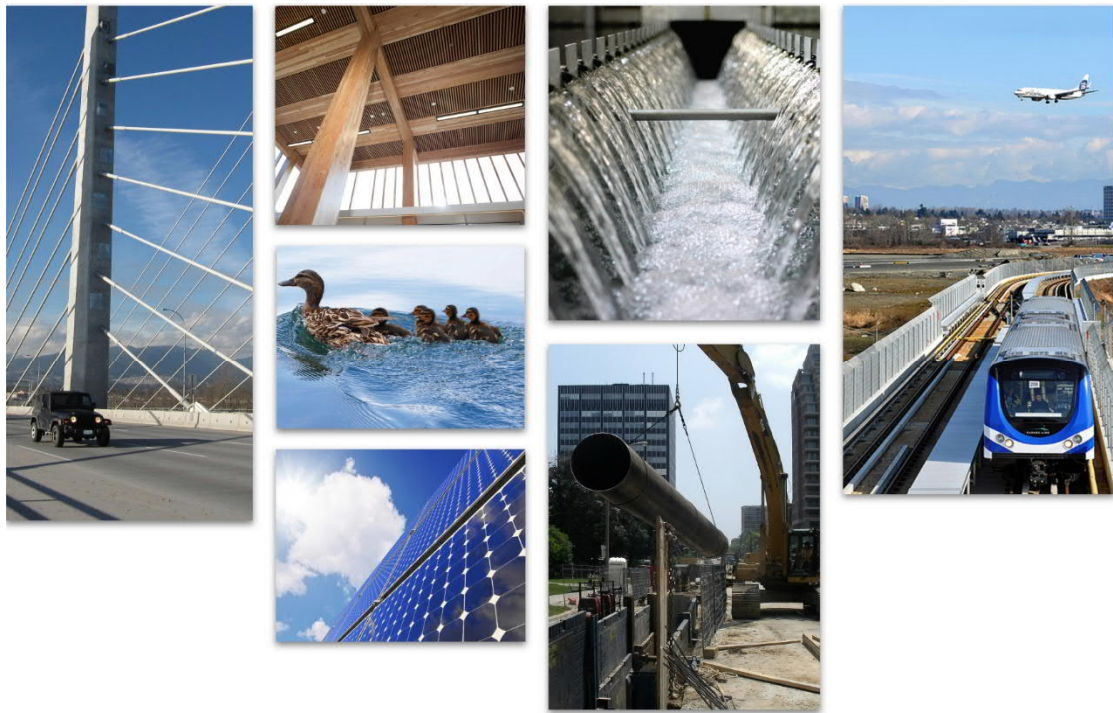


REPORT

City of Wetaskiwin

Utility Master Plan Update - Sanitary



JUNE 2021

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EXECUTIVE SUMMARY

The City of Wetaskiwin (the City) retained Associated Engineering to complete an update to their Sanitary Master Plan (2014), which includes an update to the City's existing sanitary model. The model updates will allow the City to plan and budget for infrastructure upgrades and system expansions to accommodate growth.

The project objective is to provide an update to the existing Sanitary Master Plan including planning and budgeting of infrastructure upgrades and system expansion to accommodate City growth. The scope of the project includes:

- Convert and update the existing sanitary model using PCSWMM software and the June 2018 Infrastructure Grid Map, respectively.
- Conduct a flow monitoring program over the summer of 2020 to obtain flow and rainfall data to calibrate and validate the model.
- Use the updated model to complete and document the following tasks for the City:
 - Identify and address any capacity issues within the existing system.
 - Use the future growth scenarios, which were previously created in collaboration with the City Planning Department, for the 2020 Water and Storm Master Plan updates.
 - Develop future sanitary models for the future growth scenarios, including an ultimate system scenario (future development to City limits).
 - Identify high-level sewer size requirements for future growth scenarios.
- Provide cost estimates for the recommended improvements to the existing system, system upgrades and future expansion.

The existing sanitary system within the City includes approximately 86 km of sewer pipe with over 1000 sanitary manholes. There are three sanitary lift stations (Moseson, Northeast and Southeast), six forcemains, and the Wastewater Lagoons. Both the Northeast and Southeast Lift Stations pump flow into the City's Wastewater Lagoons located in the northeast corner of the City. The existing sanitary model was developed in 2005 using XPSWMM software and was converted to a PCSWMM model in 2020 as part of this study. The PCSWMM model includes hydraulic network data consisting of pipes, manholes, orifices, pumps etc. as well as hydrologic parameters.

A flow monitoring program was conducted between May and October 2020. The program consisted of six monitoring sites in strategically selected locations within the sanitary sewer system, and two tipping-bucket style rain gauges. Associated Engineering completed extensive data processing and statistical analysis of the flow and rainfall data.

The Dry Weather Flow (DWF) model calibration results were found to be within 35% of observed flows, on average. Model validation results were found to be within 40% of observed flows. Based on these values, the model was considered slightly conservative with reasonable validation for DWF parameters. The Wet Weather Flow (WWF) calibration and validation was simulated for three of the largest storm events that occurred over the 2020 season (April to October).

The largest storm event during the flow monitoring period occurred on August 11, 2020 ($\approx$ 1:5-Year design storm event). However, due to the spatial variability of rainfall over an area, some Flow Monitors did not respond during this storm event. Therefore, the August 7, 2020 event was used as a second calibration event ($\approx$ 1:2-Year design storm event). Modelled peak flows were found to be within 10% of observed flows during the August 7 event and 50% of

observed flows during the August 11 event, on average. The model was validated with the June 30-July 1, 2020 storm event ($\approx$ 1:2-Year design storm event). Results showed that modelled and observed flows matched reasonably well at each monitoring site. On average, peak flows were found to be within 15% of the observed flows.

The existing system performance was assessed by simulating various design storm events. Overall, the existing sanitary sewer system provides close to a 1:100-Year level of service with no surcharge to ground. However, localized sections of pipes are over capacity for design storm events equal to or greater than the 1:5-Year 4-Hour design storm, specifically, the 47 Street/56 Avenue trunk. Shallow manholes exist within the central part of the City (City Centre and Central subdivisions), which could lead to basement flooding during a more severe storm.

Associated Engineering identified several required upgrades to the existing sanitary system based on the system's performance during a 1:100-Year, 4-Hour design storm event. These upgrades were mostly within the City Centre area and focused on increasing pipe capacity, changing pipe grades with zero or negative slopes, and lowering surcharge levels within shallow manholes. A capital cost of **\$7.4 Million** was developed in 2021 dollars to complete these upgrades. Note, this cost includes 30% Engineering and Contingency.

An Ultimate Future System Expansion Storm Servicing Concept was developed to service the three development stages and ultimate expansion for the City of Wetaskiwin. The concept outlines proposed upgrades to the existing sanitary sewer by including the estimated future flows from each growth area under the 1:100-Year, 4-Hour design storm event.

Some key conclusions and recommendations are as follows:

- Overall, the existing sanitary sewer system provides close to a 1:100-Year level of service with no surcharge to ground. However, localized sections of pipes are over capacity for design storm events equal to or greater than the 1:5-Year 4-Hour design storm event.
- Shallow manholes exist within the central part of the City (City Centre and Central subdivisions), which could lead to basement flooding during a more severe storm.
- The City implement a continuous sanitary sewer flow monitoring program.
- Additional calibration and validation of the developed model is recommended as more observed data becomes available.
- Several upgrades were proposed to address pipe capacity issues within the City's existing sanitary sewer system during the 1:100-Year design storm event. This provides a robust system to mitigate the impacts of climate change which increases the frequency of storm events within our region.
- Further refinement of each proposed existing sanitary system upgrade should be completed during preliminary design.
- Based on the information available to date, additional pumping capacity will be required at both the Northeast and Southeast Lift Stations for future development. The Northeast Lift Station is estimated to require an increase in the pumping capacity for Stage 1 development. The Southeast Lift Station will require an increase to the pumping capacity for ultimate development.
- The Ultimate Sanitary Servicing Concept be followed as development within the City progresses. Development should progress in an orderly manner with discouragement of "leap-frogging".

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1 INTRODUCTION

1.1 Background

The City of Wetaskiwin (the City) retained Associated Engineering to complete an update to their Sanitary Master Plan, which was last updated in 2014. As part of this update, Associated Engineering proposed to convert and update the City's existing sanitary model, which was last updated in 2005. The model updates will allow the City to plan and budget for infrastructure upgrades and system expansions to accommodate growth. **Figure 1-1** presents the project area.

