,920	$95,676	$47,838	$470,000
	Pavement Rehabilitation		N/A	476	Metres	$1,030	$490,280	$147,084	$73,542	$720,000
						EX Upgrade 20 Sub-Total:	**$809,200**	**$242,760**	**$121,380**	**$1,190,000**
21	500mm Watermain	44 Street between 70 and 75 Avenue	PVC	451	Metres	$1,090	$491,590	$147,477	$73,739	$720,000
	Pavement Rehabilitation		N/A	451	Metres	$1,030	$464,530	$139,359	$69,680	$680,000
						EX Upgrade 21 Sub-Total:	**$956,120**	**$286,836**	**$143,418**	**$1,400,000**
22	400mm Watermain	80 Avenue crossing 44 Street	PVC	85	Metres	$950	$80,750	$24,225	$12,113	$120,000
	Pavement Rehabilitation		N/A	85	Metres	$1,030	$87,550	$26,265	$13,133	$130,000
						EX Upgrade 22 Sub-Total:	**$168,300**	**$50,490**	**$25,245**	**$250,000**
						Existing System Upgrade Total:	**$10,750,000**	**$3,230,000**	**$1,620,000**	**$15,770,000**

[1]Costs herein are comparable to other municipalities. Costs are representative of 2024 dollars.

[2]The total cost has been rounded to the nearest $10,000.

Table B.2: Cost Estimates for Future Servicing Overview

Item	Material	Quantity	Units	Unit Cost[1]	Sub-Total	Contingency (30%)	Engineering (15%)	Total Cost[2]
300mm Watermain	PVC	59,218	Metres	$740	$43,821,320	$13,146,396	$6,573,198	$63,550,000
400mm Watermain	PVC	6,637	Metres	$950	$6,305,150	$1,891,545	$945,773	$9,150,000
Reservoir Storage Capacity	-	20,454	Cubic Metres	$1,100	$22,499,400	$6,749,820	$3,374,910	$32,630,000
Pumping Capacity	-	197	Litres per Second	$20,000	$3,940,000	$1,182,000	$591,000	$5,720,000
				Total	**$76,565,870**	**$22,969,761**	**$11,484,881**	**$111,050,000**

[1]Costs herein are comparable to other municipalities. Costs are representative of 2024 dollars.

[2]The total cost has been rounded to the nearest $10,000.

Table B.3: Cost Estimates for Capital Planning

Horizon	ID	Item	Material	Quantity	Units	Unit Cost[1]	Sub-Total	Contingency (30%)	Engineering (15%)	Total Cost[2]
3-Year	FUT SER 1	400mm Watermain	PVC	741	Metres	$950	$703,950	$211,185	$105,593	$1,030,000
						Total Cost:	**$703,950**	**$211,185**	**$105,593**	**$1,030,000**
	FUT SER 2	300mm Watermain	PVC	1,047	Metres	$740	$774,780	$232,434	$116,217	$1,130,000
						Total Cost:	**$774,780**	**$232,434**	**$116,217**	**$1,130,000**
	FUT SER 3	300mm Watermain	PVC	360	Metres	$740	$266,400	$79,920	$39,960	$390,000
						Total Cost:	**$266,400**	**$79,920**	**$39,960**	**$390,000**
	FUT SER 4	300mm Watermain	PVC	396	Metres	$740	$293,040	$87,912	$43,956	$430,000
						Total Cost:	**$293,040**	**$87,912**	**$43,956**	**$430,000**
5-Year	FUT SER 5	300mm Watermain	PVC	2,097	Metres	$740	$1,551,780	$465,534	$232,767	$2,260,000
						Total Cost:	**$1,551,780**	**$465,534**	**$232,767**	**$2,260,000**
	FUT SER 6	300mm Watermain	PVC	1,442	Metres	$740	$1,067,080	$320,124	$160,062	$1,550,000
						Total Cost:	**$1,067,080**	**$320,124**	**$160,062**	**$1,550,000**
	FUT SER 7	300mm Watermain	PVC	431	Metres	$740	$318,940	$95,682	$47,841	$470,000
						Total Cost:	**$318,940**	**$95,682**	**$47,841**	**$470,000**
	FUT SER 8	300mm Watermain	PVC	635	Metres	$740	$469,900	$140,970	$70,485	$690,000
						Total Cost:	**$469,900**	**$140,970**	**$70,485**	**$690,000**
	FUT SER 9	300mm Watermain	PVC	134	Metres	$740	$99,160	$29,748	$14,874	$150,000
						Total Cost:	**$99,160**	**$29,748**	**$14,874**	**$150,000**
10-Year	FUT SER 10	300mm Watermain	PVC	7,442	Metres	$740	$5,507,080	$1,652,124	$826,062	$7,990,000
						Total Cost:	**$5,507,080**	**$1,652,124**	**$826,062**	**$7,990,000**
	FUT SER 11	300mm Watermain	PVC	2,784	Metres	$740	$2,060,160	$618,048	$309,024	$2,990,000
						Total Cost:	**$2,060,160**	**$618,048**	**$309,024**	**$2,990,000**
	FUT SER 12	300mm Watermain	PVC	396	Metres	$740	$293,040	$87,912	$43,956	$430,000
		400mm Watermain	PVC	1,705	Metres	$950	$1,619,750	$485,925	$242,963	$2,350,000
						Total Cost:	**$1,912,790**	**$573,837**	**$286,919**	**$2,780,000**
	FUT SER 13	300mm Watermain	PVC	2,023	Metres	$740	$1,497,020	$449,106	$224,553	$2,180,000
		400mm Watermain	PVC	523	Metres	$950	$496,850	$149,055	$74,528	$730,000
						Total Cost:	**$1,993,870**	**$598,161**	**$299,081**	**$2,910,000**
	FUT SER 14	300mm Watermain	PVC	886	Metres	$740	$655,640	$196,692	$98,346	$960,000
		400mm Watermain	PVC	331	Metres	$950	$314,450	$94,335	$47,168	$460,000
						Total Cost:	**$970,090**	**$291,027**	**$145,514**	**$1,420,000**
	FUT SER 15	Reservoir Storage Capacity	-	1,891	Cubic Metres	$1,100	$2,080,100	$624,030	$312,015	$3,020,000
						Total Cost:	**$2,080,100**	**$624,030**	**$312,015**	**$3,020,000**
20-Year	FUT SER 16	300mm Watermain	PVC	1,862	Metres	$740	$1,377,880	$413,364	$206,682	$2,000,000
						Total Cost:	**$1,377,880**	**$413,364**	**$206,682**	**$2,000,000**
	FUT SER 17	300mm Watermain	PVC	1,613	Metres	$740	$1,193,620	$358,086	$179,043	$1,740,000
						Total Cost:	**$1,193,620**	**$358,086**	**$179,043**	**$1,740,000**
	FUT SER 18	300mm Watermain	PVC	1,220	Metres	$740	$902,800	$270,840	$135,420	$1,310,000
						Total Cost:	**$902,800**	**$270,840**	**$135,420**	**$1,310,000**
	FUT SER 19	300mm Watermain	PVC	3,656	Metres	$740	$2,705,440	$811,632	$405,816	$3,930,000
						Total Cost:	**$2,705,440**	**$811,632**	**$405,816**	**$3,930,000**
	FUT SER 20	300mm Watermain	PVC	5,228	Metres	$740	$3,868,720	$1,160,616	$580,308	$5,610,000
						Total Cost:	**$3,868,720**	**$1,160,616**	**$580,308**	**$5,610,000**
	FUT SER 21	300mm Watermain	PVC	3,311	Metres	$740	$2,450,140	$735,042	$367,521	$3,560,000
						Total Cost:	**$2,450,140**	**$735,042**	**$367,521**	**$3,560,000**
	FUT SER 22	Reservoir Storage Capacity	-	10,267	Cubic Metres	$1,100	$11,293,700	$3,388,110	$1,694,055	$16,380,000
						Total Cost:	**$11,293,700**	**$3,388,110**	**$1,694,055**	**$16,380,000**
	FUT SER 23	Pumping Capacity	-	101	Litres per Second	$20,000	$2,020,000	$606,000	$303,000	$2,930,000
						Total Cost:	**$2,020,000**	**$606,000**	**$303,000**	**$2,930,000**
Ultimate	FUT SER 24	300mm Watermain	PVC	14,524	Metres	$740	$10,747,760	$3,224,328	$1,612,164	$15,590,000
		400mm Watermain	PVC	3,337	Metres	$950	$3,170,150	$951,045	$475,523	$4,600,000
						Total Cost:	**$13,917,910**	**$4,175,373**	**$2,087,687**	**$20,190,000**
	FUT SER 25	300mm Watermain	PVC	7,731	Metres	$740	$5,720,940	$1,716,282	$858,141	$8,300,000
						Total Cost:	**$5,720,940**	**$1,716,282**	**$858,141**	**$8,300,000**
	FUT SER 26	Reservoir Storage Capacity	-	8,296	Cubic Metres	$1,100	$9,125,600	$2,737,680	$1,368,840	$13,240,000
						Total Cost:	**$9,125,600**	**$2,737,680**	**$1,368,840**	**$13,240,000**
	FUT SER 27	Pumping Capacity	-	96	Litres per Second	$20,000	$1,920,000	$576,000	$288,000	$2,790,000
						Total Cost:	**$1,920,000**	**$576,000**	**$288,000**	**$2,790,000**

[1]Costs herein are comparable to other municipalities. Costs are representative of 2024 dollars.

[2]The total cost has been rounded to the nearest $10,000.

