Stantec

CITY OF RED DEER

WATER MODEL UPDATE

FINAL REPORT

June 29, 2023

Prepared for:
City of Red Deer
4914 48 Avenue
Red Deer AB T4N 3T3

Prepared by:
Stantec Consulting Ltd.
1100, 4900 50 Street
Red Deer AB T4N 1X7

Project Number: 110170064

Revision	Description	Author	Date	Quality Check	Date	Independent Review	Date
0	Final Draft Report	Johnny Ke	April 2023	Joel Sawatzky	April 2023	Todd Simenson	April 2023
1	Final Report	Johnny Ke	June 2023	Joel Sawatzky	June 2023	Todd Simenson	June 2023

Water Model Update
Final Report

This document entitled Water Model Update was prepared by Stantec Consulting Ltd. ("Stantec") for the account of City of Red Deer (the "Client"). The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by: Ahmed Sharaf, Ph.D., E.I.T., PMP

PROFESSIONAL ENGINEER ALBERTA
JOHNNY QINGSHENG KE
ID#103082
29 Jun. 2023

Prepared by: ______________________
Signature

Johnny Ke, M.Sc., P.Eng.
Printed Name

PROFESSIONAL ENGINEER ALBERTA
JOEL SAWATZKY
2023-06-29 112605

Quality Review by: ______________________
Signature

Joel Sawatzky, P.Eng.
Printed Name

Water Model Update
Final Report

PROFESSIONAL ENGINEER ALBERTA
TODD K. SIMENSON

Approved by: 65230 June 29, 2023

Signature

Todd Simenson, P.Eng.

Printed Name

Permit to Practice:

PERMIT TO PRACTICE
STANTEC CONSULTING LTD.
Signature
Date 2023-06-29 Member 65821
PERMIT NUMBER: P 0258
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

TABLE OF CONTENTS

List of Tables

List of Figures

Executive Summary

Stantec Consulting was retained to complete an update to the Water Model which also included performing an analysis on the existing system, various emergency response situations and to evaluate several growth scenarios. The City's water distribution system consists of four pressure zones as presented below with their nominal target Hydraulic Grade Line (HGL) elevations:

- Water Treatment Plant Pressure Zone (HGL 919 m)
- East Hill Pressure Zone (HGL 940 m)
- South Pressure Zone (HGL 930 m)
- Queens Business Park Pressure Zone (HGL 955 m)

Existing System Analysis

Overall, the City's existing water distribution system performs well during the Average Day Demand (ADD), Maximum Day Demand (MDD) and Peak Hour Demand (PHD) scenarios with only a few minor deficiencies found.

The analysis of the existing system showed that some pressures were outside of the design standards for both the MDD and PHD scenarios, however all were considered to be within an acceptable range. The reservoir fill analysis showed that the night filling practice led to distribution system pressures below the design standards, however they are also deemed to be within an acceptable range and no complaints have been received.

The Water Treatment Plant Pressure Zone HGL was once set a lower level at 917 m to minimize water loss, however, the hydraulic analysis shows that the HGL of the pressure zone should be set at 919 m to minimize the number of junctions with pressures below 300 kPa. In a similar case, the South Pressure Zone HGL was at 920 m. The hydraulic model results suggest that the HGL of the South Pressure Zone should be set at 924 m or higher to eliminate the pressures below 300 kPa.

The fire flow analysis was conducted on all the junctions in the model, and it was found that there are several areas that do not have sufficient available fire flows. However, addressing the deficiencies in the existing developed areas are not a high priority as the buildings have been in operation for decades. Although upgrading the watermains to address the fire flow deficiencies and other minor deficiencies is not a high priority, a comprehensive improvement list on the watermain upgrades is enclosed as **Appendix B**.

Based on the hydraulic model outcomes, pump capacities in the pump stations are not considered to be an issue with the delivery of fire flows in the existing system. The Glendale Pump Station is critical for the delivery of fire flows to the Edgar Industrial Area in the north-west corner of the Water Treatment Plant Pressure Zone. As a result, it is recommended that fire storage be maintained at all times at the Glendale Reservoir.

Emergency Analysis

The City took a proactive approach with emergency response planning and requested Stantec to complete a model analysis for various emergency scenarios. The goal of this task was to determine how the existing system including the WTP and all pump stations perform under these emergency conditions. Three emergency events were analyzed as follows:

1. Tracing analysis: assess how accidental spill contamination migrates
2. 900 mm Trunk Analysis: assess the impact when the 900 mm trunk is off-line
3. Fire Pump Analysis: assess the impact the system when the Olymel fire pump is running

Tracing Analysis Results and Conclusions

The results for the various on-line reservoir scenarios and the two demand scenarios (ADD and MDD) are presented in color coded trace percentage contour maps located in **Appendix C** which provide visual aids for the Operations team to prepare valve shut off plans, public notifications, etc. at the time of spill contamination. The following observations and conclusions can be drawn from the trace analysis for the above trace source, operational, and demand scenarios:

- Having different pressure zones using local pump/booster stations (e.g., East Hill and Queens Business Park Pressure Zones) or Pressure Reducing Valves (e.g., South Pressure Zone) creates barriers to the contaminant propagation until it reaches the water feeding point(s) of the pressure zone. Contamination migrates from the upstream pressure zone to the downstream zones, but not in the opposite direction.
- Once the contaminant migrates from a source and reaches another pump/booster station, the new station acts as a new trace node and the contaminant propagates faster in the downstream watermains.
- The South and Queens Business Park pressure zones are the least vulnerable to contamination sourcing from the WTP. The contaminant migrates to Queens Business Park Pressure Zone after the Queens Business Park reservoir is contaminated. The South Pressure Zone can be contaminated from Mountview and Lancaster.
- Being the main source of water to the water distribution system including the other pump/booster stations, the WTP reservoir and high lift pump station is the most critical as it leads to the greatest contaminant propagation. The Clearview pump station is the second most critical station as it is the main supply source to the East Hill and South pressure zones.
- The Clearview pump station can receive contamination from the WTP in 6-8 hours depending on the run time of pump/booster stations and the demand scenario.
- Minimal impact on the existing regional customers was observed when Glendale is the source node. The greatest impact is when the WTP is the source node as most of the regional flows are delivered directly from the WTP.