The existing sanitary model was developed in 2005 using XPSWMM software and was converted to a PCSWMM model in 2020 as part of this study. PCSWMM is a fully dynamic computer model designed for simulating flows and water levels within sewer systems. It is capable of simulating real storm events, design flows, reverse flows, and surcharging/backwater conditions. The converted model was updated based on the June 2018 Infrastructure Grid Map and used to identify and address any capacity issues within the City's sanitary system. In addition, the model was used to plan for future growth of the City.

1.2 Study Area

The City of Wetaskiwin is located approximately 70 km south of the City of Edmonton. The present corporate boundaries encompass approximately 20 km². Refer to **Figure 1-1** for a Location Plan.

The topography of the area generally drains toward the east with the highest elevations occurring within the west portion of the City and the lowest elevations located within the northeast, near the wastewater lagoons.

The City Zoning Map (January 2018) was used for the existing developed areas to establish infiltration potential into the wastewater system. The City includes residential areas of various densities including single family homes, condominiums, and apartment complexes. In addition, there is an airport located within the southwest area of the City and an industrial area within the southeast. Concentrated commercial developments are located within the downtown core area along 50 Street and along Highway 13/2A (56 Street).

The City has an urban wastewater, or sanitary, collection system. The wastewater system includes gravity sewers ranging in size from 100 to 1200 mm in diameter, manholes, lift stations, and forcemains.

1.3 Project Objectives and Scope

The project objective is to provide an update to the existing Sanitary Master Plan including planning and budgeting of infrastructure upgrades and system expansion to accommodate City growth. The scope of the project includes:

- Convert and update the existing sanitary model using PCSWMM software and the June 2018 Infrastructure Grid Map, respectively.
- Conduct a flow monitoring program over the summer of 2020 to obtain flow and rainfall data to calibrate and validate the model.
- Use the updated model to complete and document the following tasks for the City:
 - Identify and address any capacity issues within the existing system.
 - Use the future growth scenarios, which were previously created in collaboration with the City Planning Department, for the 2020 Water and Storm Master Plan updates.

- Develop future sanitary models for the future growth scenarios, including an ultimate system scenario (future development to City limits).
- Identify high-level sewer size requirements for future growth scenarios.
- Provide cost estimates for the recommended improvements to the existing system, system upgrades and future expansion.

1.4 References

The following information was reviewed in preparation for this report:

1. Reynolds Alberta Museum Sanitary Servicing Final Report, Infrastructure Systems Ltd., November 1988
2. City of Wetaskiwin Sanitary Sewer Assessment, UMA Engineering Ltd., August 2005
3. City of Wetaskiwin Sewage Treatment Facility Study, Associated Engineering, December 2005
4. City of Wetaskiwin North East Lift Station Upgrades Preliminary Design, EXH Engineering Services Ltd., June 2006
5. City of Wetaskiwin Utilities System Overall Master Plan, MPE Engineering Ltd., April 2014
6. Flow Data Analysis, McElhanney, February 2019
7. City of Wetaskiwin Municipal Engineering Standards, December 2018
8. 2018 Infrastructure Grid Map

1.5 Abbreviations

Abbreviation	Phrase
ADWF	Average Dry Weather Flow
ASP	Area Structure Plan
DWF	Dry Weather Flow
FLAIR	Flow Approach Improvement Ramp
GIS	Geographic Information System
GLF	Grade Line Factors
GST	Goods and Services Tax
GPM	Gallons per Minute
ha	Hectares
HDPE	High Density Polyethylene
HGL	Hydraulic grade line
IDF	Intensity-Duration-Frequency
I/I	Inflow and Infiltration
km	Kilometre
km ²	Square kilometres
L/c/day	Liters per capita per day
L/ha/day	Liters per hectare per day
L/s	Litres per second
L/s/ha	Litres per second per hectare
m	Metre
m/s	Metres per second
m ³ /s	Cubic metres per second
m ²	Square metres
m ³	Cubic metres
mm	Millimetre
mm/hr	Millimetres per hour
PE	Polyethylene
PF	Peak Factor
PDWF	Peak Dry Weather Flow
PVC	Polyvinyl Chloride
R ²	Index of Determination
RDI	Rainwater-Dependent Inflow
RDII	Rainwater-Dependent Inflow and Infiltration
TLF	Theoretical Loading Factors
WWF	Wet Weather Flow

1.6 Previous Studies

1.6.1 Reynolds Alberta Museum Sanitary Servicing Final Report – Infrastructure Systems Ltd. 1988

This report outlines seven sanitary servicing options for the Reynolds Alberta Museum and adjacent developable lands west of the City. The study recommended the construction of a large diameter sanitary trunk around the south edge of the City to the Southeast Lift Station.

The Millard Street Main (referred to in this report as the 40 Avenue Trunk) was constructed in 1990, following this study, and flows along the southern City boundary into the Southeast Lift Station. This trunk services the Reynolds Alberta Museum and other developments within the south portion of the City. The 50 Street Lift Station and trunk, Lyalta Lift Station, and old Southeast Lift Station were decommissioned.

1.6.2 City of Wetaskiwin Sanitary Sewer Assessment – UMA Engineering Ltd. 2005

The 2005 Sanitary Sewer Assessment established a sanitary servicing plan to address the capacity of the existing system and future servicing requirements.

As part of this study, a model of the existing and future sanitary sewer systems was developed using XPSWMM software. The model was calibrated using rainfall and flow monitoring data collected from May to August 2004. Calibration of the dry weather flows was completed using monitored data from June 7 to June 9, 2004. The wet weather flows were calibrated using rainfall events on July 11 and July 25, 2004. These rainfall events corresponded to a 1:5-Year and 1:2-Year design storm event, respectively, based on the Edmonton International Airport Intensity-Duration-Frequency (IDF) curves. Additional flow and rainfall monitoring was recommended to verify the model calibration.

It was recommended to update the sanitary model as new data becomes available and for the City to adopt the 10-Year, 4-Hour rainfall event as the design storm event. In addition, recommendations were provided for areas within the existing system experiencing capacity issues. Recommendations for servicing of future developments and upgrades to the existing lift stations were also provided.

1.6.3 City of Wetaskiwin Sewage Treatment Facility Study – Associated Engineering 2005

This report outlines an assessment completed of the existing sewage treatment system within the City. The City identified problems within their sanitary treatment system, including plugged diffuser laterals, concrete deterioration in the intercell flow structures, failure of effluent discharge valves etc. Recommendations were outlined to improve the reliability and performance of the City's sewage facility. These include removing and spreading accumulated sludge from the lagoon cells, replacing plugged or leaking aerators, installing filter cloth and rip-rap within the cells for erosion control, replacing intercell flow structures, installing flushing connections and installing additional pumps, standby power, and gas monitors in the Northeast Lift Station.

In addition to the issues within the sanitary treatment system, a pending regulatory concern was also identified. At current wastewater flow rates, the City falls below Environment Canada's threshold for ammonia. However, with the proposed development of a new meat packing facility serviced by the City, the future flows will exceed this threshold. It was recommended for the City to consider lagoon improvements and higher-rate biological processes to remove ammonia.

1.6.4 City of Wetaskiwin Northeast Lift Station Upgrades Preliminary Design – EXH Engineering Services Ltd. 2006

This report outlines the preliminary design for the Northeast Lift Station to accommodate the future design flows, as recommended in the Sanitary Sewer Assessment study (UMA, 2005).

The Northeast Lift Station was constructed in 1976 as a wet well-dry well configuration. It was equipped with two pumps and a standby power generator capable of driving both pumps. The preliminary design of upgrading this lift station recommended upgrading the existing pumping system, installation of a newly upgraded pump, verification of the wet well volume, upgrading the power supply system, upgrading the standby power supply, and upgrading the control system.

The Northeast Lift Station upgrades were completed in 2007.