ISL

APPENDIX
Condition Assessment Tables

C

Table C.1: Existing System Proposed Upgrades Risk Assessment - Fire Flow Availability

Upgrade No.	Category	Existing Available Fire Flow	Upgraded Available Fire Flow	Raw Score	Weighted Score
		%	%		
1	Fire Flow	55%	100%	4	1.60
2	Fire Flow	43%	100%	5	2.00
3	Fire Flow	34%	100%	5	2.00
4	Fire Flow	40%	100%	5	2.00
5	Fire Flow	40%	100%	5	2.00
6	Fire Flow	59%	100%	4	1.60
7	Fire Flow	34%	100%	5	2.00
8	Fire Flow	68%	100%	3	1.20
9	Fire Flow	68%	100%	3	1.20
10	Fire Flow	49%	100%	5	2.00
11	Fire Flow	59%	100%	4	1.60
12	Fire Flow	100%	100%	1	0.40
13	Fire Flow	100%	100%	1	0.40
14	Fire Flow	64%	100%	3	1.20
15	Fire Flow	55%	100%	4	1.60
16	Fire Flow	42%	100%	5	2.00
17	Fire Flow	22%	100%	5	2.00
18	Fire Flow	48%	100%	5	2.00
19	Fire Flow	69%	100%	3	1.20
20	Fire Flow	54%	100%	4	1.60
21	Fire Flow	100%	100%	1	0.40
22	Fire Flow	62%	88%	2	0.80

Table C.2: Existing System Proposed Upgrades Risk Assessment - Existing Impact

Upgrade No.	Category	Impacted Area			Raw Score	Weighted Score
		Area (ha)	Parcels	Landuse		
1	Fire Flow	143.50	10	Industrial	4	1.20
2	Fire Flow	6.20	9	Industrial	1	0.30
3	Fire Flow	2.10	20	Public Service	3	0.90
4	Fire Flow	1.80	19	Industrial	3	0.90
5	Fire Flow	4.80	8	Commercial	4	1.20
6	Fire Flow	5.20	40	Commercial	2	0.60
7	Fire Flow	1.50	11	Residential	1	0.30
8	Fire Flow	4.30	5	Industrial	2	0.60
9	Fire Flow	3.60	4	Industrial	1	0.30
10	Fire Flow	6.00	30	Public Service	4	1.20
11	Fire Flow	5.10	2	Commercial	2	0.60
12	Fire Flow	Overall	Overall	Industrial	1	0.30
13	Fire Flow	Overall	Overall	Commercial	1	0.30
14	Fire Flow	3.20	6	Indusitral	4	1.20
15	Fire Flow	3.20	6	Commercial	4	1.20
16	Fire Flow	1.70	15	Residential	4	1.20
17	Fire Flow	1.70	15	Residential	5	1.50
18	Fire Flow	1.20	5	Commercial	4	1.20
19	Fire Flow	10.70	1	Industrial	1	0.30
20	Fire Flow	1.60	2	Commercial	3	0.90
21	Fire Flow	Overall	Overall	Commercial	1	0.30
22	Fire Flow	28.70	14	Commercial	3	0.90

Note:
Upgrades proposed for system redundancy and strengthening that don't directly improve fireflow deficiencies will have an "Overall" impacted area.

Table C.3: Existing System Proposed Upgrades Risk Assessment - Generalized Pipe Condition

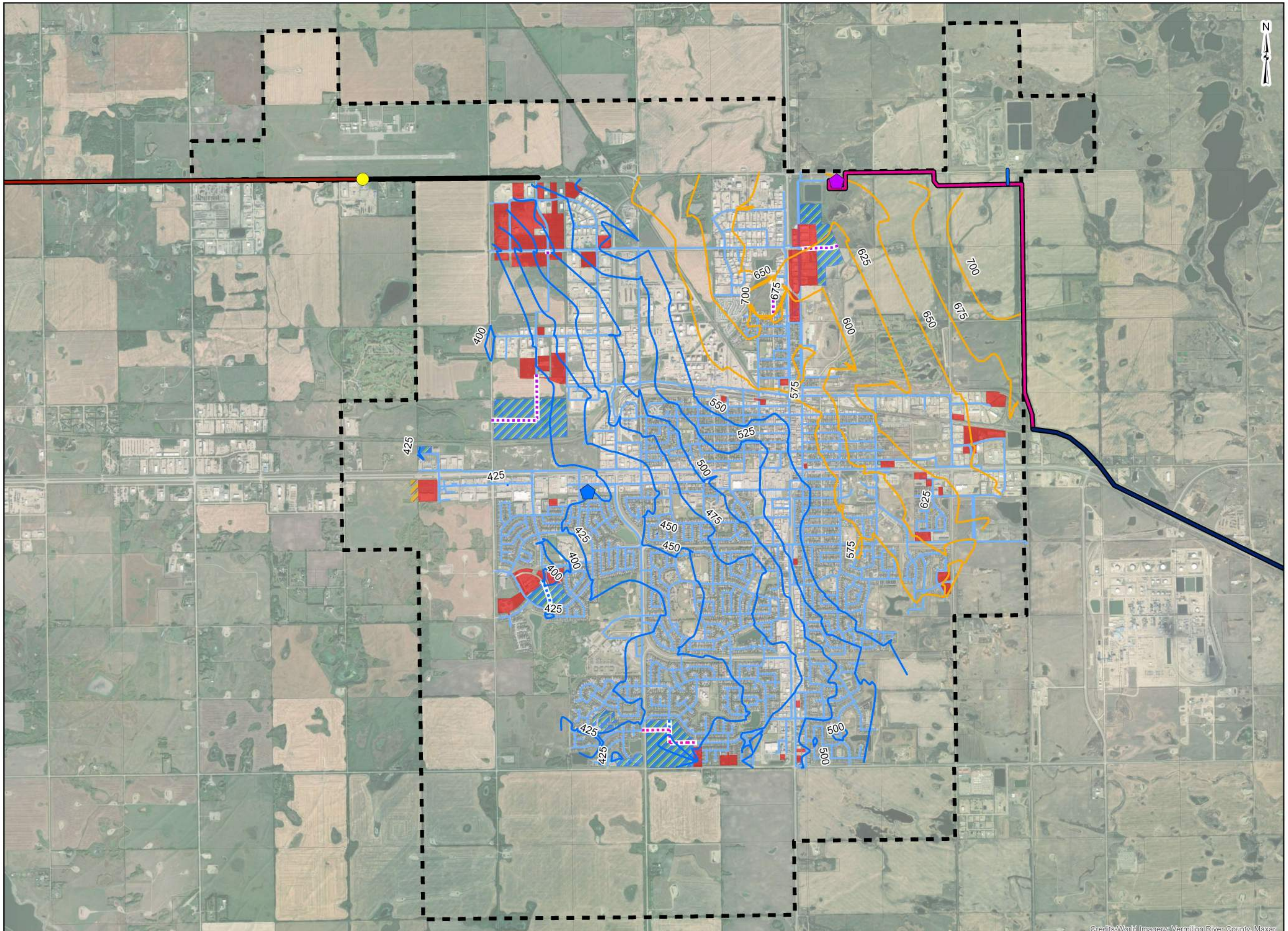
Upgrade No.	Category	Length	Generalized Pipe Condition	Raw Score	Weighted Score
1	Fire Flow	419.00	N/A	1	0.20
2	Fire Flow	457.00	Fair	3	0.60
3	Fire Flow	93.00	N/A	1	0.20
4	Fire Flow	225.00	Poor	4	0.80
5	Fire Flow	181.00	Fair	3	0.60
6	Fire Flow	150.00	N/A	1	0.20
7	Fire Flow	192.00	Unacceptable	5	1.00
8	Fire Flow	542.00	Fair	3	0.60
9	Fire Flow	153.00	Fair	3	0.60
10	Fire Flow	205.00	N/A	1	0.20
11	Fire Flow	272.00	Good	2	0.40
12	Fire Flow	201.00	Good	2	0.40
13	Fire Flow	511.00	N/A	1	0.20
14	Fire Flow	173.00	Fair	3	0.60
15	Fire Flow	104.00	Fair	3	0.60
16	Fire Flow	442.00	Poor	4	0.80
17	Fire Flow	110.00	N/A	1	0.20
18	Fire Flow	226.00	Poor	4	0.80
19	Fire Flow	1176.00	N/A	1	0.20
20	Fire Flow	476.00	Fair	3	0.60
21	Fire Flow	451.00	N/A	1	0.20
22	Fire Flow	85.00	N/A	1	0.20

Table C.4: Existing System Proposed Upgrades Risk Assessment - Road Condition Upgrade Potential

Upgrade No.	Category	Length	Imagery Year	Road Condition	Upgrades which can be coupled with road work	Road Condition Upgrade Potential	Raw Score	Weighted Score
1	Fire Flow	419	2009	Dirt road/unpaved	Very High	Excellent	5	0.50
2	Fire Flow	457	2012	Fair	Moderate	Fair	3	0.30
3	Fire Flow	93	2012	Poor	High	Good	4	0.40
4	Fire Flow	225	2012	Fair/Poor	Moderate	Fair	3	0.30
5	Fire Flow	181	2012	Very Poor	Very High	Excellent	5	0.50
6	Fire Flow	150	2022	Good	Low	Poor	2	0.20
7	Fire Flow	192	2012	Fair	Moderate	Fair	3	0.30
8	Fire Flow	542	2016	Very Good	Negligible	Negligible	1	0.10
9	Fire Flow	153	2016	Very poor	High	Good	4	0.40
10	Fire Flow	205	2012	Fair	Some	Fair	3	0.30
11	Fire Flow	272	2022	Dirt road/unpaved	Very High	Excellent	5	0.50
12	Fire Flow	201	2022	Dirt road/unpaved	Very High	Excellent	5	0.50
13	Fire Flow	511	2022	ROW	Negligible	Negligible	1	0.10
14	Fire Flow	173	2018 - 2019	Poor	High	Good	4	0.40
15	Fire Flow	104	2019	Good	Low	Poor	2	0.20
16	Fire Flow	442	2019	Fair	Moderate	Fair	3	0.30
17	Fire Flow	110	2022	Dirt road/unpaved	Very High	Excellent	5	0.50
18	Fire Flow	226	2019	Fair	Moderate	Fair	3	0.30
19	Fire Flow	1176	2022	Good	Low	Poor	2	0.20
20	Fire Flow	476	2012	Fair	Some	Fair	3	0.30
21	Fire Flow	451	2022	Fair	Some	Fair	3	0.30
22	Fire Flow	85	2022	Good	Negligible	Negligible	1	0.10

APPENDIX
Interim Scenario Results

D



Legend

Study Area
Water Treatment Plant
West End Reservoir
ACE Tie-in Location
Existing Watermain

ACE Water Line

ACE Water Line
City of Lloydminster Owned ACE Water Line

SaskWater Line

City of Lloydminster Owned SaskWater Line 450 mm
City of Lloydminster Hydrant Service Line 250 mm
SaskWater Line

Proposed Pipe Diameter

200 mm Watermain
250 mm Watermain
300 mm Watermain
400 mm Watermain

Future Parcel Tie-In

New Service
Existing Service
Serviced But Vacant
Airport Expansion

Average Day Pressure Contours

Less than 273 kPa
Between 273 kPa and 350 kPa
Between 350 kPa and 550 kPa
Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