900 mm Trunk Analysis Conclusions and Recommendations

The 900 mm diameter trunk from the WTP high lift pump station was turned off in the existing system WaterCAD model under the maximum day demand scenario. The hydraulic simulation results indicated that:

- When the WTP high lift pump station's 900 mm discharge trunk is turned off, the flow delivered to the distribution system can only pass through the 500/400 mm diameter trunk.
- The 48-hour EPS model results indicated that, regardless of how full the water reservoirs (75%-100%) are initially and with or without the NRD regional demands, water pumped through the 500/400 trunk can meet the emergency LOS (minimum pressure of 140 kPa).
- When the shut-off valve in the NRD regional line is not closed, the PSV might shut off the regional flow when the residual pressure drops below 586 kPa.
- Although these model simulation results indicated that the distribution system can be operated without the 900 mm trunk to meet the emergency LOS (pressure higher than 140 kPa) within the 48 hours simulation, operating the system at lower pressure for such a long period of time would result in numerous low pressure complaints from water users in the City.
- Furthermore, there would not be the required available firefighting capacity throughout the City due to the low residual pressure and low water volume stored in the local reservoirs (the Glendale and Lancaster reservoirs were depleted). It is recommended the distribution operations team coordinate with the fire department for emergency planning for the 900 mm trunk off-line scenario.

The above analysis results were from the WaterCAD simulations with specific operating conditions. The City can explore other operating conditions by adjusting the settings in the WaterCAD model.

Fire Pump Operation Impacts

The WaterCAD model of the City's existing water distribution system was utilized to assess the impacts of the fire pump operation in the Olymel facility. The available fire flow was determined to be 281.7 L/s (4,465 gpm) in the Olymel facility site without compromising the pressure constraint of 20 psi. At 4,000 gpm (252.4 L/s), the minimum pressure observed was 156 kPa (22.6 psi). As such, the City should instruct the Olymel facility to control the fire flow so it does not exceed this limit, otherwise the pressure within the City's water system could drop below 20 psi. This can be achieved by installing a pressure gauge on the suction pipe of the pump to ensure that pressure would not drop below 20 psi. A alarm should be installed to alert the pump operator when the pressure drops close to 22 PSI.

When the Olymel fire pump is running, the available flow for firefighting at other locations in the vicinity will be reduced. The water model simulation indicated that the available fire flows will drop below 75 L/s in the Olymel neighborhood as presented in **Figure 5-10**. These results imply that there will not be sufficient flow in the area when two simultaneous fire events happen near the Olymel facility. However, there is a negligible drop in available fire flows in areas further away from the Olymel facility.

Growth Scenarios Analysis

The City has prioritized the development of three proposed growth areas: Queens Business Park, Hazlett Lake and the western area across of Hwy 2 of Hazlett Lake (Hazlett Lake west area). The City and Stantec took a collaborative approach to develop the six (6) growth scenarios and divided the three larger areas into 10 service areas which are presented in the following table below along with the total new area and projected demands. The 10 service areas are illustrated in **Figure 6-1**.

Scenario No.	Service Area										Total New Area (ha)	Current Standard MDD (l/s)	Relaxed Standard MDD (l/s)
	A	B	C	D	E	F	G	H	I	J			
1	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	560.0	191.2	148.1
2	✔	✔	✔	✔	✔		✔				250.1	121.1	99.4
3	✔	✔	✔	✔			✔	✔			276.3	124.8	103.9
4	✔	✔	✔	✔							165.7	96.6	83.1
5	✔	✔	✔						✔		178.1	94.2	81.5
6	✔	✔	✔		✔						183.4	101.1	86.1

Note: The "✔" symbol implies that the area is included in the growth scenario. The total new area excludes the existing developed area in Area A.

To postpone or delay the construction of the proposed North Reservoir/ Pump Station and its dedicated 900 mm diameter fill line, the hydraulic model was revised to extend the existing Queens Business Park distribution system to service the areas in the six growth scenarios. The local watermains were added into the WaterCAD hydraulic model based on the previous servicing studies. Stantec conducted and evaluated the hydraulic performance simulation with two sets of service standards - the current City servicing standards, and a set of relaxed standards. The model results indicated that, with the expanded distribution system, it is possible to service the all the growth areas with only a few upgrades in the system. The opinion of probable costs of the proposed upgrades are presented in the following table.

Upgrade No.	Recommended Upgrade Description	Opinion of Probable Cost (2023 CDN)
1	Install a new 600 mm / 500 mm transmission main connecting the Queens Pump Station discharge to the proposed watermains in the Hazlett Lake area. Install a PRV at the end of the transmission main before the connection.	$6.5M
2	Install a new 400 mm transmission main connecting the Queens Business Park Pump Station distribution main with the Hazlett Lake west area.	$0.8M
3	Install a 150 HP pump to Queens Business Park Pump Station	$1.2M
4	Expansion of Queens Business Park Reservoir storage by 2000 m^3	$2.0M
	Total	**$10.5 M**

The upgrade items 1 to 3 are needed for all the six growth scenarios. Item 4, the Queens Business Park Reservoir expansion, is only needed to support the full development of Growth Scenario 1 under the current design standards. If the actual demands are less than the demands projected with the current design standards, the reservoir storage expansion is not required. In the other growth scenarios, reservoir storage expansion is not necessary.

Considering that Edgar, Johnstone Park and Glendale subdivisions will have substandard (<300 kPa) residual pressures in the Growth scenarios, it is suggested the City install pressure loggers in the water pipes within these neighbourhoods to monitor the residual pressures as the development in the growth area advances. In-house booster pumps can be installed to boost the pressure in the buildings' plumbing systems if necessary. The developers should design the buildings according to low available fire flows in the west portion of Area I in Growth Scenario 5.