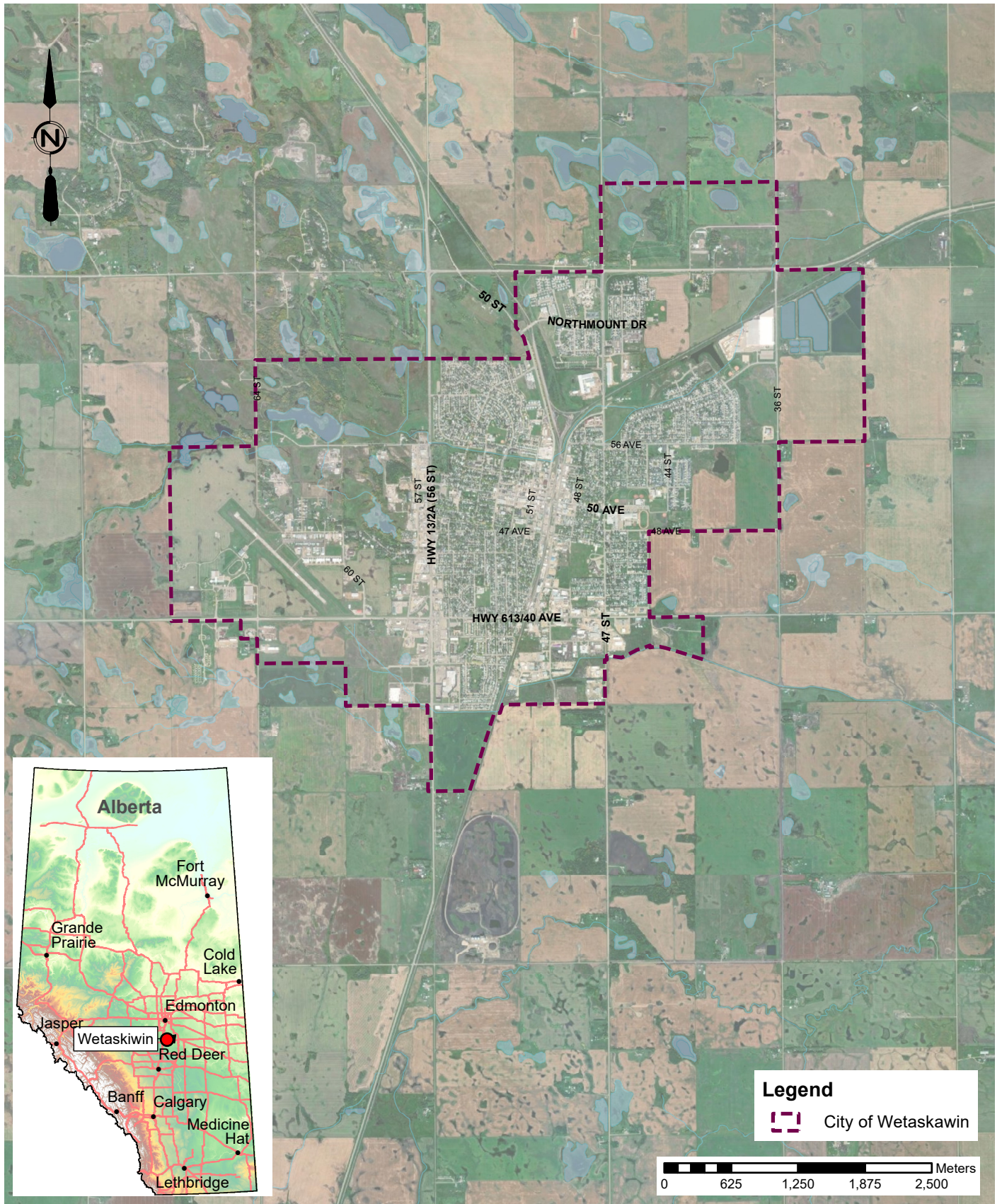
1.6.5 City of Wetaskiwin Utilities System Overall Master Plan – MPE Engineering Ltd. 2014

The 2014 Utilities System Overall Master Plan discusses the existing sanitary system, previous recommendations, modelling, and recommendations. The modelling included using FlowMaster Version 8 to model bottleneck areas, within the existing sanitary system, identified in the 2005 Sanitary Sewer Assessment. The 2004 XPSWMM model was not updated as part of this work.

The overall masterplan recommended replacements within the existing sanitary system to meet the 5 and 25-Year growth horizons. In addition, it was recommended for the City to complete a detailed study on the Southeast and Northeast Lift Stations. Recommendations for re-directing sewage were also outlined as well as implementation of an Inflow and Infiltration (I/I) program.

1.6.6 Flow Data Analysis – McElhanney 2019

The 2019 Flow Data Analysis technical memorandum discusses the validation of the sewer flows measured at the Wetaskiwin Northeast Lift Station and the Southeast Lift Station. Six sources of data were reviewed in the analysis to validate the flows, including record data, drawdown tests and lift station monitoring data. The analysis evaluated the difference sources to determine inconsistencies and identify reliable data sources to establish design flow criteria. The study concluded that record data for the Southeast Lift Station is accurate, while the Northeast Lift Station data is not. It was concluded that a plausible source of inaccuracy for the Northeast Lift Station lies within the record data (i.e.: likely an error within the measuring equipment). It was recommended that the City recalibrate or replace the Northeast Lift Station Doppler Flow Meter and conduct further analysis on I/I within their system.



PLOT DATE: 6/11/2021 2:30:15 PM
SAVE DATE: 5/11/2021 2:30:15 PM
DWG PATH: I:\edmgr\15-01\working\2020-3787-400\gcs\AcMap\Fig-1-1_ProjectArea.mxd

2 DESIGN CRITERIA

2.1 General

The City of Wetaskiwin Municipal Engineering Standards (December 2018) define the standards for sanitary sewers as follows ([Table 2-1](#)).

Table 2-1
City of Wetaskiwin Municipal Engineering Standards – Current Sanitary Sewer Design Criteria

Design Criteria	Value
Population Density	R1 Zoning (Single Dwelling) – 95 persons/ha R2 Zoning (Low Density Residential) – 105 persons/ha R3 Zoning (Medium Density Residential) – 230 persons/ha R4 Zoning (High Density Residential) – 250 persons/ha
Average Sewage Generation Rate	320 L/c/day
Peaking Factor	$1 + 14/(4 + \sqrt{P})$ where P = contributing population in 1,000s
Minimum Commercial/Institutional Peaking Factor	3.0
Average Commercial Sewage Generation Rate	40,000 L/ha/day
Average Industrial Sewage Generation Rate	20,000 L/ha/day
Inflow and Infiltration (I/I) Allowance	Inflow – 0.4 L/s for every manhole located within a sag Infiltration – 0.28 L/s/ha

Weeping tiles, roof leaders, and other stormwater connections are not permitted to tie-in to the sanitary sewer system.

The Engineering Standards include IDF values obtained from the Edmonton City Centre Airport curve data for 1984-2010. However, in 2018, EPCOR updated their IDF curves for the City of Edmonton encompassing 32 years of records (1984-2015). Therefore, it was recommended in the 2020 Stormwater Master Plan Update (Associated Engineering) that the City update their Municipal Engineering Standards to include the use of the most up-to-date IDF data for the region. Associated Engineering will use the 2018 EPCOR IDF curves for design storm event simulations within this study.

2.2 Gravity Sewers

The following standards apply to gravity sewers within the City.

- Minimum pipe diameter 200 mm in residential areas and 250 mm in industrial/commercial areas.
- Flow velocities should be between 0.6 and 3.0 m/s.
- Manning's roughness value of 0.013. This value was used for all gravity sewers represented in the PCSWMM model.
- Sewer capacity should not be less than the estimated design flow/0.86. However, existing sewer capacities with less capacity are accepted.
- Minimum pipe slope of the first upstream section should be a minimum of 0.6%. Minimum slopes in other sections shall follow [Table 2-2](#). However, existing slopes less than below are accepted.

- Maximum distance between manholes shall not exceed 120 m and are required at all changes in diameter, grade, direction, junctions, main ends, and either end of a curved sewer.
- Minimum drop of 12 mm shall be provided between manhole inlets and outlets. Drop structures are required where inlet and outlet elevations differ by 750 mm or greater.
- Pipe obverts (crowns) should be placed at the same elevation where changes in pipe diameter occur.
- Sewer mains shall be made of PVC or concrete.
- Manholes shall be a minimum 1200 mm diameter and made of reinforced concrete.

Table 2-2
Minimum Gravity Sewer Slope

Pipe Diameter (mm)	Minimum Slope (%)
200	0.40
250	0.28
300	0.22
375	0.15
450	0.12
≥525	0.10

2.3 Lift Stations and Forcemains

Gravity sewer systems shall be provided wherever possible to minimize operation and maintenance requirements for lift stations and forcemains within the City. Where necessary, forcemains shall be designed in accordance with watermain requirements and constructed from PVC or HDPE.