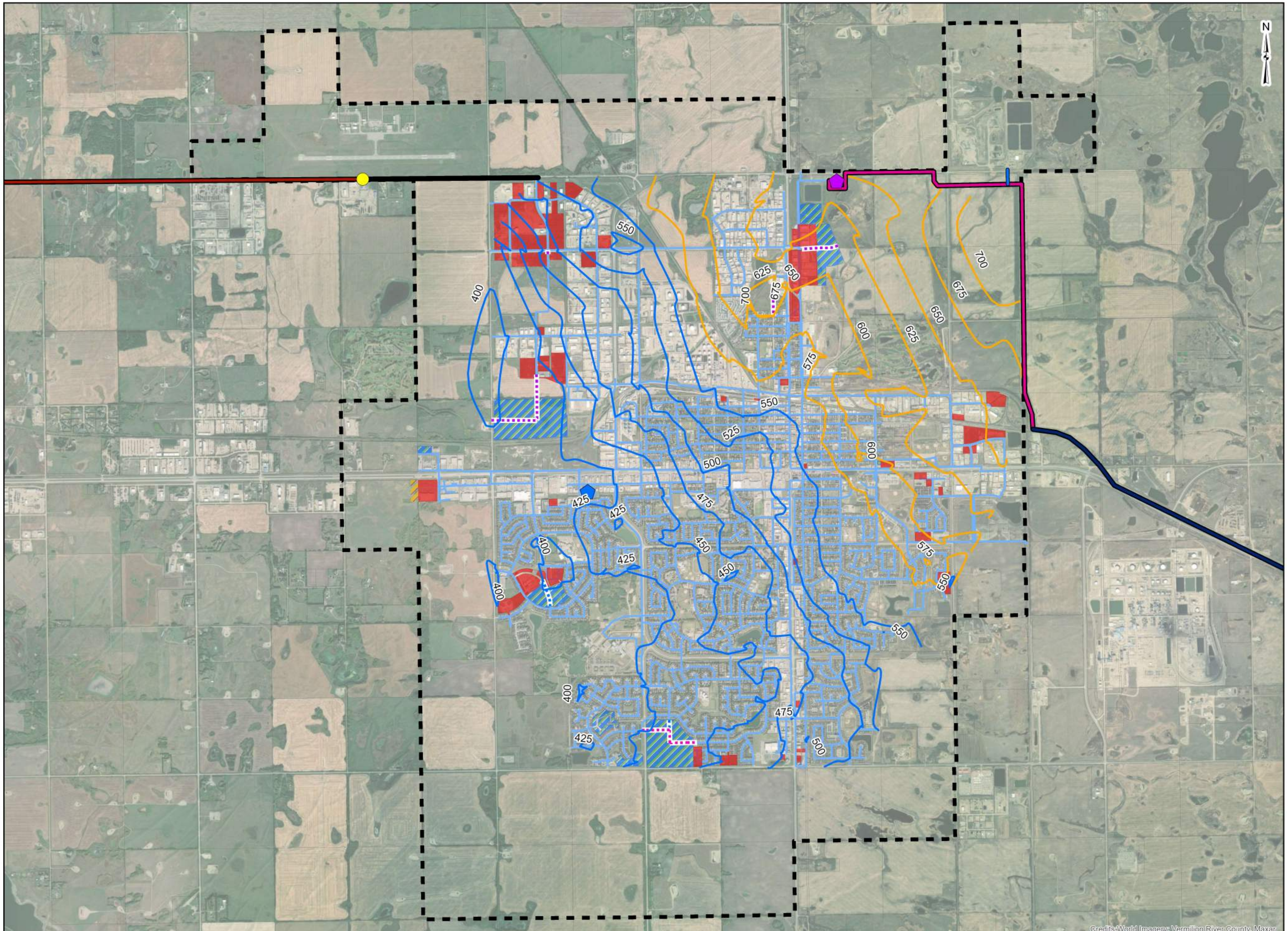
0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.1
FUTURE 3 YEAR SERVICING CONCEPT
PRESSURE DURING
AVERAGE DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

ISL

LLOYDMINSTER



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Max Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.2
FUTURE 3 YEAR SERVICING CONCEPT
PRESSURE DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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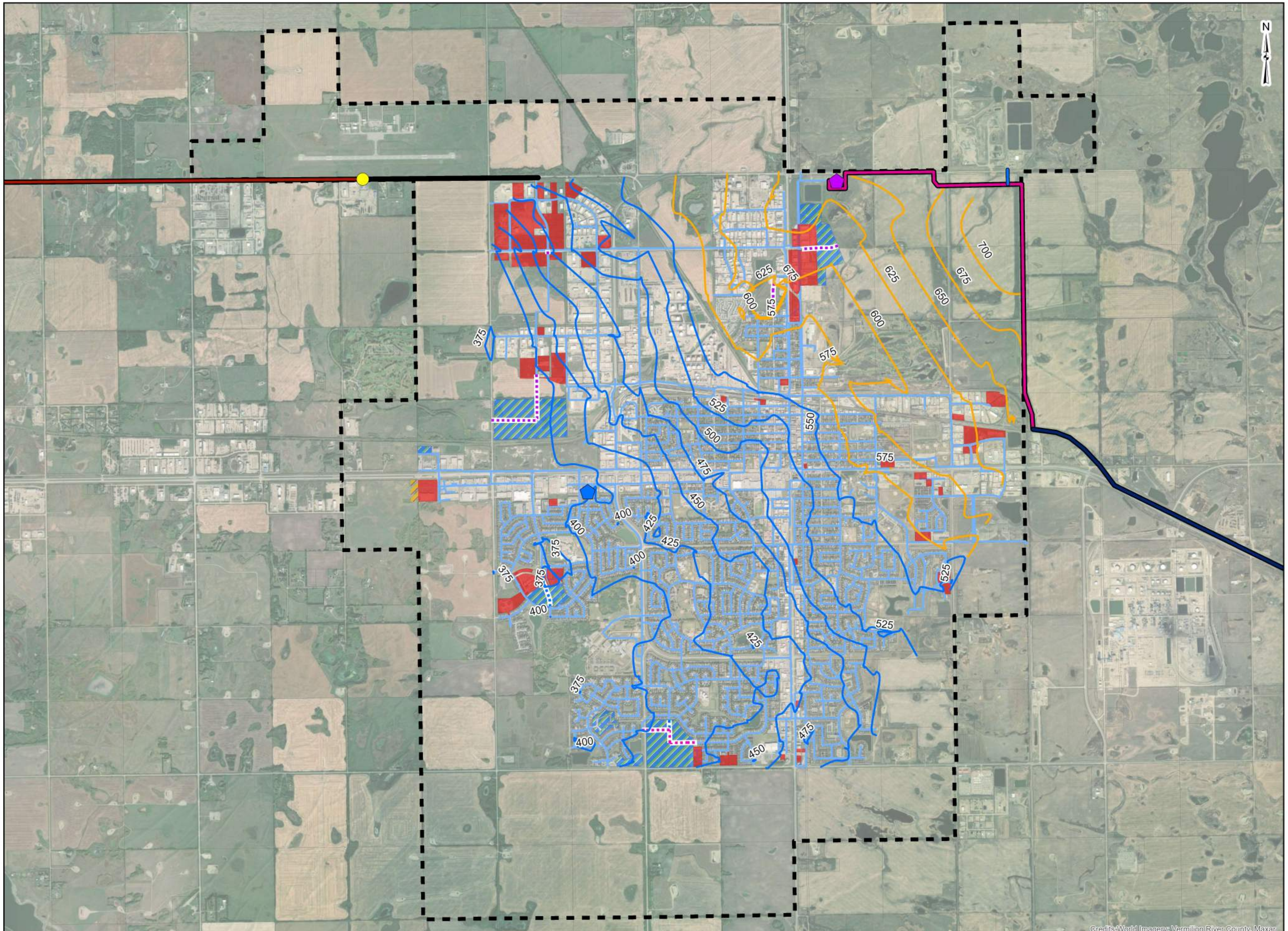

Legend

Study Area
Water Treatment Plant
West End Reservoir
ACE Tie-in Location
Existing Watermain

ACE Water Line

ACE Water Line
City of Lloydminster Owned ACE Water Line

SaskWater Line

City of Lloydminster Owned SaskWater Line 450 mm
City of Lloydminster Hydrant Service Line 250 mm
SaskWater Line

Proposed Pipe Diameter

200 mm Watermain
250 mm Watermain
300 mm Watermain
400 mm Watermain

Future Parcel Tie-In

New Service
Existing Service
Serviced But Vacant
Airport Expansion

Peak Hour Pressure Contours

Less than 273 kPa
Between 273 kPa and 350 kPa
Between 350 kPa and 550 kPa
Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.3
FUTURE 3 YEAR SERVICING CONCEPT
PRESSURE DURING
PEAK HOUR DEMAND
LLOYDMINSTER WATER MASTER PLAN