Abbreviations

AC	Asbestos Cement
ADD	Average Day Demand
CI	Cast Iron
DI	Ductile Iron
EHPZ	East Hill Pressure Zone
FF	Fire Flow
Ha	Hectare
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
HLPS	High Lift Pump Station (in the Water Treatment Plant)
HP	Horsepower
km	Kilometer
kPa	Kilopascals
kwh	Kilowatt Hour
L/s/ha	Liters per second per hectare
Lcpd	Liters per capita per day
MDD	Maximum Day Demand
MLD	Million Liters per Day
NRDRWSC	North Red Deer River Water Services Commission
O&M	Operation and Maintenance
PHD	Peak Hour Demand
PLC	Programmable Logic Controller
PRV	Pressure Reducing Valve
PSI	Pounds per square inch
PSV	Pressure Sustaining Valve
PVC	Polyvinyl Chloride
QPZ	Queens Business Park Pressure Zone
SCADA	Supervisory Control and Data Acquisition
SPZ	South Pressure Zone
TDH	Total Dynamic Head
VFD	Variable Frequency Drive
WTP	Water Treatment Plant
WTPPZ	Water Treatment Plant Pressure Zone

1 Introduction

The City of Red Deer (the City) delivers potable water to the users within the city and the regional customers - Red Deer County, and the North Red Deer River Water Services Commission (NRDRWSC) through the water distribution system. In 2013, Stantec completed the Water Distribution System Study which identified deficiencies within the existing system and proposed upgrades to the system and for the near future (infill and stage 1 development) and for the long-term future (stage 2 development). City staff have recently updated the hydraulic model including the pipe network, pumping operations, and consumption data up to and including the new infrastructure in 2021 using as-built data from the completed upgrades. The City has also completed hydrant flow testing at 21 locations across the City.

The City has requested further analysis on the existing system and future development scenarios. This scope of work is to utilize the recently updated model to:

- Review the existing model for a complete and thorough understanding.
- Verify the accuracy of the updated model through review and calibration.
- Perform an analysis and evaluate the existing system to optimize performance and gain operational efficiencies in the current transmission and distribution systems. This includes identifying the existing hydraulic performance deficiencies and proposing improvements and optimizations to increase the effectiveness and efficiency.
- Emergency planning and preparedness through pollutant trace simulation, an analysis with the 900 mm main from the Water Treatment Plant taken offline, and through fire flow analysis when the major fire pump at Olymel is in operation.
- Complete an analysis for various growth scenarios to better plan for future infrastructure requirements. This will include developing optimal servicing strategies for the possible growth scenarios in the north with the goal to delay major infrastructure upgrades while maintaining the level of service in the water distribution system.
- Provide a report that summarizes the analysis completed.

The City retained Stantec to complete the above scope of work in the following chapters:

- Existing Model Review and Model Calibration
- Existing System Analysis
- Emergency Response Analysis
- Growth Scenario Analysis

In the December 2021 kick off meeting, the City and Stantec agreed to submit the study progress in the form of the Chapters in the overall report, instead of independent technical memorandums.

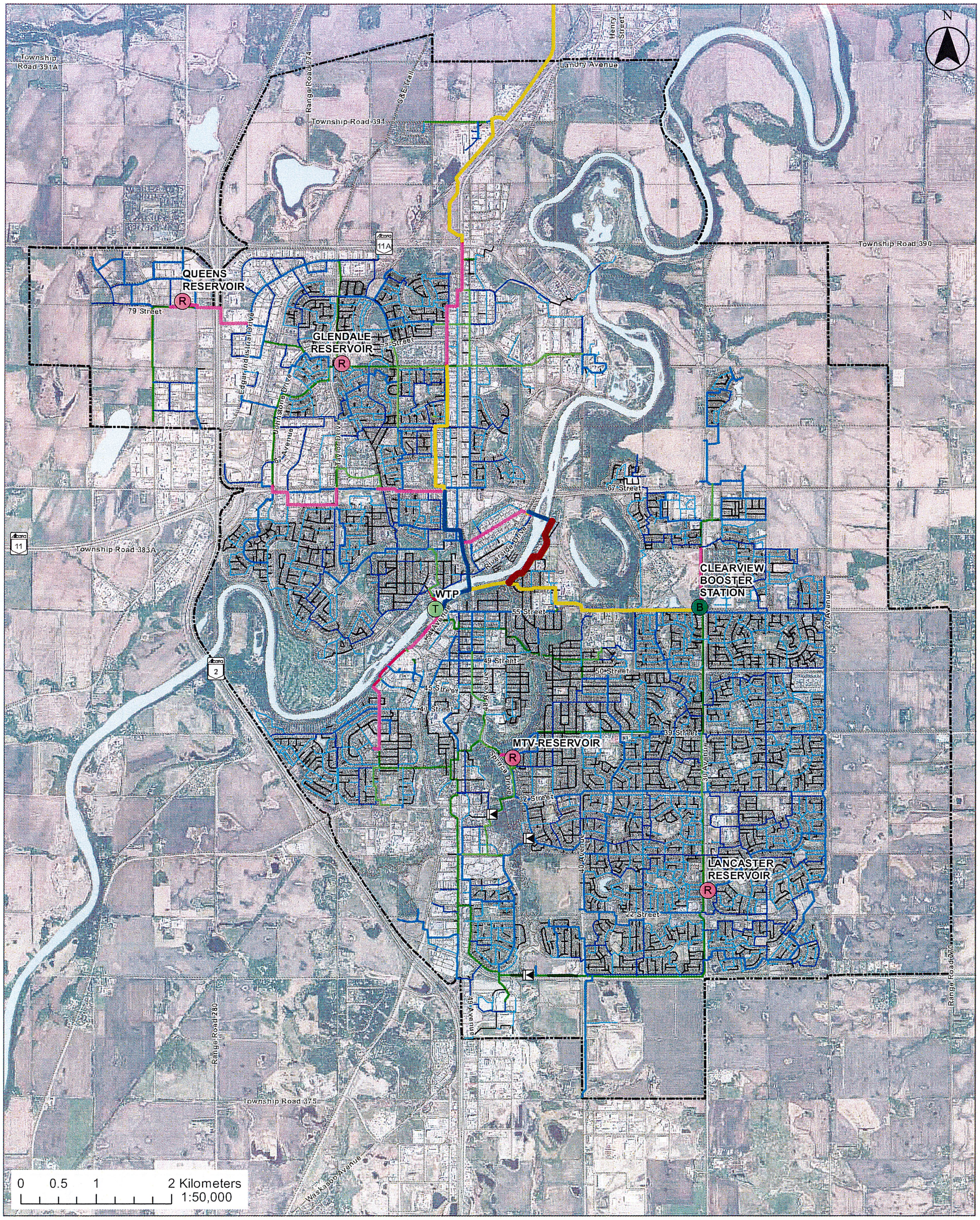
This 2023 final submittal contains the study results of all the chapters.