2.4 Dry Weather Flows

Existing domestic sanitary flows were calibrated in the updated PCSWMM model as described in [Section 5](#). The values differ from those in [Section 2.1](#) as they have been calibrated for specific land uses and areas within the City and include baseflows. These values represent a percentage of the water consumption demand based on historical records for the past 5 years which were summarized within the City of Wetaskiwin Water Master Plan Update (Associated Engineering, 2020). The calibrated values used in the model were as follows:

- Residential (low density) 200 L/c/day
- Residential (medium-high density) 125 L/c/day
- Commercial 5,250 L/ha/day
- Industrial 7,920 L/ha/day
- Institutional 4,000 L/ha/day

Population densities were used to estimate the population for residential land use areas. These values also differ from those in [Section 2.1](#). These values were used in conjunction with the per capita daily sewage generation rate above to estimate the flows within the sanitary system. The residential population densities developed within the City of Wetaskiwin Water Master Plan Update (Associated Engineering, 2020) were used as follows:

Single Family Residential/Low Density Residential (R1, R1A, R1N, R1R, R2, MH, PUD, RE, RMX, MH)	40 people/ha
Multi-Family Residential/Medium Density Residential (R3)	80 people/ha
High Density Residential (walk-up apartments) (R4, R5)	200 people/ha

The diurnal variation of dry weather flow (DWF) was modelled using diurnal curves developed based on the 2020 flow monitoring data and compared to the 2005 XPSWMM model inputs. These diurnal curves represent the hourly variation of flow relative to the average flow and are discussed in more detail in [Section 5](#).

It is recommended that the City of Wetaskiwin Municipal Engineering Standards continue to be used by developers for design purposes of all new local and lateral sewers.

2.5 Wet Weather Flows

The wet weather flow (WWF) includes the sanitary or DWF described above and the I/I component generated by rainwater entering the sewer system through manhole vents and joints, pipe joints, and house weeping tiles. Prior to 2005, house weeping tiles within Wetaskiwin were typically connected to the sanitary sewer system and have been found to generate significant inflow rates during storm events.

WWF simulation within PCSWMM is discussed further in [Section 5](#). The I/I components were calibrated using rainfall and sewer flow data from the 2020 flow monitoring program. It is recommended that the City of Wetaskiwin Municipal Engineering Standards continue to be used by developers for design purposes of all new local and lateral sewers.

2.6 Land Use

The existing land use was provided by the City. The population densities and average sewage generation rates established above were applied in conjunction with land use for each City parcel to establish the system flows to each sanitary sewer manhole.

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3 EXISTING SANITARY SEWER SYSTEM

3.1 Existing Facilities

The existing sanitary system within the City includes approximately 86 km of sewer pipe with over 1000 sanitary manholes. There are three sanitary lift stations (Moseson, Northeast and Southeast), six forcemains, and the Wastewater Lagoons. Both the Northeast and Southeast Lift Stations pump flow into the City's Wastewater Lagoons located in the northeast corner of the City. **Figure 3-1** shows the existing sanitary system and land use. The existing collection system is made up of three main trunks:

- The 56 Avenue Trunk;
- The Garden Meadows Trunk; and
- The 40 Avenue Trunk.

The 56 Avenue Trunk begins at 57 Street and runs east along 56 Avenue to 51 Street, north along 51 Street, and eventually turning east and connecting to Garden Meadows Drive at Garnet Crescent. The trunk varies in size from 600 mm to 675 mm in diameter. The 56 Avenue Trunk services residential land use in the northwest corner of the City, as well as some highway commercial areas along 56 Street.

The Garden Meadows Trunk begins at 47 Street and 56 Avenue and flows northeast along Garden Meadows Drive eventually into the Northeast Lift Station. The trunk varies in size from 600 mm to 1200 mm in diameter. The Garden Meadows trunk conveys flow from other smaller trunks within the City, namely the 56 Avenue Trunk, the Downtown Trunk (50 Street and 44 Avenue to 47 Street and 56 Avenue), and the Parkside Trunk (Wetaskiwin Civic Centre – 50 Avenue to 44 Street and 56 Avenue). This trunk services the north and central areas of the City including a mix of mostly residential and downtown commercial land uses.

The 40 Avenue Trunk begins at the Reynolds Alberta Museum on the west side of the City and flows along the southern City boundary into the Southeast Lift Station. The trunk varies in size from 300 mm to 1050 mm in diameter. The 40 Avenue Trunk services a mix of residential, commercial, and industrial land uses within the south portion of the City. Future developments within the south and west City boundaries are proposed to be serviced by this trunk as development progresses.

The Northeast Lift Station, located east of 36 Street and north of Garden Meadows Drive, contains three pumps: two 3890-GPM Patterson Pumps and one Chicago pump (OSC 10) which were installed in 2009. One Patterson Pump was rebuilt with a new impeller in 2015. The wet well dimensions are reported as 5.3 m by 3.1 m.

The Southeast Lift Station, located at Range Road 240 north of 40 Avenue, contains three 2100-GPM Aurora pumps (Aurora 614A) which were rebuilt in 2008. A 500 mm diameter forcemain pumps flows from the Lift Station into the Wastewater Lagoons. The wet well dimensions are reported as 5.7 m by 4.2 m.

The Moseson Lift Station, located on 48 Street between 48 and 49 Avenues, pumps flows into the Downtown Trunk via a 200 mm forcemain. There are two 75-GPM pumps (Flygt NT3102.181) installed in 2010 and 2014, respectively. The wet well dimensions are reported as 2.8 m by 1.1 m.

Prior to 2001, house weeping tiles were typically connected to the sanitary sewer system in Wetaskiwin. According to the 2005 Sanitary Sewer Assessment, despite the City discouraging weeping tile connections since 2001, newer properties still included the connections. The 2005 XPSWMM model was built assuming 100% of the residential areas had weeping tile connections. Based on discussions with the City in 2021, we have assumed that weeping tiles exist in all developments prior to 2005. Areas added to the model as part of the Master Plan Update have been assumed to provide sump pumps that drain overland and do not enter the sanitary system.

3.2 Model Update

The existing model, which was developed for the Sanitary Sewer Assessment in 2005, was updated as part of this project. The model update consisted of the following:

- Conversion from XPSWMM to PCSWMM model.
- New sanitary systems constructed after 2005 based on the June 2018 Infrastructure Grid Map and record drawings provided by the City.
- Low flow assessment.
- Model calibration and validation (discussed in [Section 5](#)).

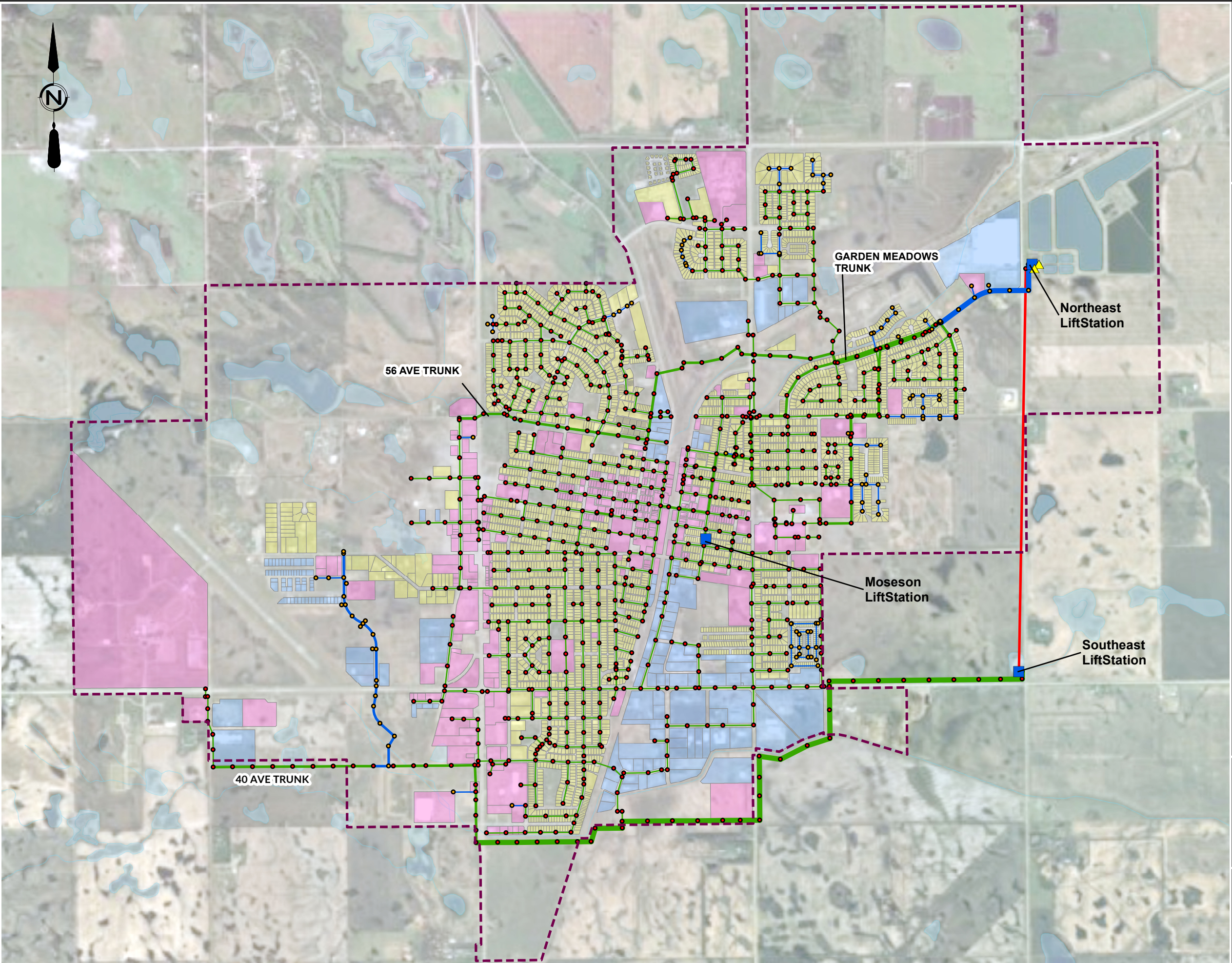
As previously highlighted, PCSWMM is a 1D fully dynamic computer software designed for simulating flows and levels within sewer systems. This software is capable of simulating real storm events, design flows, reverse flows, forcemains, pump stations and surcharging/backwater conditions. The sanitary network layers from the July 2018 Infrastructure Grid map were superimposed and compared to the model layers within GIS after conversion from the existing XPSWMM model to the PCSWMM model. The new sanitary systems within the City which were constructed after 2005 are presented in [Figure 3-1](#).