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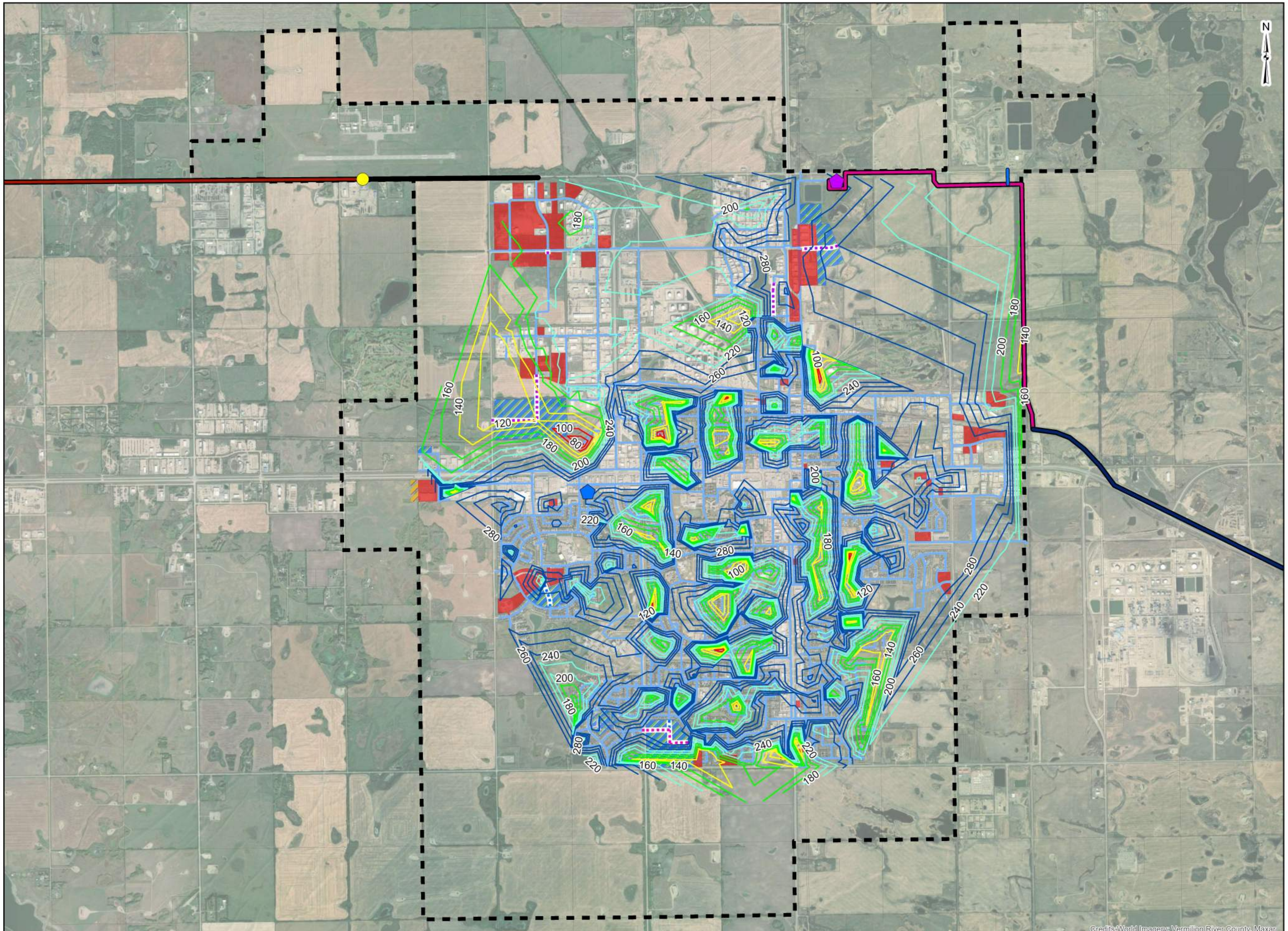


Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Fire Flow Contour

- Less than 100 L/s
- Between 100 and 150 L/s
- Between 150 and 185 L/s
- Between 185 and 225 L/s
- Between 225 and 300 L/s

Number on the contour indicates the available fire flow in L/s.

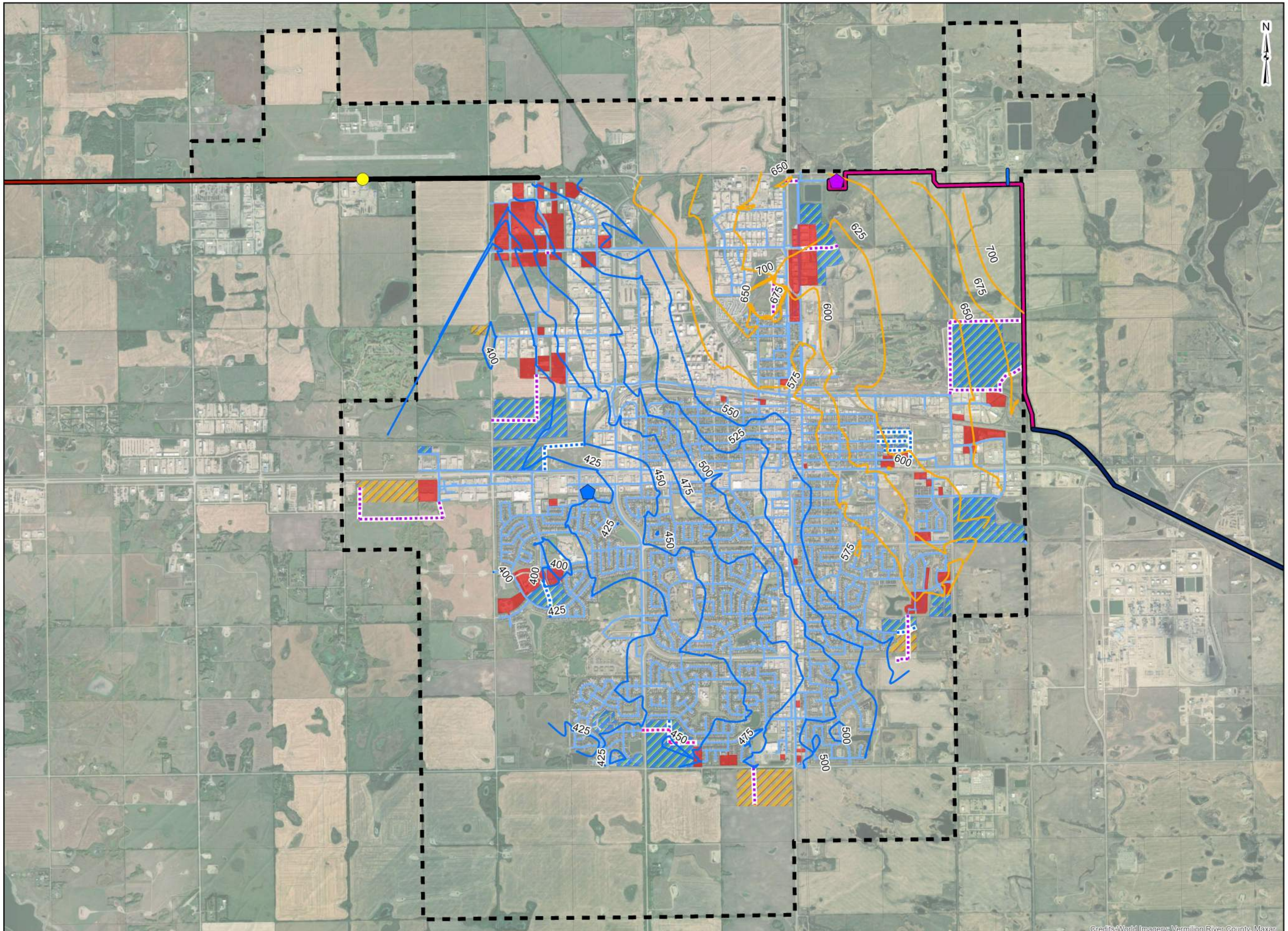
0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.4
FUTURE 3 YEAR SERVICING CONCEPT
AVAILABLE FIRE FLOW DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

ISL

LLOYDMINSTER



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Average Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.5
FUTURE 5 YEAR SERVICING CONCEPT
PRESSURE DURING
AVERAGE DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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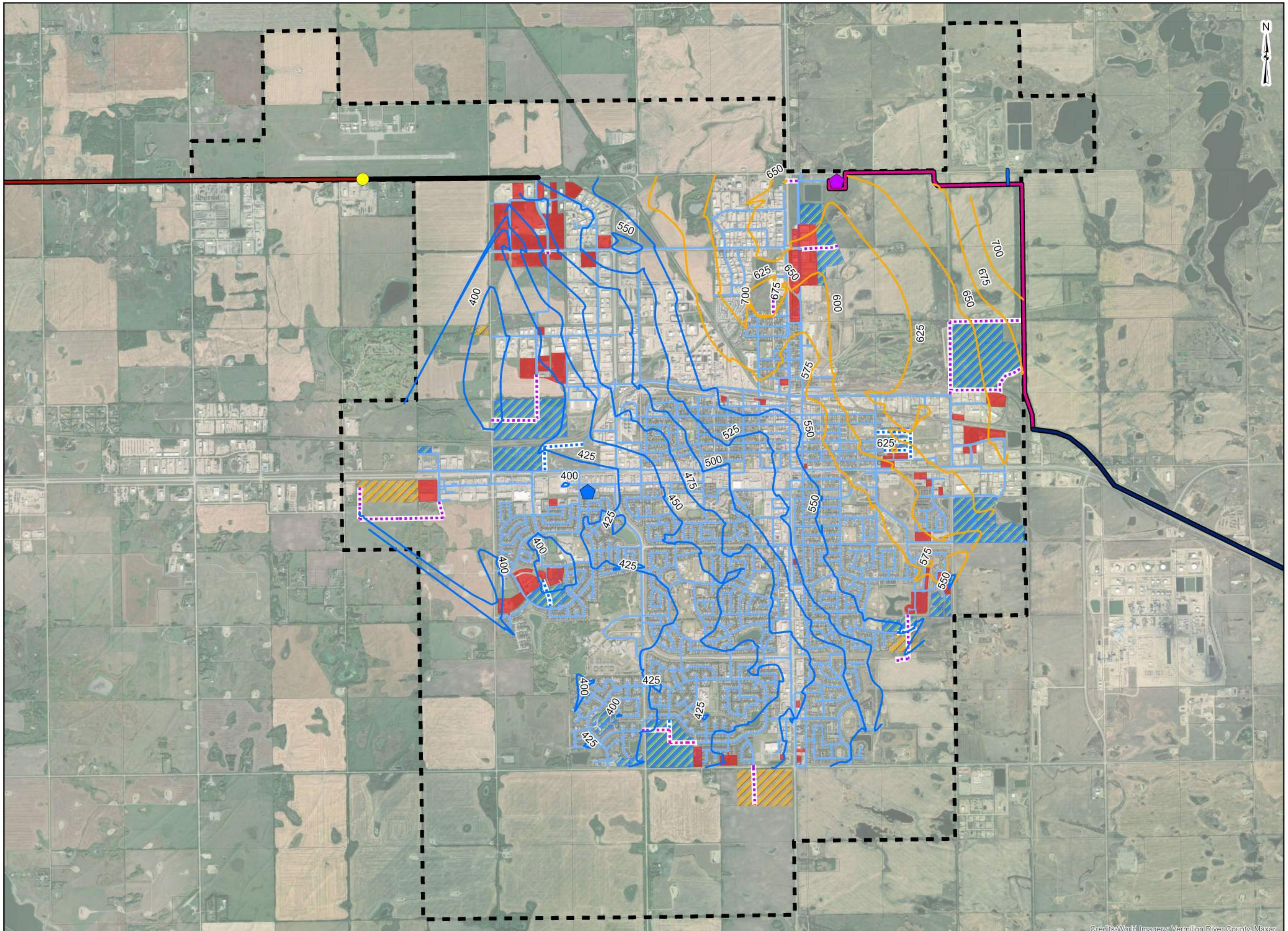


Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Max Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