2 Existing Water Distribution System

Potable water for the City of Red Deer is diverted from the Red Deer River and treated at the City of Red Deer Water Treatment Plant located on 54 Avenue on the south side of the Red Deer River. The City of Red Deer currently operates with four pressure zones within the City boundaries, in addition to supplying water to the North Red Deer River Water Services Commission (NRDRWSC) and Red Deer County. There are six pumping facilities, five of which have reservoirs for water storage and one of which is an in-line booster station. **Figure 2-1** depicts the City's current water distribution system.

From 2013 to 2015 Stantec completed a Water Distribution Study for the City of Red Deer which included the development of hydraulic water models, evaluation of the City's 2013 system, and growth horizons for future development. The distribution system has been extended to service the new developments within the City limits.

The following sections provide a further detailed description of the City's pipe network, pressure zones, and facilities.



PRV

Red Deer City Limits

B Booster Station

R Reservoir

T Water Treatment Plant

Pipe Network Diameter

100 mm	350 mm	750 mm
150 mm	400 mm	900 mm
200 mm	450 mm	1050 mm
250 mm	500 mm	1200 mm
300 mm	600 mm	>1200 mm

Project No.: 110170064

Stantec

Figure 2.1: Existing Water Distribution System

Water Master Plan Update

City of Red Deer

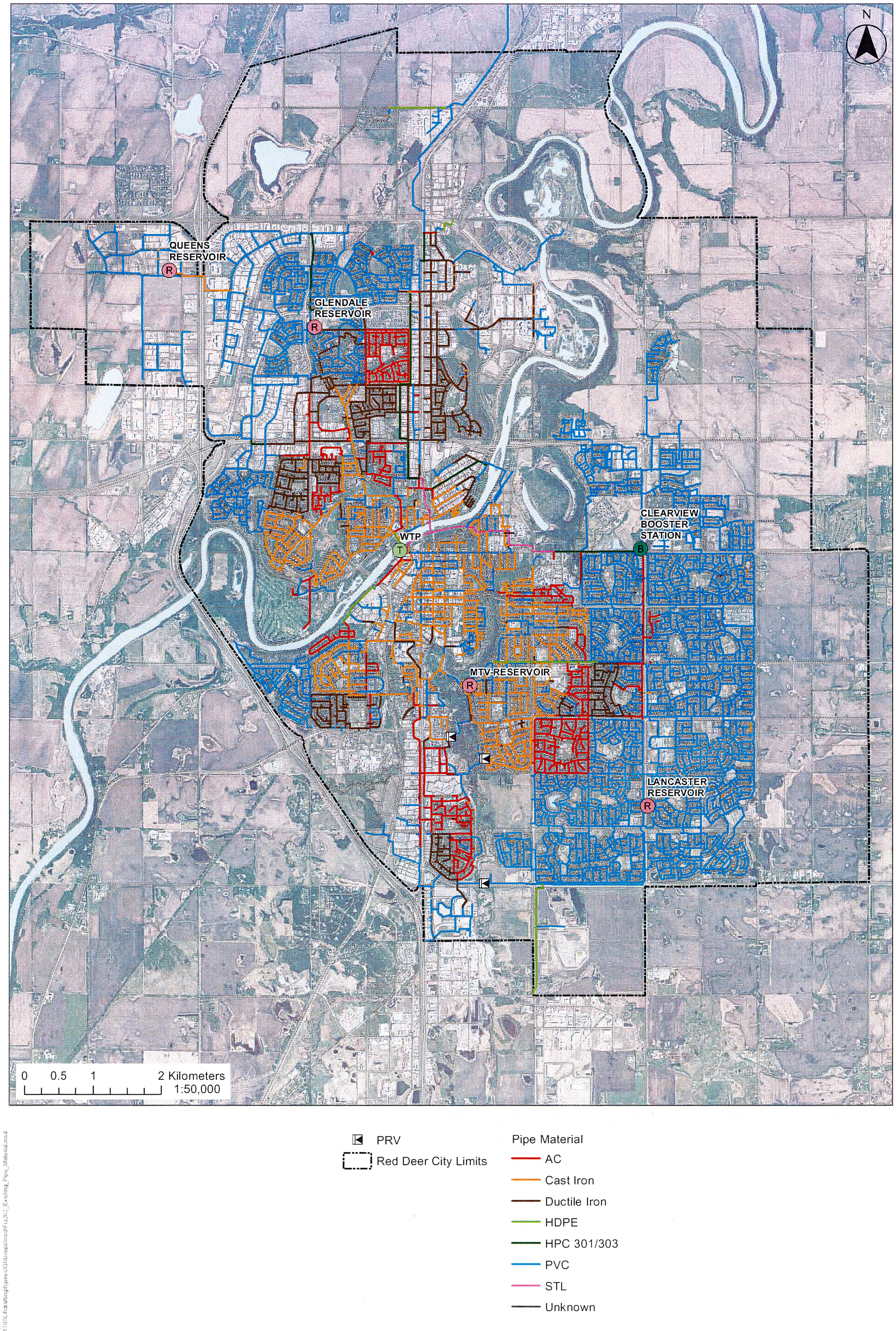
2.1 Pipe Network

The City's watermain network includes over 641 km of pipe varying in size from 100 mm to 1200 mm. The new pipe installed in the City's system is typically PVC unless there are special circumstances that require other pipe types such as HDPE for Horizontal Directional Drilling (HDD) installations. Many of the development areas within the City that are older than 30 years have cast Iron, ductile iron, and asbestos cement pipe. The cast iron pipe is the oldest pipe in the system which is typically in areas that are older than 50 years. **Figure 2-2** illustrates the pipe material types for the watermains (100 mm diameter or larger) within the current distribution system. **Table 2-1** presents a summary of pipe sizes and pipe types within the City of Red Deer's water system.