Land use and population densities for the developed areas were updated within the converted model based on the design criteria outlined in [Section 2](#). DWF contributing areas were aggregated from the cadastre GIS layer provided by the City. Each contributing area was assigned to the closest manhole using GIS tools and SQL coding language. The contributing area for I/I includes the DWF catchments and road areas based on a buffered City roadway drawing. Road area was assigned to manholes on each road.

There is a 75 mm PE low-pressure sewer servicing the country residential and residential mixed-use lots between 62 Street and 61 Street north of 47 Avenue on the west side of the City within the Annexation 92 lands. The low-pressure sewer system was not modelled explicitly; however, this area was represented within the model as a lumped catchment contributing to the gravity sewer starting at 62 Street and 47 Avenue.

Based on discussions with the City, the other country residential lots on the west side of the City were not serviced by the City's sanitary sewer system. Therefore, they were excluded from the modelled area. The excluded areas consist of the By-the-Lake Park building facilities and properties along 64 Street, 56 Avenue, and 47 Avenue. Areas contributing DWF are illustrated in [Figure 3-1](#).

The PCSWMM model includes hydraulic network data consisting of pipes, manholes, orifices, pumps etc. as well as hydrologic parameters. Most hydraulic network data was available within the Infrastructure Grid Map and provided record drawings. Where data was missing, engineering judgement was used. Hydrologic parameters for diurnal patterns and unit hydrographs for computation of DWFs and WWFs were based on local experience and calibration to the flow monitoring data discussed in [Section 5](#).



Legend

 Sanitary Lagoon

 Sanitary Lift Station

 Sanitary Manhole added 2020

 Sanitary Manhole

 Sanitary Forcemain

 City of Wetaskawin

Sanitary Pipe added 2020 (diameter)

 <375

 375 - 675

 >675 - 1200

Sanitary Pipe (diameter)

 <375

 375 - 675

 >675 - 1050

Land Use Parcel

 Residential

 Commercial/Institutional

 Industrial

FIGURE 3-1

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

EXISTING SANITARY SEWER COLLECTION SYSTEM

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL

4 FLOW MONITORING PROGRAM

As part of the update to the City's Sanitary Master Plan, a Flow Monitoring Program was required. Associated Engineering partnered with SFE Global Inc. (SFE) to conduct flow monitoring within the City between May and October 2020. The objective of the monitoring program was to collect reliable flow data within the sanitary sewer system for model calibration and validation of flows. The 2020 flow monitoring program consisted of six monitoring sites in strategically selected locations within the sanitary sewer system, and two tipping-bucket style rain gauges. SFE installed and operated the equipment. In addition, they collected the flow monitoring data and maintained an online database. Associated Engineering provided the following services pertinent to the Flow Monitoring Program:

- Project Management;
- Flow and rainfall data processing;
- Quality control and assurance; and
- Finalized flow and rainfall database.

4.1 Flow Monitor and Rain Gauge Locations

Figure 4-1 shows the location of the flow monitors and rain gauges that were installed and operated in 2020.

Appendix A provides detailed maps of each site. **Table 4-1** provides an overview of each site, its instrumentation and operation. Associated Engineering chose flow monitor locations based on system characteristics (e.g.: pipe size, slope) and catchment characteristics (e.g.: land use, area). The flow monitors were installed in late April and removed in late October 2020.

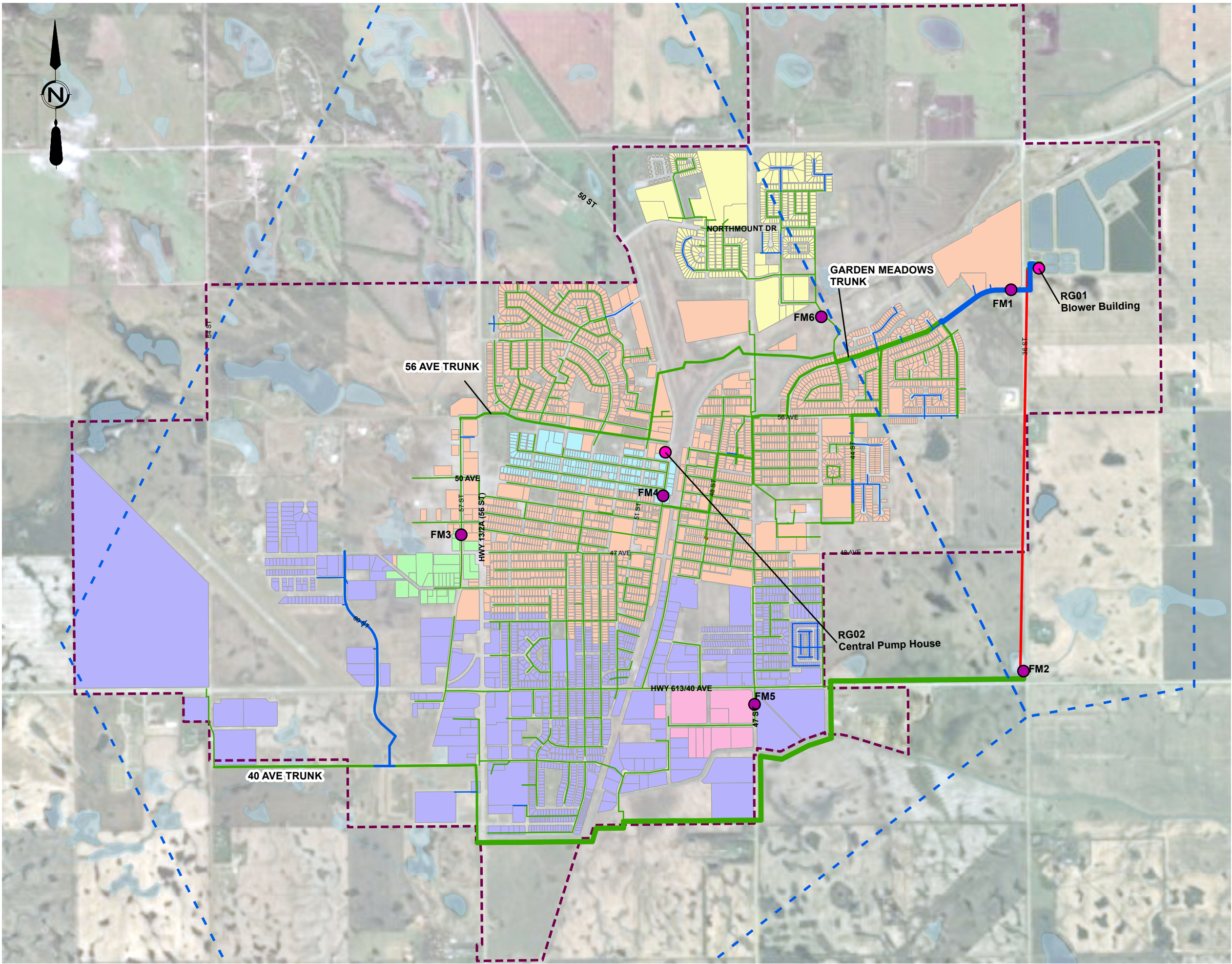
4.2 Flow Monitor and Rain Gauge Catchment Areas

Figure 4-1 illustrates the estimated catchment areas for each flow monitor. **Table 4-1** provides a summary of the estimated catchment area and land use for each flow monitor site.