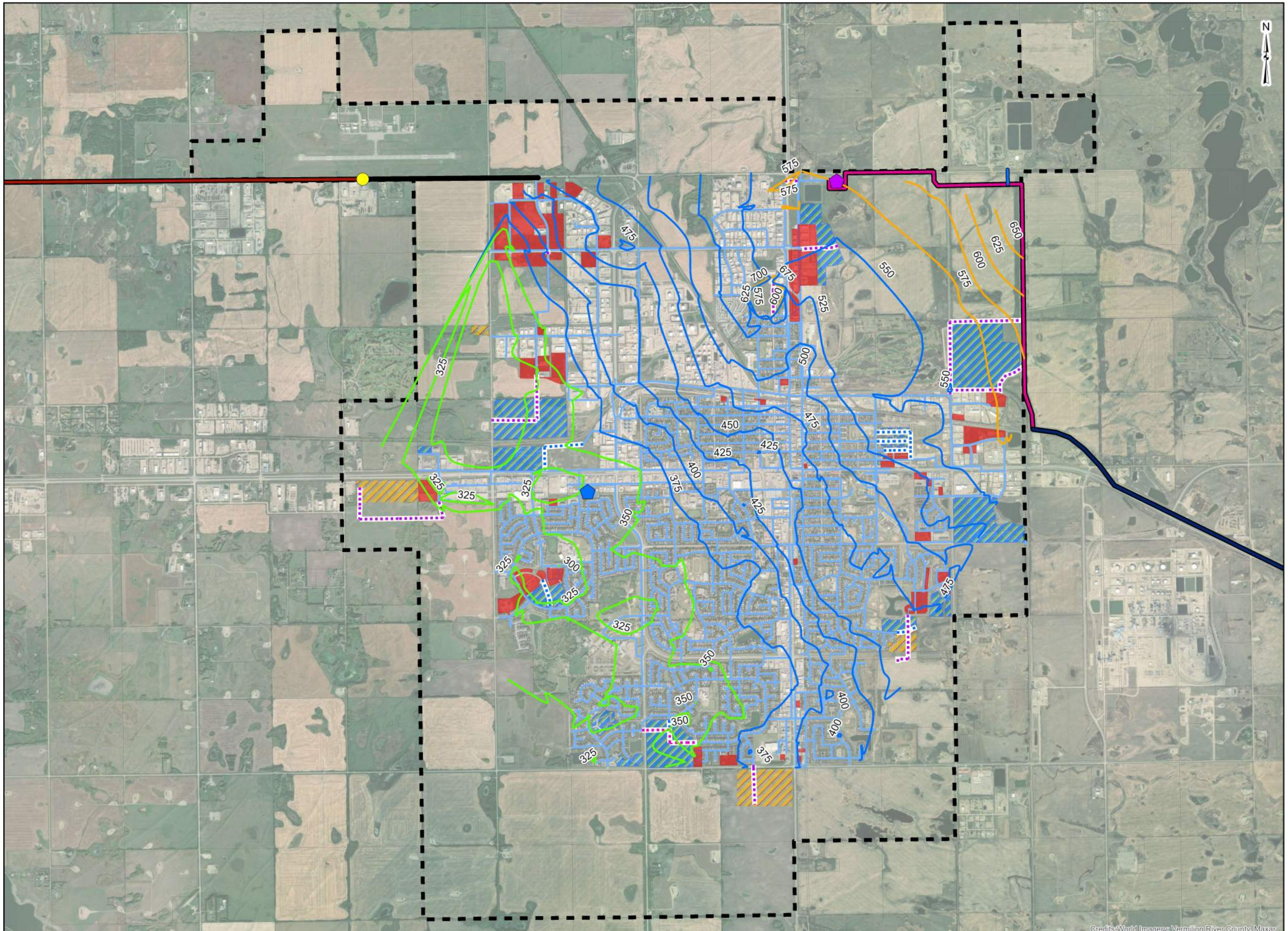
Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.6
FUTURE 5 YEAR SERVICING CONCEPT
PRESSURE DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

ISL LLOYDMINSTER



Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Peak Hour Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.7
FUTURE 5 YEAR SERVICING CONCEPT
PRESSURE DURING
PEAK HOUR DEMAND
LLOYDMINSTER WATER MASTER PLAN

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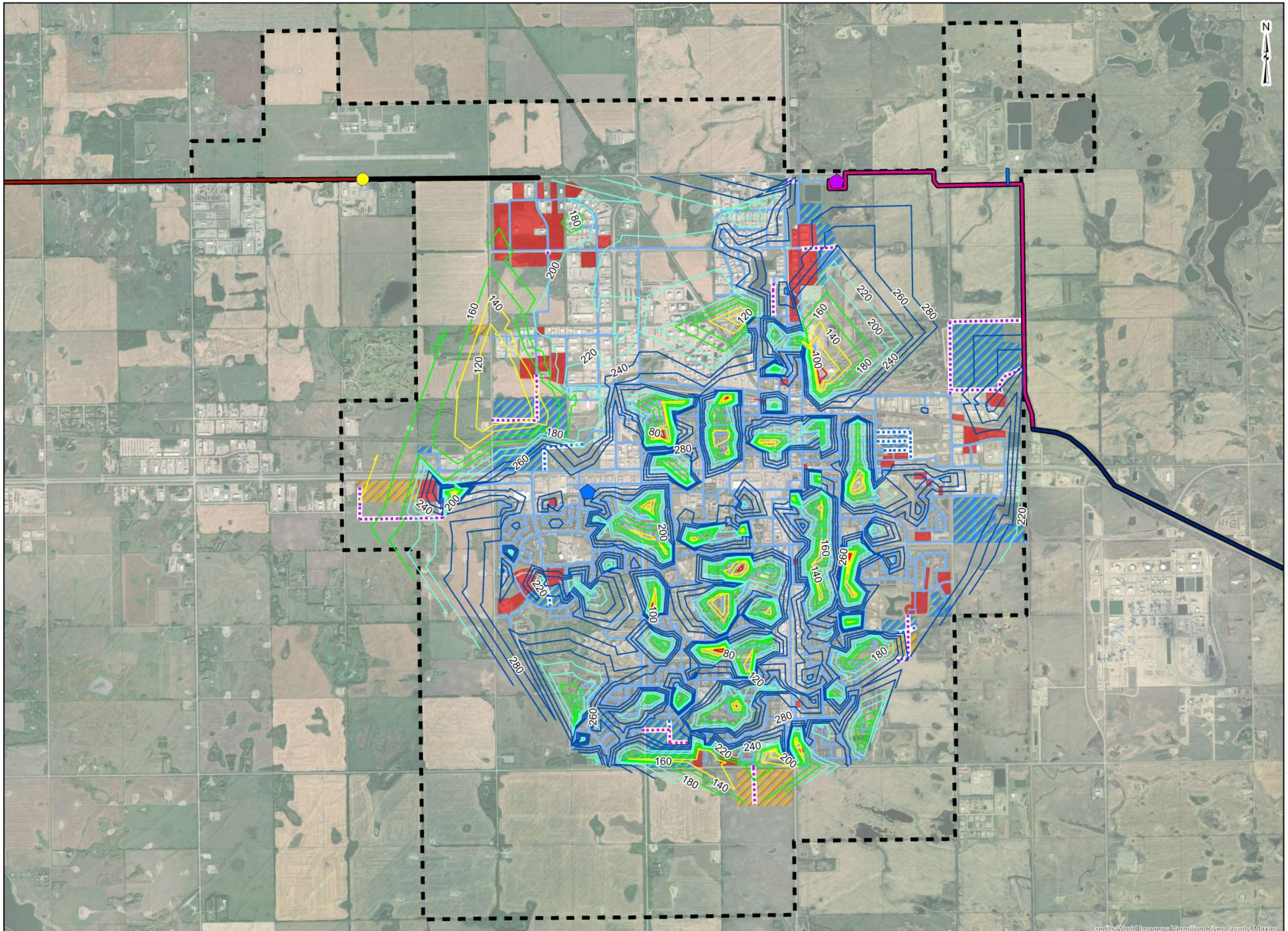

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Fire Flow Contours

- Less than 100 L/s
- Between 100 and 150 L/s
- Between 150 and 185 L/s
- Between 185 and 225 L/s
- Between 225 and 300 L/s

Number on the contour indicates the available fire flow in L/s.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.8
FUTURE 5 YEAR SERVICING CONCEPT
AVAILABLE FIRE FLOW DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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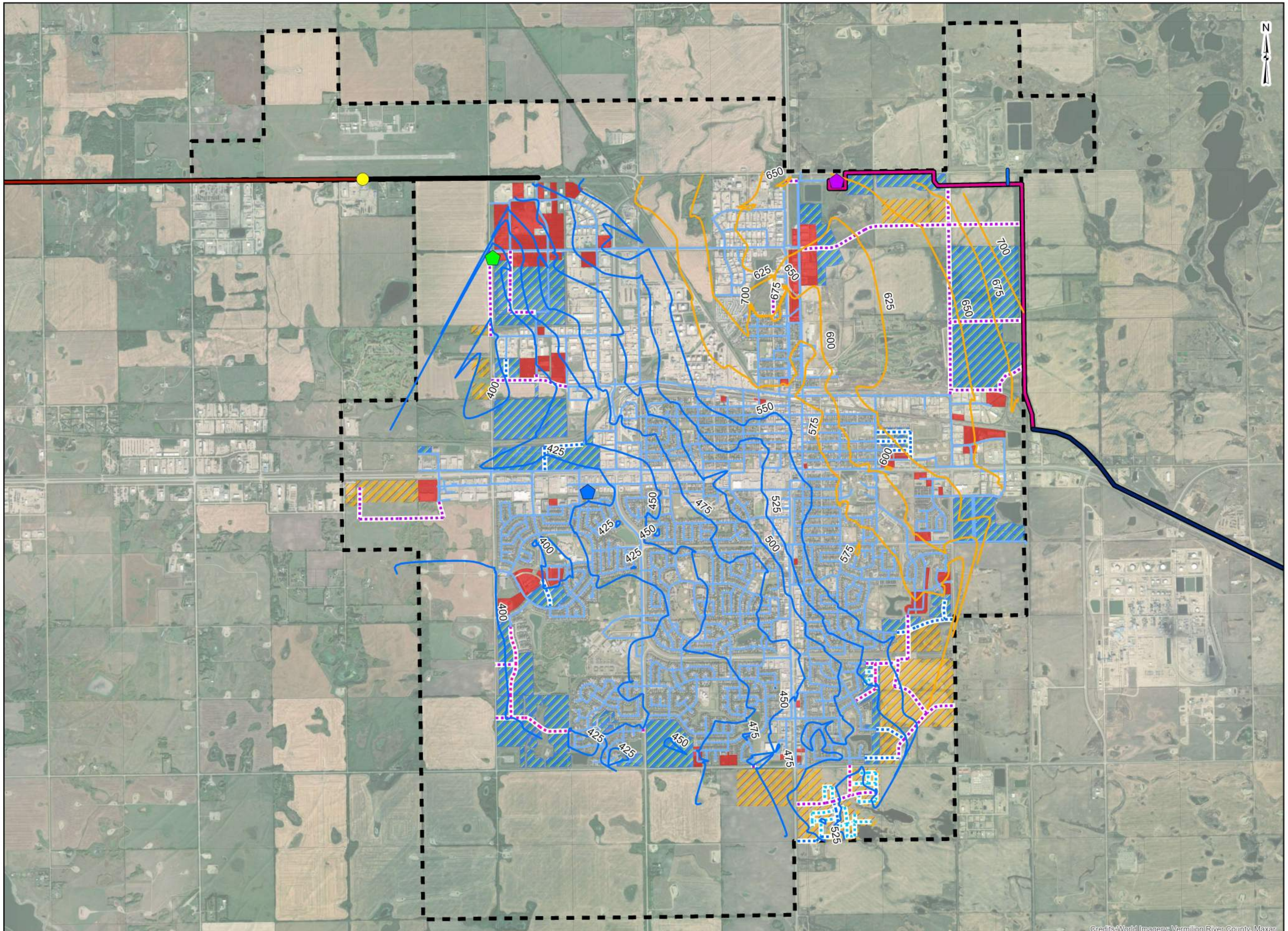