Table 2-1: Summary of Existing Watermain Type and Diameter

Pipe Dia. (mm)	Pipe Length (m)								
	Cast Iron (CI)	Ductile Iron (DI)	Asbestos Cement (AC)	PVC	HDPE	Steel	Concrete	Other/ unknown	Total
100	3,586	469	277	398	-	-	-	-	**4,730**
150	49,615	17,858	12,528	130,960	280	-	167	-	**211,408**
200	17,013	23,200	20,159	133,153	-	85	-	-	**193,610**
250	10,956	8,902	6,941	62,871	-	71	-	26	**89,767**
300	7,547	10,205	8,424	47,828	1,696	366	-	3	**76,069**
350	1,568	5,149	5,425	581	835	169	-	-	**13,727**
400	3,271	2,247	6,255	12,329	1,527	162	1,278	-	**27,069**
450	-	-	-	605	-	16	75	-	**696**
500	606	36	2,237	4030	-	168	2,354	-	**9,431**
600	-	-	-	-	567	54	-	-	**621**
750	-	-	-	4,832	-	2,175	3,215	-	**10,222**
900	-	-	-	341	-	1,431	672	-	**2,444**
1050	-	-	-	-	-	-	-	-	**0**
1200	-	-	-	920	-	-	-	-	**920**
Total	**94,162**	**68,066**	**62,246**	**398,848**	**4,905**	**4,697**	**7,761**	**29**	**640,714**

The watermains with their pipe material are presented in **Figure 2-2**.



Project No.: 110170064

Figure 2.2: Existing Pipe Material

Water Master Plan Update
City of Red Deer

2.2 Pressure Zones

The City's water distribution system consists of four pressure zones as presented below with their nominal target Hydraulic Grade Line (HGL) elevations:

- Water Treatment Plant Pressure Zone (HGL 919 m)
- East Hill Pressure Zone (HGL 940 m)
- South Pressure Zone (HGL 930 m)
- Queens Business Park Pressure Zone (HGL 950 m, future 955 m)

The pressure zones were established based on land topography and are regulated by pumping facilities and/or pressure reducing valves. **Figure 2-3** shows the coverage of the existing pressure zones.

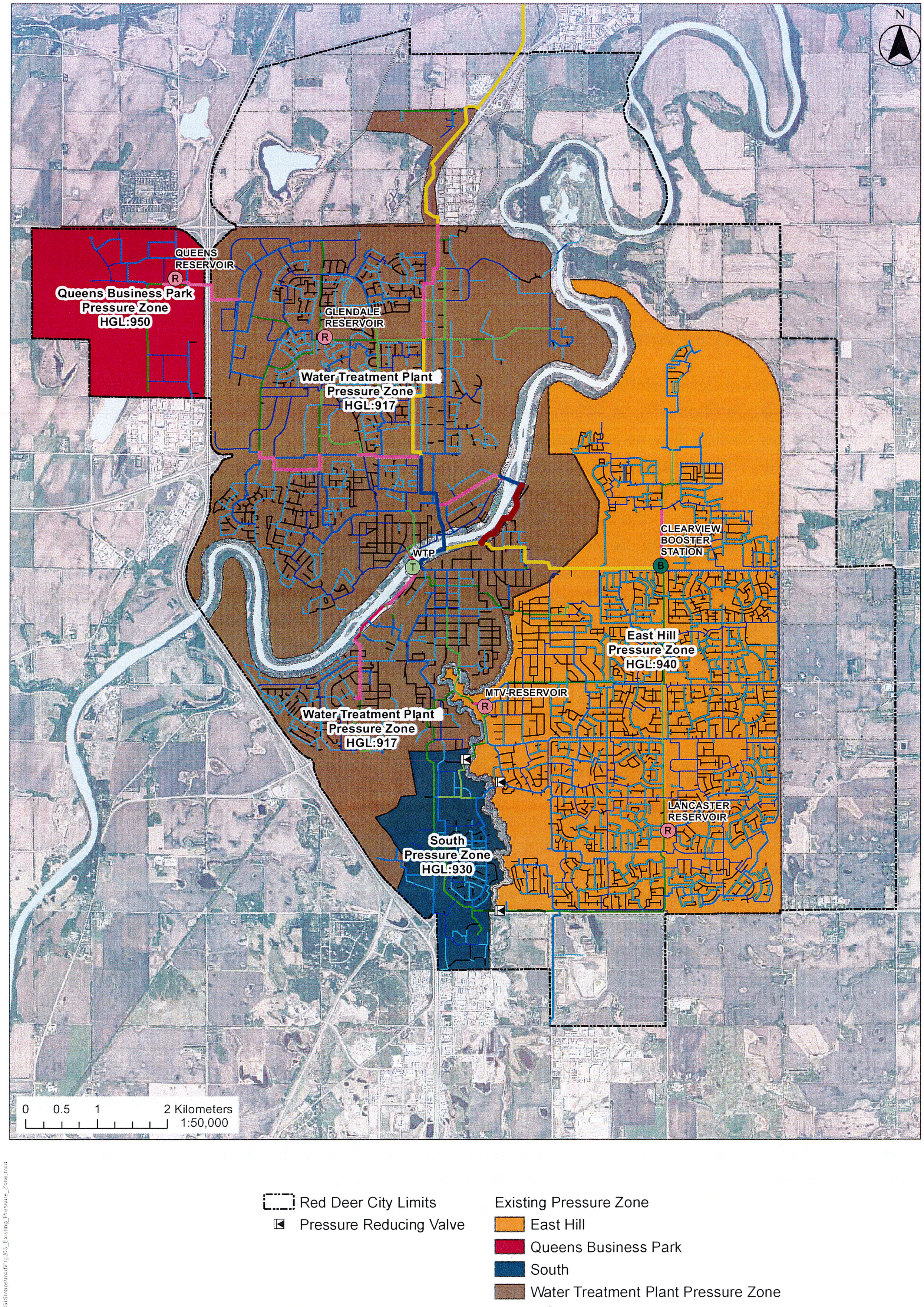
2.2.1 Water Treatment Plant Pressure Zone (WTPPZ HGL 919 m)

The Water Treatment Plant Pressure Zone (WTPPZ) is considered the largest pressure zone within the City. In addition to the High Lift Pump Station (HLPS), Clearwell Reservoir and Bellevue Reservoir within the WTP, this pressure zone contains the Glendale Reservoir and Pump Station. Ground surface elevations in the WTPPZ range from 846 m at the lowest area to 888 m at the highest point. The operational Hydraulic Grade Line (HGL) was set at 919 m but is currently lowered to 917 m in an effort to reduce the unaccountable water loss within the distribution system.