Flow Monitors 1 and 2 are located upstream of the Northeast and Southeast Lift Stations, respectively. Therefore, these monitor catchments include the entire City of Wetaskiwin encompassing residential, commercial, industrial, and institutional land uses. The Flow Monitor 1 catchment area includes Flow Monitors 3, 4, and 6. The Flow Monitor 2 catchment area includes Flow Monitor 5.

Flow Monitor 3 services a mixed residential and commercial land use catchment on the west side of the City. Flow Monitor 4 has a primarily residential catchment within the Old Centennial and City Centre North West neighbourhoods which also includes some institutional land use and a small amount of industrial area along 50 Street. The catchment area for Flow Monitor 5 is made up entirely of light industrial land use located within the Southeast Industrial Park. Flow Monitor 6 services a large residential area north of the railway within the Northmount and Aspen Ridge neighbourhoods which includes the hospital, commercial, and industrial areas.

In addition, **Figure 4-1** illustrates the approximate area of influence for Rain Gauges 1 and 2 determined using GIS tools.



- Legend**
- Rain Gauges
 - Flow Monitor Locations
 - Sanitary Forcemain
 - Estimated Rain Gauge Area of Influence
 - City of Wetaskawin
- Sanitary Pipe added 2020 (diameter)**
- <375
 - 375 - 675
 - >675 - 1200
- Sanitary Pipe (diameter)**
- <375
 - 375 - 675
 - >675 - 1050
- Estimated Flow Monitor Catchment**
- Monitor 1
 - Monitor 2
 - Monitor 3
 - Monitor 4
 - Monitor 5
 - Monitor 6

FIGURE 4-1

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

2020 MONITORING PROGRAM LOCATIONS

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL

Table 4-1

Wetaskiwin Sanitary Flow Monitor Summary

SITE	PIPE SIZE (mm)	PIPE ASSET ID (NAME)	LOCATION	INSTALL DATE	REMOVAL DATE	Total Catchment Area (ha)	Landuse Area (ha)				
							Residential	Commercial	Industrial	Institutional	Road Area
01	1200	C_2020_63	North of Garden Meadows Drive and West of the Home Hardware Parking Lot	07-May-20	29-Oct-20	399.5	216.3	36.0	40.7	45.4	61.1
02	1050	1244	Northwest of the intersection of Range Road 240 and HWY 613 near the SE Lift Station	29-Apr-20	29-Oct-20	330.9	73.0	40.6	94.6	100.9	21.9
03	250	1386	South of the intersection at 48 Avenue and 57 Street	29-Apr-20	29-Oct-20	12.9	7.7	4.4	0.0	0.0	0.8
04	375	1499	South of the intersection at 51 Avenue and 50 Street	29-Apr-20	29-Oct-20	21.8	9.2	4.2	0.3	3.5	4.7
05	250	1211	South of the intersection at 48 Avenue and 47 Street	29-Apr-20	29-Oct-20	17.6	0.0	0.0	16.1	0.0	1.5
06	300	1920	South of 63 Avenue	29-Apr-20	16-Oct-20	58.7	32.2	1.0	7.1	12.8	5.5
RG01			Blower Building	29-Apr-20	29-Oct-20						
RG02			Central Pump House	29-Apr-20	29-Oct-20						

4.3 Instrumentation

4.3.1 Flow Monitors

Area-Velocity meters were used at each flow monitor site. This type of monitor uses a pressure sensor to measure depth and an ultrasonic velocity sensor to measure velocity under both full and partially-full gravity pipe conditions. In addition, two sensors were installed at each site to provide backup and quality control data where variable flows or sediment accumulation has the potential to occur.

All sites were inspected and cleaned during bi-weekly maintenance visits and manual depth and velocity measurements were taken to verify meter operations and accuracy. Any required repairs or maintenance were made at these times. All monitor data was compiled automatically and posted to an online database. Associated Engineering reviewed this data on a bi-weekly basis for quality control and provided SFE with maintenance requests.

During installation, SFE noted debris and sediment accumulation at several flow monitor sites. Flow Monitor 6 was required to be moved in the field due to debris in the initially selected manhole. In addition, a FLAIR device was installed at Flow Monitor 3 and 5 on June 11, 2020. The FLAIR device – short for [Flow Approach Improvement Ramp](#) – is a flow conditioning device developed by Associated Engineering that has been used in several previous projects ([Photo 4-1](#)). This is a weir that creates uniform flow conditions at the sensor and improves the accuracy of the flow meter measurements. These are typically required when monitoring flow within smaller diameter pipes (e.g. less than 300 mm in diameter).



**Photo 4-1
FLAIR Device**

4.3.2 Rain Gauges

Two tipping-bucket rain gauges were installed to measure rainfall rates, which vary substantially over time and space during storm events. The gauges were installed on the Blower Building near the wastewater lagoons (RG01) and on the Central Pump House (RG02) as shown in [Figure 4-1](#).

A tipping-bucket rain gauge records rainfall in 0.25 mm increments over 5-minute time periods. The operation and accuracy of each rain gauge was verified with a measured volume of water during installation and upon removal.

4.4 Data Review and Analysis

4.4.1 Flow Data Processing

Equipping monitoring sites with two flow monitors provides backup in the event of a flow monitor malfunction as well as an independent check to ensure accuracy of the monitor. In addition, manual depth and velocity measurements are made during each site maintenance visit to verify accuracy of the flow monitor. This approach generates large data sets which need to be processed to generate the flows required for this study.

During the data processing stage, flow data is analyzed under a rigorous quality control process to compile the final data base. Associated Engineering uses a custom-designed spreadsheet tool to complete this data processing and to produce quality and consistent data.

The flow data processing stage involves the following:

- Confirming pipe sizes and monitor site locations.
- Screening to identify device malfunctions and velocity drop-outs during low-flow periods.
- Scatterplot comparison of depth and velocity readings to check for consistency and stability and to substitute for velocity drop-outs.
- Comparison with manual measurements and rainfall data.
- Discarding or correcting suspect or unreliable data or adjusting depth or velocity readings where indicated.
- Comparing depth and velocity measurements to calculate the final flow readings.
- Reviewing the final flow data to ensure consistency.

In general, the flow data was found to be of good quality. Throughout the course of the monitoring period, connectivity issues were experienced making real-time data review difficult.

To illustrate the data review process, **Figure 4-2** displays the raw level readings taken by the two sensors at Flow Monitor 4. The level data indicates that one sensor stopped working for a period of approximately a week around August 15. **Figure 4-3** displays the raw velocity readings taken at the same site.

The primary issue affecting data accuracy within a sanitary sewer is deposition of solids during low-flow periods. This affects the velocity sensors and causes data drop-outs when the sensors become buried. This is apparent in **Figure 4-3** during most nighttime periods. Occasionally, one or more of the depth sensors is affected by ragging or calibration shifts. This demonstrates the value of the redundant flow monitoring strategy.

Figure 4-4 displays the final calculated flows for Flow Monitor 4 after the data processing and quality control. All sites were processed and reviewed in a similar manner.