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Average Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.9
FUTURE 10 YEAR SERVICING CONCEPT
PRESSURE DURING
AVERAGE DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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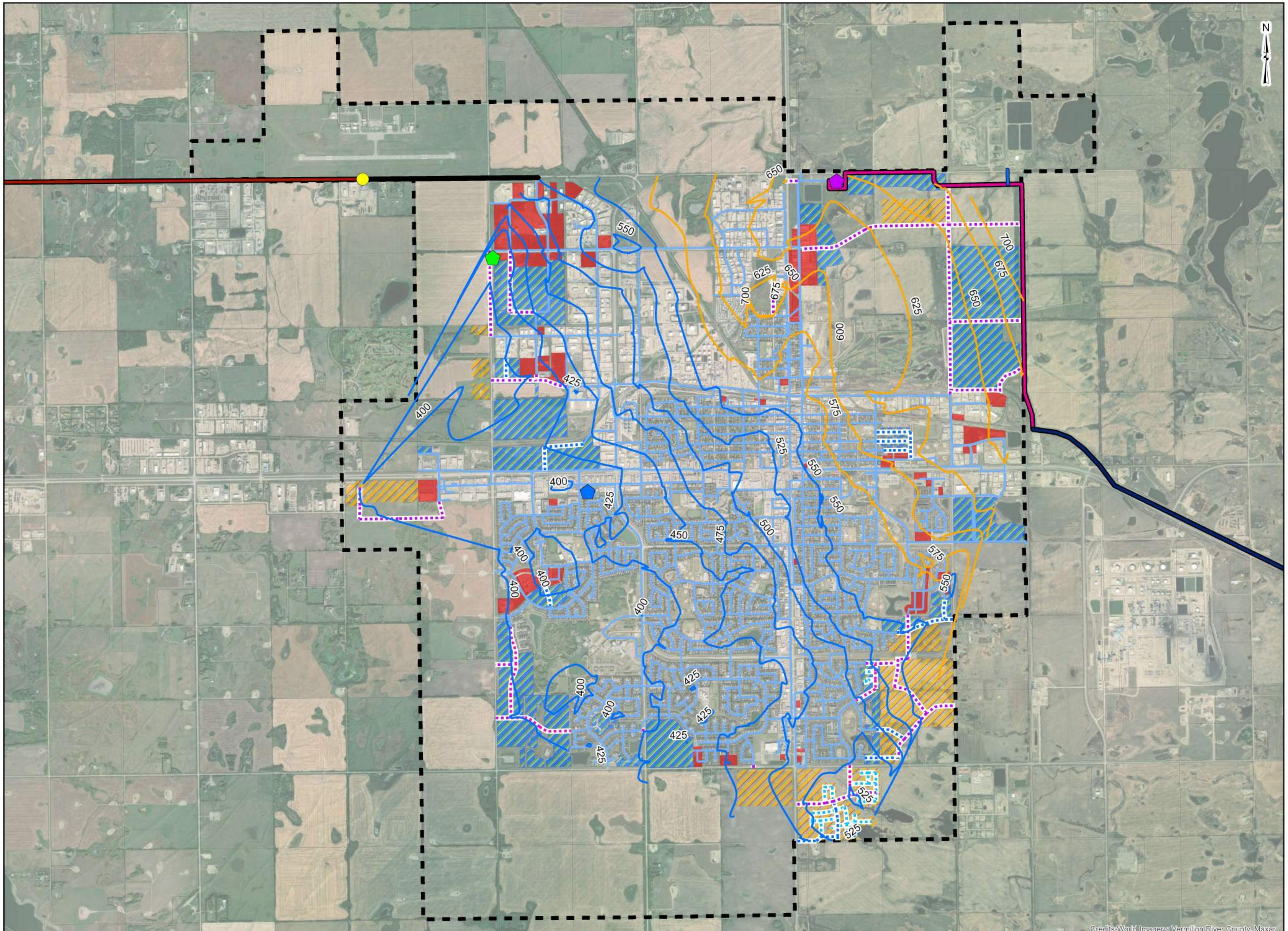

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Max Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

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FIGURE D.10
FUTURE 10 YEAR SERVICING CONCEPT
PRESSURE DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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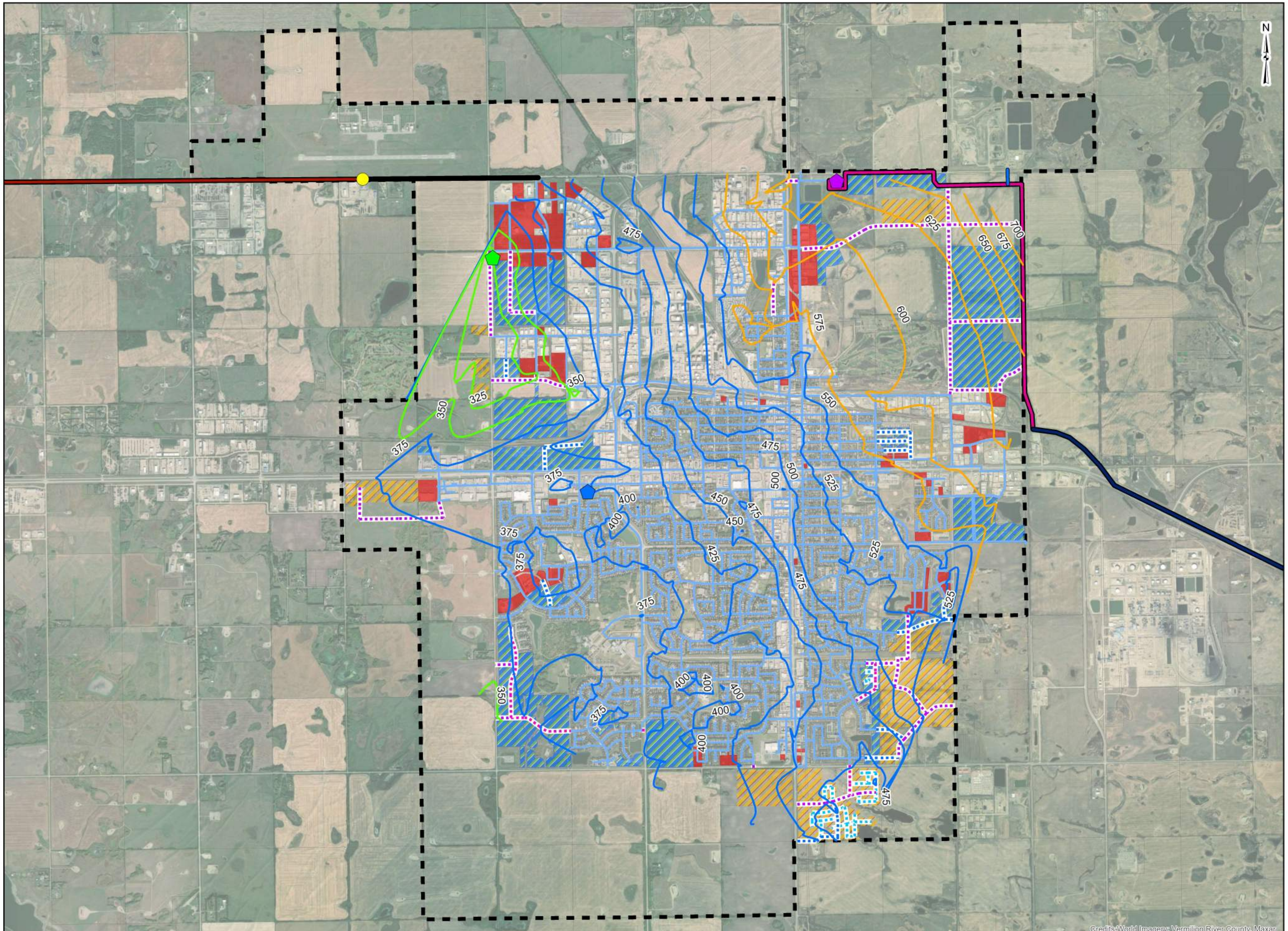

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Peak Hour Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the pressure in kPa.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.11
FUTURE 10 YEAR SERVICING CONCEPT
PRESSURE DURING
PEAK HOUR DEMAND
LLOYDMINSTER WATER MASTER PLAN