The Red Deer River divides the WTPPZ into south and north portions. The WTP HLPS is located in the downtown area, south bank of the Red Deer River. The HLPS delivers the treated water to the north portion through three river crossing trunks, including a 900 mm diameter steel pipe constructed in 1978, a 900 mm diameter HDPE pipe installed in 2007, and a 600 mm diameter HDPE pipe recently installed in 2020. The aged 200 mm and 400 mm diameter cast iron river crossing pipes were decommissioned following the installation of the 600 mm diameter HDPE pipe.

The majority of the time, the WTPPZ is dependent on the high lift pumps at the WTP to provide all flows and pressure to the zone. The Glendale Reservoir and Pump Station is located in the north section of the zone and is operated manually during periods of high demands to supplement the Water Treatment Plant. The Glendale Reservoir is filled from the distribution system during the night (typically 12 am to 6 am). The Mountview Pump Station, which is in the East Hill Pressure Zone, is also able to distribute water into WTPPZ.

Historically there has been times of low pressure in the WTPPZ in the north-west corner of the city surrounding the Glendale Reservoir and in Edgar Industrial Park. Ground surface elevations in the specific areas that experience lower pressures are in the range of 885 m to 888 m, which is high given the current hydraulic grade from the Water Treatment Plant is 917 m. These areas are typically just below the City's servicing standard of 300 kPa (43.5 psi) and are considered, acceptable for these specific circumstances.



Project No.: 110170064

Stantec

Figure 2.3: Existing Pressure Zones(2022)
Water Master Plan Update
City of Red Deer

Water for the North Red Deer River Water Services Commission (NRDRWSC) is fed from the WTPPZ through the Pressure Sustaining Valve (PSV) located south of the Blindman River, north of the current north city limit. The PSV is set to allow regional flow through at or higher than 87 PSI (600 kPa) and to shut off at 85 PSI (586 kPa).

2.2.2 East Hill Pressure Zone (EHPZ HGL 940 m)

The East Hill Pressure Zone (EHPZ) is located on the east side of a large plateau within the City of Red Deer with a target operation HGL at 940 m. Water is provided to the East Hill Pressure Zone from the Clearview Booster Station, Mountview Reservoir and Lancaster Reservoir. The Clearview Booster Station is connected to the 750mm trunk along the 55 Street, which is a branch from the WTP High Lift Pump Station discharge trunk. The Mountview Reservoir is filled from the 500 mm diameter pipe branching from the main along Spruce Drive in the Water Treatment Plant Pressure Zone. The Lancaster Reservoir is located within the East Hill Pressure Zone and is filled from the distribution system in the East Hill Pressure Zone during periods of low water demand. All water supplied to the Lancaster Reservoir has been pumped by either the Clearview Booster Station or the Mountview Pumping Station. The Lancaster Reservoir is filled during the night (typically 12 am to 6 am) and pumps water to assist with periods of high demand in the East Hill Pressure Zone.

The recently developed Garden Heights and Evergreen subdivisions are fed with a single watermain from the EHPZ. The City is planning to loop the distribution network into these two subdivisions in the future.

2.2.3 South Pressure Zone (SPZ HGL 930 m)

The South Pressure Zone (SPZ) is fed by the East Hill Pressure Zone through three pressure reducing valves (PRVs) in the three PRV chambers which are identified as the 47 Avenue PRV, Selkirk Boulevard PRV and 19 Street PRV chambers. There is no storage reservoir or pumping facilities within this Pressure Zone. The pressure reducing valves for the SPZ have a target HGL of 930 m. The SPZ is connected to the WTPPZ with one 400 mm diameter connection in the boulevard at 3310 Gaetz Avenue (west side of Gaetz Ave), and this connection is normally closed. Ground surface elevations in the SPZ range from 877 m at the lowest point and 891 m at the highest point. Currently, the SPZ HGL is set at 920 m.

2.2.4 Queens Business Park Pressure Zone (QPZ HGL 955 m)

The Queens Business Park Pressure Zone is located to the west of Highway 2 and services the Queens Business Park area. The Queens Business Park Reservoir and Pump Station is currently the only storage and pumping facility within the Queens Business Park Pressure Zone. The Queens Business Park Reservoir is filled with a dedicated supply line extended from the WTPPZ distribution system. Ground surface elevations in the Queens Business Park Pressure Zone range from 884 m at the lowest point to 923 m at the highest point. Currently the QPZ is operating at a HGL of 950 m. The ultimate design HGL of QPZ is 955 m.

2.3 Facilities

2.3.1 Water Treatment Plant and Bellevue Reservoir

The City of Red Deer WTP is located on 54 Avenue. The WTP High Lift Pump Station, sitting above the 6,000 m^3 underground reservoir, distributes the treated drinking water for the entire City of Red Deer water distribution system and the regional customers which are the NRDRWSC and Red Deer County. The pumps in the WTP High Lift Pump Station are vertical turbine pumps which are driven by Variable Frequency Drives (VFDs). There is one 350 Horsepower (HP), one 700 HP and two 900 HP pumps which are set to maintain the current target discharge header pressure of 630 kPa corresponding to a 917 m HGL.

The Bellevue reservoir is a cylinder-shaped reservoir located just north of the WTP on the north side of 55 Street. The reservoir building has a water storage capacity of 7,400 m^3. The reservoir has a 400 mm dedicated fill line and 600 mm dedicated return line, and it stores fully treated water. At a minimum, storage in the Bellevue Reservoir is cycled every second day.

The two local reservoirs in the WTP are filled by the WTP process which has a nominal treatment capacity of 120 MLD or 1,388 L/s.