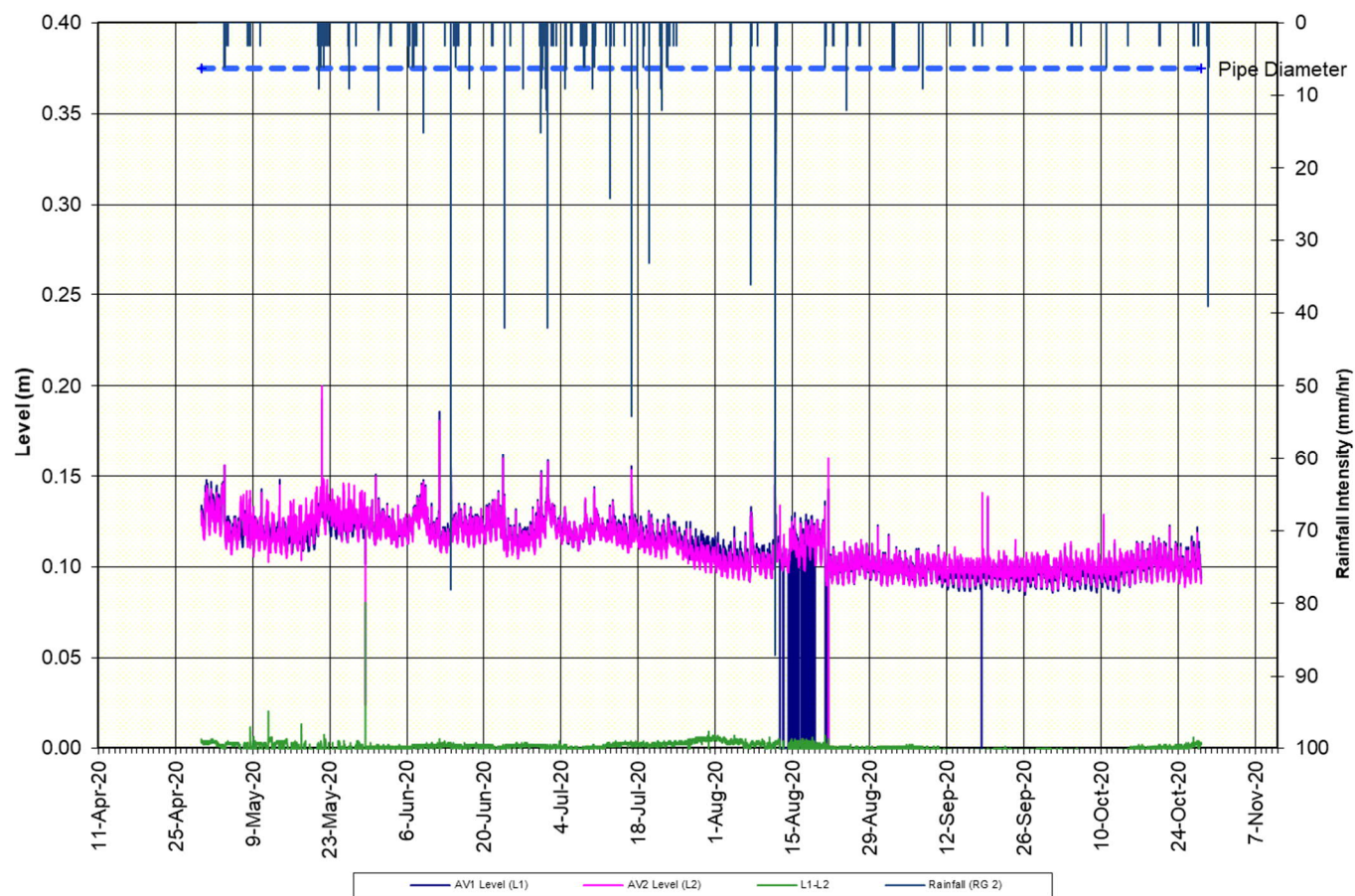


Figure 4-2
Data Processing Plot - Flow Monitor 4 Raw Levels

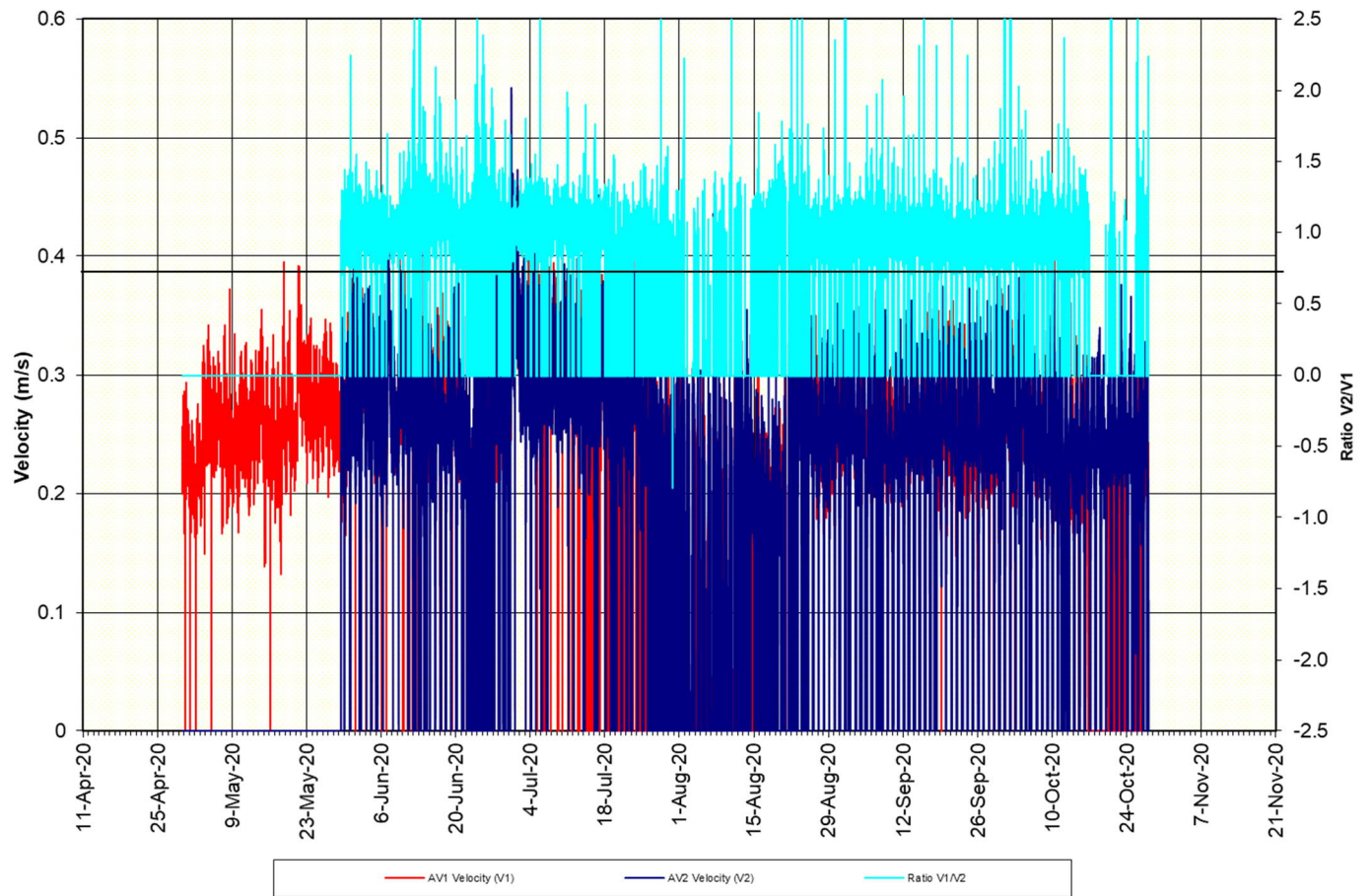


Figure 4-3
Data Processing Plot - Flow Monitor 4 Raw Velocities

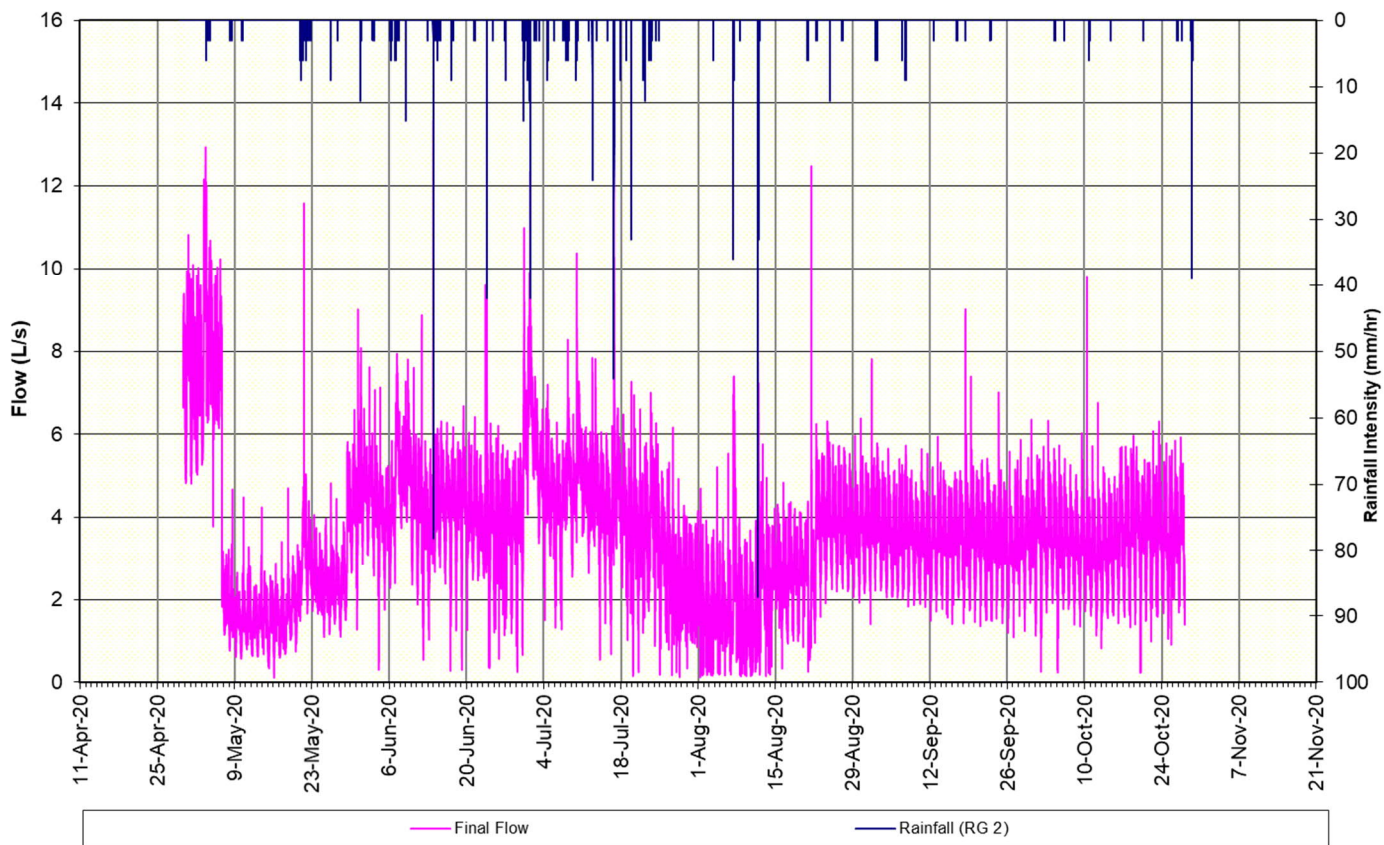


Figure 4-4
Data Processing Plot – Flow Monitor 4 Final Flows

4.4.2 Rain Gauge Data Processing

Rainfall data processing involves the comparison of validation measurements with meter readings and comparing the two rain gauges to check for inconsistent data. Overall, no data adjustments were required.

The collection of rainfall data is important for correlation with flow response within the sanitary sewer system.

Table 4-2 provides a summary of the daily rainfall depths observed at the two rain gauges installed in 2020. Days that have significant rainfall (more than 10 mm) are highlighted in yellow. The cumulative rainfall is plotted in **Figure 4-5**.

As shown in **Table 4-2**, 11 storm events had more than 10 mm of rainfall at one or both gauges. The largest events occurred on August 7 and 11.

Table 4-2
Wetaskiwin Flow Monitoring Program
Rain Gauge Summary

	Daily Total Rainfall (mm)			Daily Total Rainfall (mm)			Daily Total Rainfall (mm)			Daily Total Rainfall (mm)			Daily Total Rainfall (mm)			Daily Total Rainfall (mm)			Daily Total Rainfall (mm)	
	RG01	RG02		RG01	RG02		RG01	RG02		RG01	RG02		RG01	RG02		RG01	RG02		RG01	RG02
01-Apr-20			01-May-20	0	0	01-Jun-20	0	0	01-Jul-20	20	22.75	01-Aug-20	0	0	01-Sep-20	0	0	01-Oct-20	0	0
02-Apr-20			02-May-20	0	0	02-Jun-20	0	0	02-Jul-20	2.5	1.5	02-Aug-20	0	0	02-Sep-20	7	7.75	02-Oct-20	0	0
03-Apr-20			03-May-20	10	10	03-Jun-20	2	1.5	03-Jul-20	1.25	0.25	03-Aug-20	11	4	03-Sep-20	0	0	03-Oct-20	0	0
04-Apr-20			04-May-20	5.5	8.25	04-Jun-20	0	0	04-Jul-20	9	8.25	04-Aug-20	0	0	04-Sep-20	0	0	04-Oct-20	2.25	2.25
05-Apr-20			05-May-20	0	0	05-Jun-20	0	0	05-Jul-20	0.75	0.5	05-Aug-20	0	0	05-Sep-20	0	0	05-Oct-20	0	0