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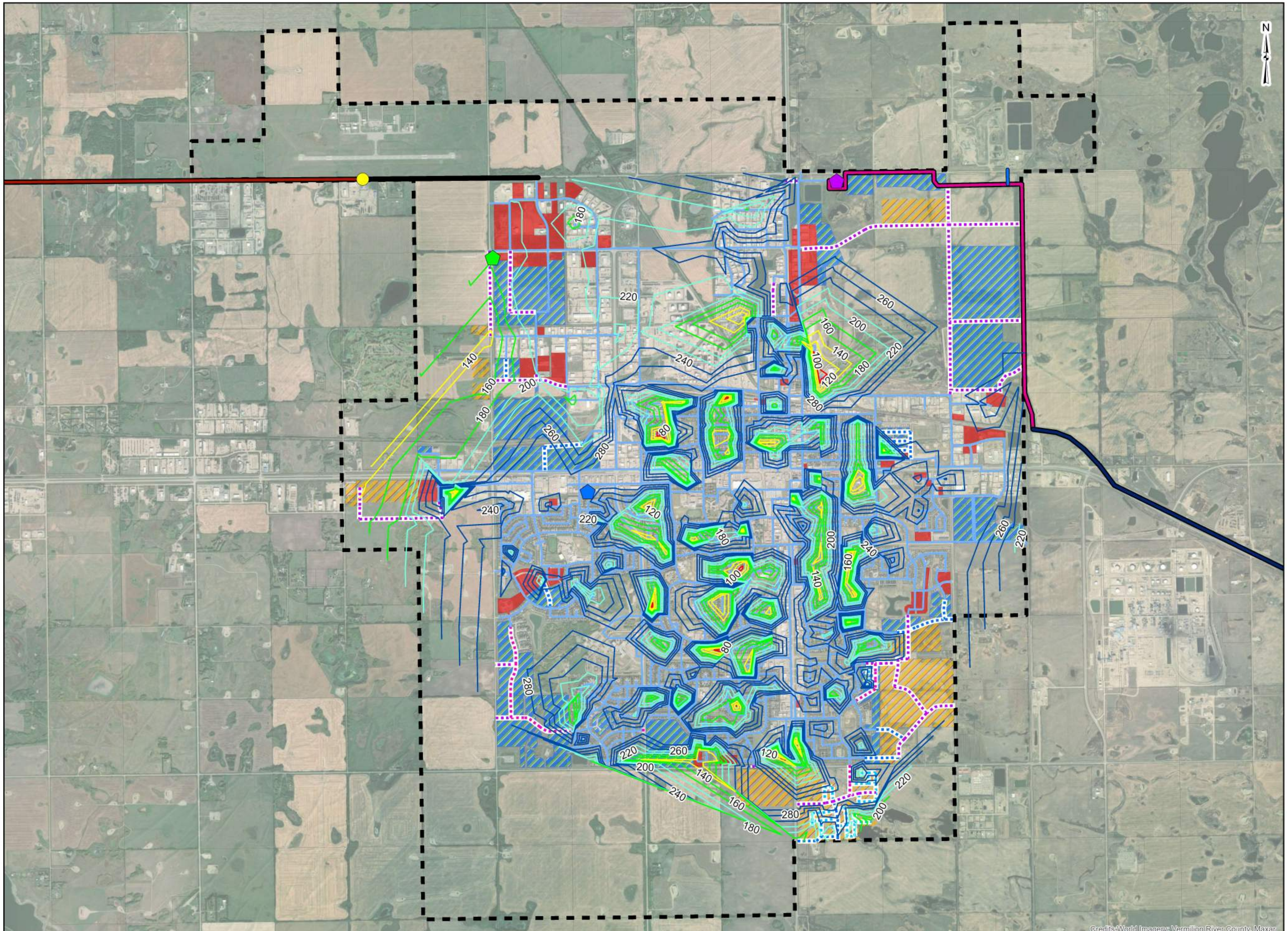

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Fire Flow Contour

- Less than 100 L/s
- Between 100 and 150 L/s
- Between 150 and 185 L/s
- Between 185 and 225 L/s
- Between 225 and 300 L/s

Number on the contour indicates the available fire flow in L/s.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.12
FUTURE 10 YEAR SERVICING CONCEPT
AVAILABLE FIRE FLOW DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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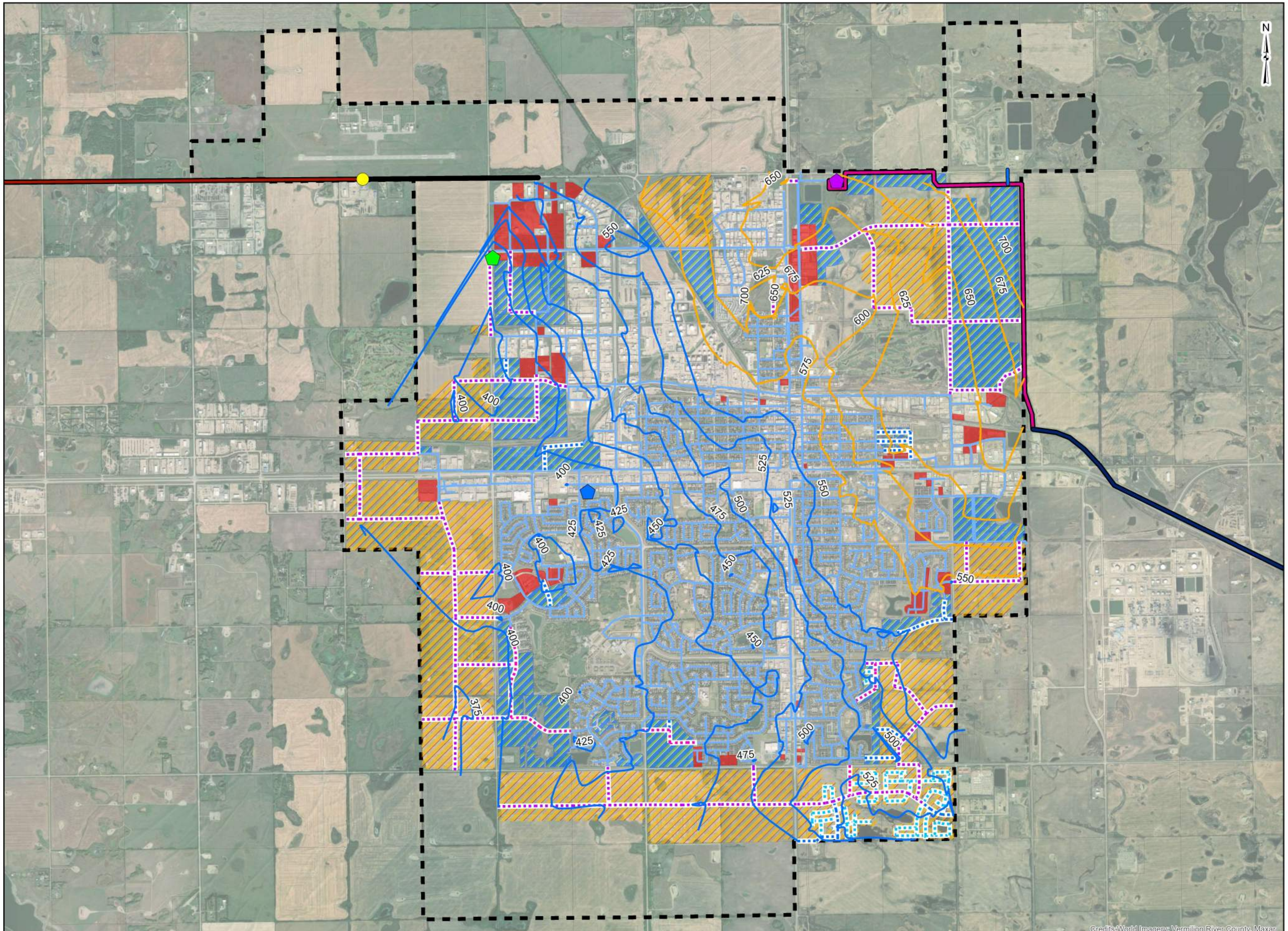

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Average Day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the available fire flow in L/s.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.13
FUTURE 20 YEAR SERVICING CONCEPT
PRESSURE DURING
AVERAGE DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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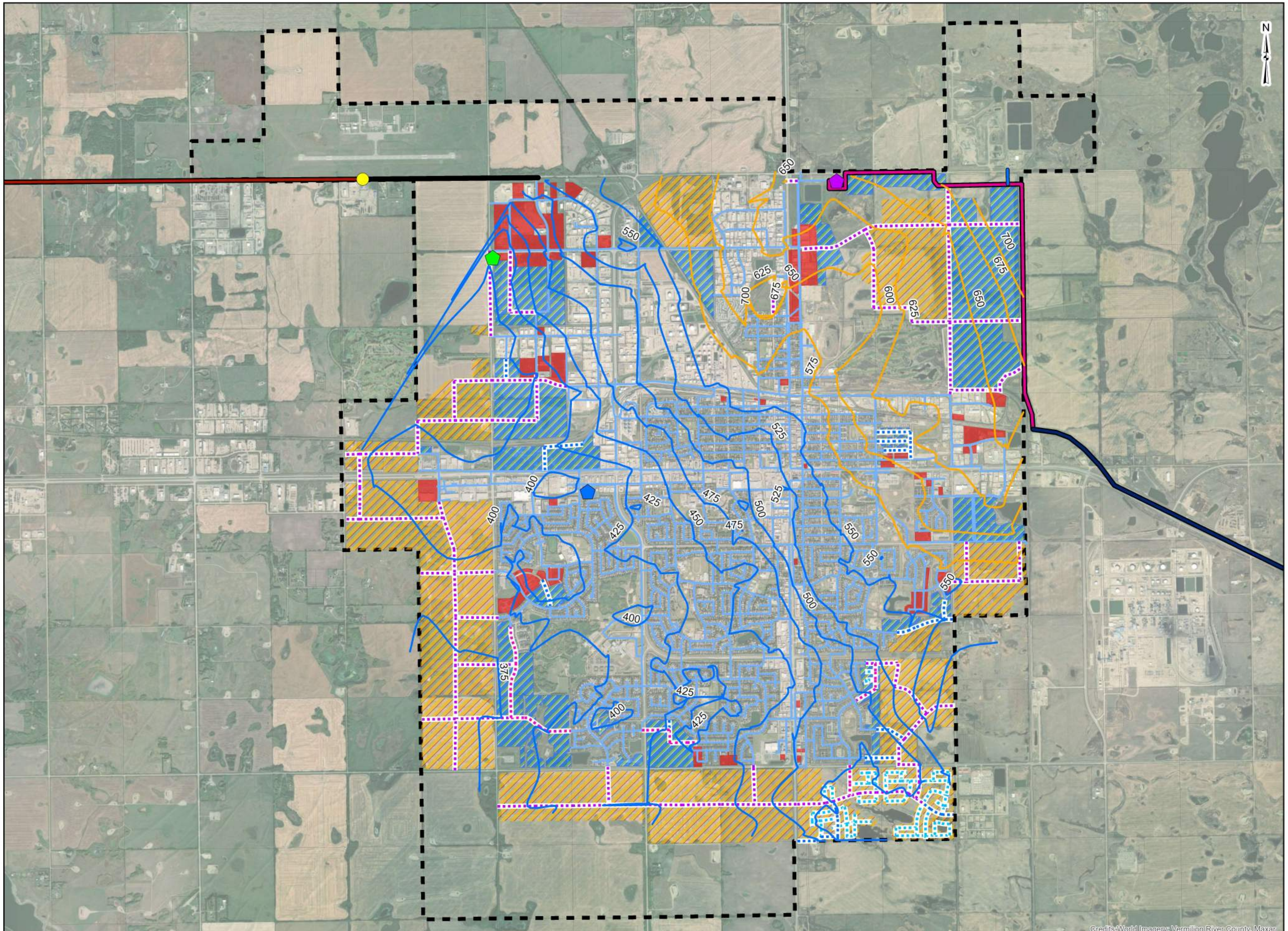