2.3.2 Glendale Reservoir and Pumping Station

The Glendale Reservoir and Pumping Station was constructed in 1980 and is located in the north portion of the Water Treatment Plant Pressure Zone. The Glendale facility includes reservoir storage of approximately 9,500 m^3 and a pumping station. The upgrades in the Glendale Reservoir were completed in 2019, including replacement of pumps P2002 / P2003 / P2004 and removal of the gas generator for the P2001 pump and piping and electrical system retrofits. The pumps are horizontally installed split case pumps, with three 125 HP distribution pumps and one 200 HP emergency pump. Instrumentation is in place to monitor discharge flows, pressure, and reservoir levels.

Although the pumps are driven by VFD, operation of the Glendale facility is controlled manually by operations staff at the Water Treatment Plant. The operators select a pump or pumps with pre-set speeds based on the estimated demands in the area. City Operations indicated that the Glendale Pumping Station has been operating at a pressure range 330 to 360 kPa targeting an average hydraulic grade of 917 m.

The reservoir is filled from the distribution system in the WTPPZ which requires the reservoir to fill during off-peak hours which typically occurs from 12 am to 6 am (night filling). The operations staff indicated that the typical fill rate is set to 180 L/s. The Glendale facility is critical during peak demands and is not required during periods of low demand.

2.3.3 Clearview Booster Station

The Clearview Booster Station is located at 3010 55 Street and was originally constructed in 1977. It boosts pressure from the Water Treatment Plant to supply water to the East Hill Pressure Zone with water at a target hydraulic grade of 940 m. The operation of the Clearview Booster Station is automated based on the pressure in the East Hill Pressure Zone targeting a discharge header pressure 545 kPa.

The original configuration of the booster station has been modified with a major upgrade that was undertaken in 2013. The upgrade included the replacement of all the original pumps with four identical 125 HP in-line horizontal split case pumps which are driven by VFD. Each pump is rated at design point of 195 L/s at 37 m. A truck fill station was installed off the discharge piping in 2021.

Water to supply the Clearview Booster Station is provided through a 750 mm pipe extending from the Water Treatment Plant Pressure Zone. As an in-line booster station, the inlet flow always matches the discharge flow. The 750 mm connects to the four pumps' suction inlets. A pressure gauge in the suction header is utilized to monitor the residual pressure on the suction pipe. Any further increase in capacity to the Clearview Booster Station would require improvements to the facilities water supply, e.g., twinning the 750 mm pipe along 55 Street.

2.3.4 Lancaster Reservoir and Pumping Station

Built in 2003 and located in the south-east portion of the East Hill Pressure Zone, the Lancaster facility contains a reservoir with a storage capacity of approximately 10,500 m^3 within two cells and a pump station consisting of four 75 HP distribution pumps which are driven by VFD. Instrumentation is in place to monitor discharge flows and pressure, and reservoir water levels. A diesel generator is connected to an automatic transfer switch that supplies site power during utility power interruption.

The pump station is manually controlled by the City's operations staff at the Water Treatment Plant. The reservoir is filled from the distribution system in the East Hill Pressure Zone which requires the reservoir to fill during off-peak hours (typically from 12 am to 6 am). The typical fill rate is 150 L/s. The Lancaster facility is critical during peak demands and is not required during periods of low demand. Note that the pumps are VFD driven and can be switched from manual to automatic control mode.

The design of the Lancaster Reservoir included a plan for future expansion of the facility. The site has room for expansion of the reservoir and the facility has room for two additional distribution pumps. Based on the space available at the site, it is estimated that the reservoir could be expanded by 5,500 m^3 if required in the future.

2.3.5 Mountview Reservoir and Pumping Station

The Mountview Reservoir and Pumping Station is located at 3536 46 Avenue. Drawings of the facility date back to the late 1950's. The system includes storage capacity for approximately 10,450 m^3. In 2020, the Mountview pump station completed a major upgrade. Three 150 HP vertical split casing pumps were installed, and the piping system was overhauled. The retrofitted facility includes the following features:

- Fill the Mountview reservoir: WTPPZ distribution system can fill the Mountview Reservoir through the Flow Control Valve (FCV) 4012 in the 300 mm inlet, with Flow Element (FE) 4010 measuring the filling flow. The typical fill rate is set at 120 L/s.
- Distribute water to EHPZ: the three pumps can withdraw water from Mountview Reservoir through the common 500 mm discharge header with FE4016 recording the discharge rate.
- Distribute water to WTPPZ: the three pumps can also discharge water back to WTPPZ by reversing the flow in the 300 mm pipe. The FCV4012 should be closed, FV4013 is opened and the FE4010 is set to record the reversed flow in this scenario.

The pumps are equipped with VFD but currently are operated manually.

2.3.6 Queens Business Park Reservoir and Pumping Station

The construction of the Queens Business Park Reservoir and Pumping Station was completed in the fall of 2008. The reservoir houses a storage capacity of 6,500 m^3 divided in two cells. The Queens Business Park Reservoir is filled through the 500 mm pipe crossing the Highway 2. The 500 mm pipe is a branch from the distribution mains along Edgar Industrial Drive.

Four pumps were installed in the pumping station including one 75 HP pump, one 100 HP and two 150 HP vertical turbine pumps. All pumps installed at the Queens Business Park Pump Station are VFD driven. The pumps are programed to operate in automatic control model to maintain a target discharge header pressure. The distribution pump common header is cross connected to the dedicated 500 mm fill pipe within the pump station. Due to the low demands in the Queens Business Park subdivision, the modularized butterfly valve in the cross-connection pipe is slightly (5%) open to prevent the distribution pump from high frequent cycling (stop-start-stop).

The Queens Business Park Reservoir and Pumping Station was designed for an ultimate hydraulic grade of 955 m which would service eight quarter sections of land that were considered during the design of the facility. The pumping station is currently operating at a hydraulic grade of 950 m as an interim measure until the higher hydraulic grade is required.

2.3.7 Storage and Pumping Capacity Summary

Storage and distribution pumps for the facilities within the City of Red Deer Water Distribution System are summarized in the following Table. Additional details are provided in the sub-sections following the Table.

Table 2-2: Facilities Summary

Facility	Pressure Zone	Storage Volume	Distribution Pumps	Typical Operation Mode	Typical Fill Time and Rate
Water Treatment Plant	Water Treatment Plant (HGL 917 m)	13,400 m^3 (Clearwell 6,000m^3+Bellevue 7,400 m^3)	HLP 101 – 900 HP HLP 102 – 700 HP HLP 103 – 350 HP HLP 104 – 900 HP	Automatic to maintain the HGL	Continuous up to 1,388 L/s
Glendale Reservoir and Pumping Station	WTP (HGL 917 m)	9,500 m^3	GDR P1 – 200 HP GDR P2 – 125 HP GDR P3 – 125 HP GDR P4 – 125 HP	Remote manual control based on demands	Night fill (12-6 am) at 180 L/s
Clearview Booster Station	East Hill (HGL 940 m)	None	CLV P1001 – 125 HP CLV P1002 – 125 HP CLV P1003 – 125 HP CLV P1004 – 125 HP	Automatic to maintain the HGL	Inline booster
Lancaster Reservoir and Pumping Station	East Hill (HGL 940 m)	10,500 m^3	LAN P1 – 75 HP LAN P2 – 75 HP LAN P3 – 75 HP LAN P4 – 75 HP	Remote manual control based on demands	Night fill at 150 L/s
Mountview Reservoir and Pumping Station	East Hill (HGL 941 m)	10,400 m^3	MTV P1 – 150 HP MTV P2 – 150 HP MTV P3 – 150 HP	Remote manual control based on demands	Night fill at 120 L/s
Queens Business Park Reservoir and Pumping Station	Queens Business Park (HGL 950 m)	6,500 m^3	QBP P5011 – 75 HP QBP P5012 – 100 HP QBP P5013 – 150 HP QBP P5014 – 150 HP	Automatic to maintain the HGL	Continuous fill at 50 L/s

2.4 Water Billing and Flow Data Analysis

In this study, the City provided the 2016-2020 user meter billing data and the pump stations' SCADA data for analysis. The billing and flow data were compiled and analyzed to calculate various aspects of the demands of the distribution system operated by the City.

2.4.1 Per Capita Demands

The annual WTP High Lift Pump Station discharge flow rate and the billing records are presented in the following table along with the population and calculated per capita demands.

Table 2-3: Metered and Billed Average Day Demands Within the City

Year	Population	Metered ADD [1](m³/d)	Metered Per Capita ADD (Lcpd)	Billed ADD[2] (m³/d)	Billed Per Capita ADD (Lcpd)
2020	104,868	30,606	292	29,573	282
2019	104,713	30,937	295	28,763	275
2018	104,070	32,505	312	30,250	291
2017	103,377	32,224	312	29,564	286
2016	100,418	31,992	319	29,360	292
Average			306		285

Notes:

1. Metered ADD was calculated from the High Lift Pump Station discharge header flow meter, subtracting the NRDRWSC flow of 93 L/s (8,035 m^3/d) and Red Deer County flow of 11.3 L/s (973 m^3/d).
2. Billed ADD was calculated using the average daily flow from the billing records on the user meters.

As indicated in **Table 2-3**, the average per capita ADD for the last 5 years, including the billed demands and the unaccounted demands, is 306 Liters per Capita per day (Lcpd). Note that this per capita ADD is a composite unit rate that includes all the demands, including all the residential, commercial, institutional water demands within the City. The current City 2020 Design Guidelines indicate a standard or 375 Lcpd for residential development and a 0.15 liter per second per hectare (L/s/ha) for non-residential development. Compared to the calculated 306 Lcpd composite ADD, the design standard is conservative.

The difference between the averaged metered ADD and billed ADD is 21 Lcpd (306-285), implying that the unaccounted water consumption, e.g., pipe leakage, unbilled public water uses, is 6.8% of the metered ADD within the City.

2.4.2 Flow Patterns

2.4.2.1 Time Series Data Process

The 5-minute interval flow data from the six pumping facilities discharge meters were analyzed to calculate the peaking factors of the demands. All flows to fill reservoirs and to meet the City demands pass through the WTP High Lift Pump Station discharge header flow meter. In the EHPZ, the flow recorded in the Clearview discharge meter contains the filling flow to Lancaster reservoir in addition to the demands within the EPHPZ and SPZ. The flows to fill the reservoirs were comparable to the local demands in the system. The metered High Lift Pump Station flow data cannot be utilized to calculate the demand peaking factors within the City as the high filling rate is skewing the flow patterns. The filling rates should be separated from the local demand flows.

The separation of flow data was based on the following mass balance principle:

- Net demand flow in WTPPZ = Metered Flow in High Lift Pump Station – NRDRWSC flow – Clearview discharge flow – Filling flow to Mountview Reservoir – Filling flow to Glendale Reservoir – Filling flow to Queens Business Park Reservoir
- Net demand flow in EHPZ and SPZ = Clearview discharge flow + Mountview discharge flow + Lancaster discharge flow – Filling flows to Lancaster reservoir

Note that flow to Red Deer County is included in the EHPZ and SPZ demand as the flow is relatively low.

Based on the above mass balance, mathematical operations were applied to the time series flow data for every time step. As the time series NRDRWSC flow data is only available from April to December 2021, the mathematical operations on the time series are limited to that time period only. The calculated demands are presented in the following table.

Table 2-4: Calculated Local Demands Based on The Time Series Flow Data

Flows	Average Value (m3/hr)	Average Value (L/s)	Average Value (m3/d)	Percentage of Total
Total Local Demand Flow	1,684	468	40,416	100%
EHPZ + SPZ + County Demand	613	170	14,712	36%
NRD Demand	334	93	8,016	20%
QPZ Demand	87	24	2,088	5%
WTPPZ Demand	650	181	15,600	39%
WTP HLPS Metered Flow	1,684	468	40,416	100%

Note: NRD Demand = NRDRWSC flow

As indicated in the above table, the total local demand, which is the sum of the all the demands in the pressure zones within the City and its regional customers, equals to the WTP HLPS metered flow in the discharge header. This verifies that the time series calculation is correct.

The resulting net demand flow time series data is utilized to develop the peaking factors as shown in the following table. The net demand flow time series data was converted to different time steps to obtain the daily (1440-minute step) and hourly (60-minute step) values. The following figure presents the daily demand flows in cmh (m^3/hour).