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Max day Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the available fire flow in L/s.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.14
FUTURE 20 YEAR SERVICING CONCEPT
PRESSURE DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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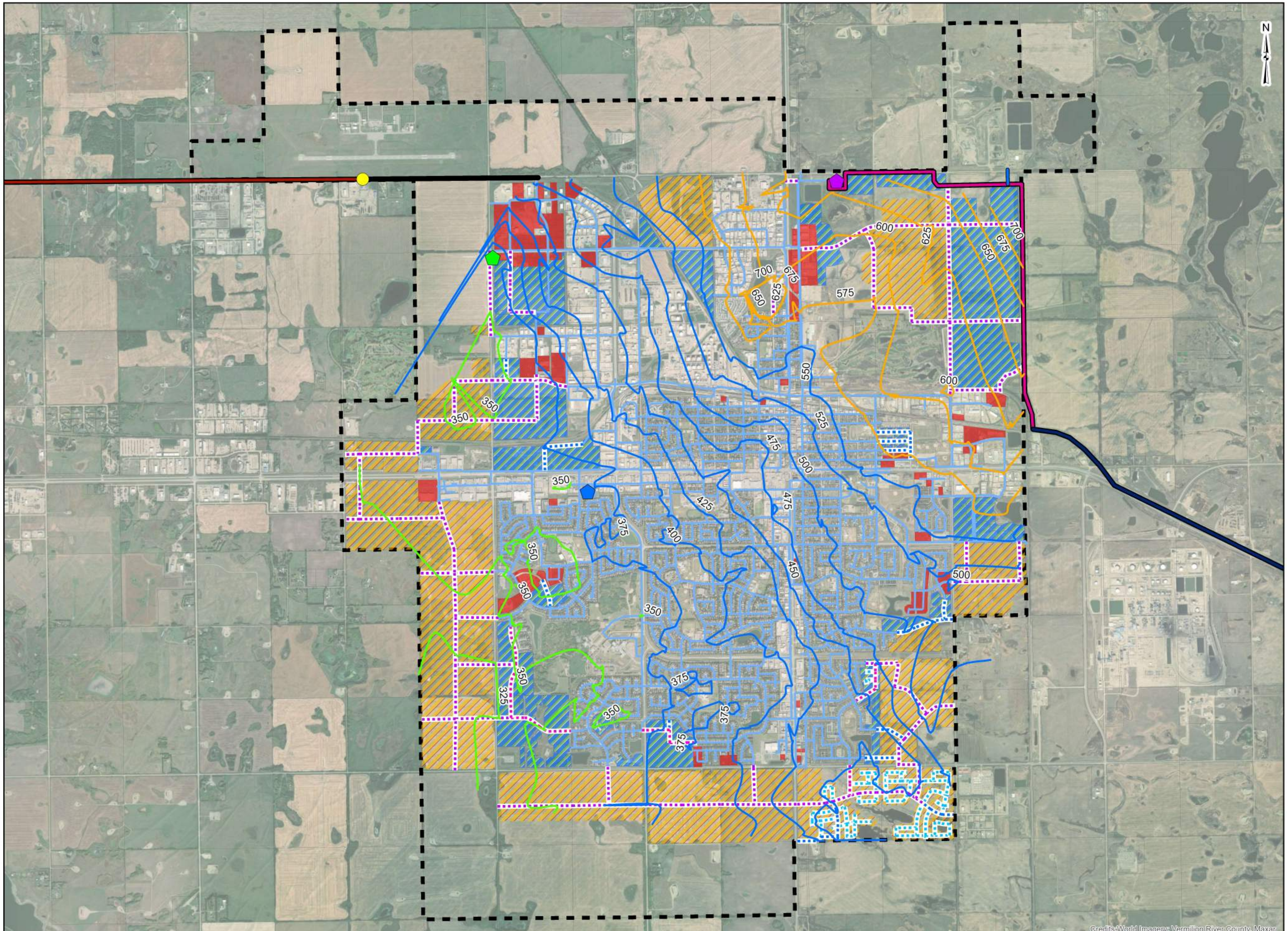

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Peak Hour Pressure Contours

- Less than 273 kPa
- Between 273 kPa and 350 kPa
- Between 350 kPa and 550 kPa
- Between 550 kPa and 700 kPa

Number on the contour indicates the available fire flow in L/s.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.15
FUTURE 20 YEAR SERVICING CONCEPT
PRESSURE DURING
PEAK HOUR DEMAND
LLOYDMINSTER WATER MASTER PLAN

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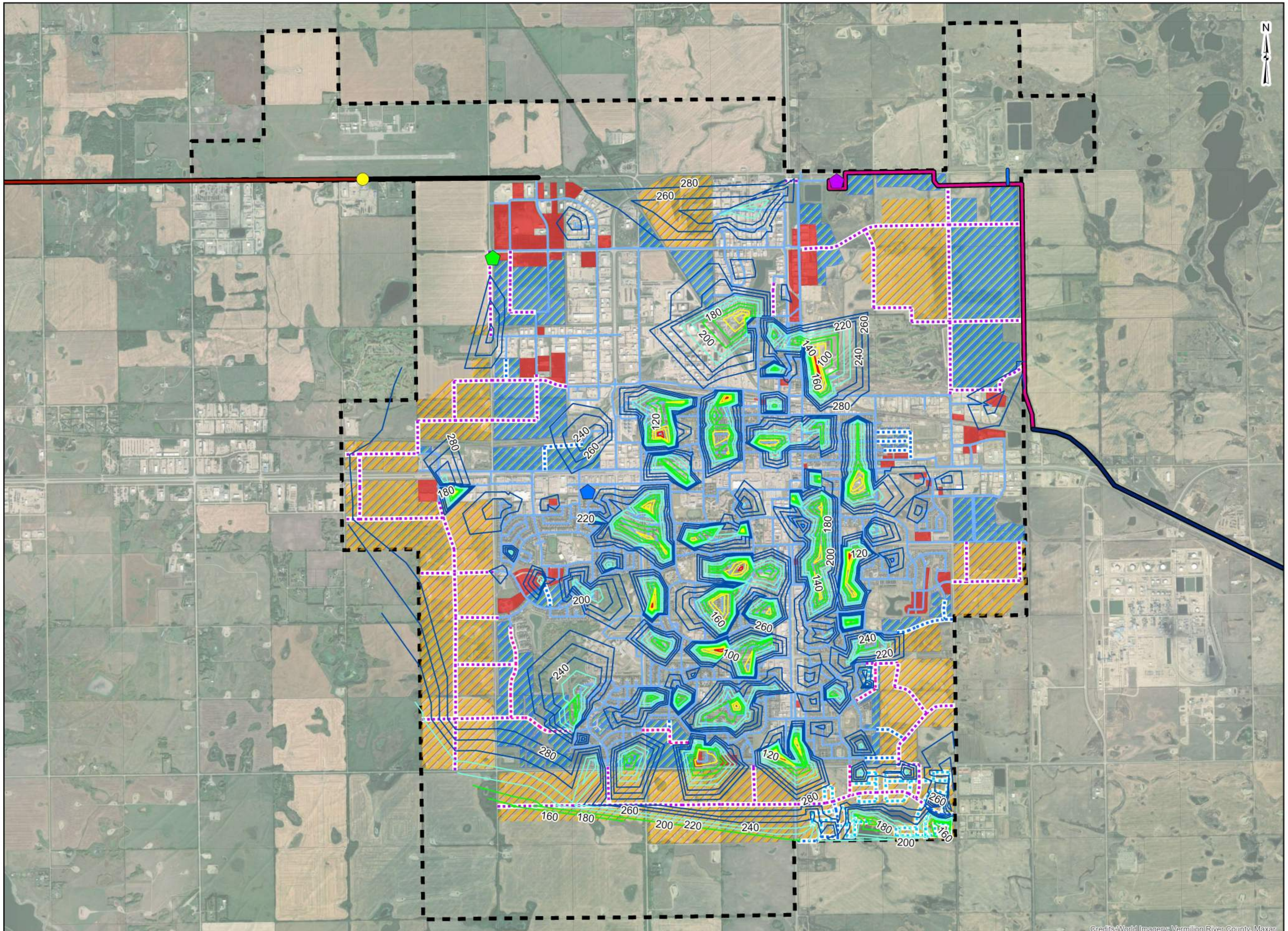

Legend

- Study Area
- Water Treatment Plant
- West End Reservoir
- Proposed Reservoir (Alternate to WER Upgrades)
- ACE Tie-in Location
- Existing Watermain

ACE Water Line

- ACE Water Line
- City of Lloydminster Owned ACE Water Line

SaskWater Line

- City of Lloydminster Owned SaskWater Line 450 mm
- City of Lloydminster Hydrant Service Line 250 mm
- SaskWater Line

Proposed Pipe Diameter

- 200 mm Watermain
- 250 mm Watermain
- 300 mm Watermain
- 400 mm Watermain

Future Parcel Tie-In

- New Service
- Existing Service
- Serviced But Vacant
- Airport Expansion

Fire Flow Contours

- Less than 100 L/s
- Between 100 and 150 L/s
- Between 150 and 185 L/s
- Between 185 and 225 L/s
- Between 225 and 300 L/s

Number on the contour indicates the available fire flow in L/s.

0 500 1,000 2,000 Meters

1:40,000 NAD 1983 UTM Zone 12N

FIGURE D.16
FUTURE 20 YEAR SERVICING CONCEPT
AVAILABLE FIRE FLOW DURING
MAX DAY DEMAND
LLOYDMINSTER WATER MASTER PLAN

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