06-Apr-20			06-May-20	0	0	06-Jun-20	3.5	2.75	06-Jul-20	0	0	06-Aug-20	0	0	06-Sep-20	2.5	2.25	06-Oct-20	0.5	0.5
07-Apr-20			07-May-20	0.25	0	07-Jun-20	17.25	22	07-Jul-20	1.75	1.25	07-Aug-20	34.5	31.5	07-Sep-20	1	2	07-Oct-20	0	0
08-Apr-20			08-May-20	1.25	1.25	08-Jun-20	2.25	3.75	08-Jul-20	9.75	14.25	08-Aug-20	1.5	1.5	08-Sep-20	0	0	08-Oct-20	0	0
09-Apr-20			09-May-20	0	0	09-Jun-20	4.25	2.5	09-Jul-20	4.25	1	09-Aug-20	0	0	09-Sep-20	0	0	09-Oct-20	0	0
10-Apr-20			10-May-20	0.25	1.25	10-Jun-20	0	0	10-Jul-20	1.25	2	10-Aug-20	0	0	10-Sep-20	0	0	10-Oct-20	2.75	2
11-Apr-20			11-May-20	0	0	11-Jun-20	0	0	11-Jul-20	0.75	0	11-Aug-20	28.75	34.5	11-Sep-20	0	0	11-Oct-20	0	0
12-Apr-20			12-May-20	0	0	12-Jun-20	1	1	12-Jul-20	0.5	5.75	12-Aug-20	2.25	1.75	12-Sep-20	0	0.25	12-Oct-20	0	0
13-Apr-20			13-May-20	0	0	13-Jun-20	15	16.25	13-Jul-20	0.25	0.25	13-Aug-20	0	0	13-Sep-20	0	0	13-Oct-20	0	0
14-Apr-20			14-May-20	0	0	14-Jun-20	5	4.75	14-Jul-20	0	0	14-Aug-20	0	0	14-Sep-20	0	0	14-Oct-20	0.25	0.25
15-Apr-20			15-May-20	0	0	15-Jun-20	1	1.5	15-Jul-20	0.25	0.25	15-Aug-20	0	0	15-Sep-20	0	0	15-Oct-20	0	0
16-Apr-20			16-May-20	0	0	16-Jun-20	0	0	16-Jul-20	0	18	16-Aug-20	0	0	16-Sep-20	0	1.75	16-Oct-20	0	0
17-Apr-20			17-May-20	0	0	17-Jun-20	2	2.75	17-Jul-20	0.25	1.25	17-Aug-20	0	0	17-Sep-20	0	0	17-Oct-20	0	0
18-Apr-20			18-May-20	0	0	18-Jun-20	0	0	18-Jul-20	0	1.75	18-Aug-20	0	0	18-Sep-20	0	0.25	18-Oct-20	0	0
19-Apr-20			19-May-20	0.25	0	19-Jun-20	0	0	19-Jul-20	0.25	4.75	19-Aug-20	0	0	19-Sep-20	0	0	19-Oct-20	0	0
20-Apr-20			20-May-20	6.5	6.5	20-Jun-20	0	0	20-Jul-20	0	0	20-Aug-20	8.75	7.5	20-Sep-20	0	0	20-Oct-20	0	1
21-Apr-20			21-May-20	33.5	30.75	21-Jun-20	0.75	0.75	21-Jul-20	0.25	0.25	21-Aug-20	0	0	21-Sep-20	0	0	21-Oct-20	0	0
22-Apr-20			22-May-20	2.75	4	22-Jun-20	0	0	22-Jul-20	0.5	6	22-Aug-20	1	1.25	22-Sep-20	0	2.25	22-Oct-20	0	0
23-Apr-20			23-May-20	0	0	23-Jun-20	5.25	6.75	23-Jul-20	0.5	9.75	23-Aug-20	0	0	23-Sep-20	0	0	23-Oct-20	0	0
24-Apr-20			24-May-20	0	0	24-Jun-20	0.75	0.5	24-Jul-20	0.25	1	24-Aug-20	2.5	2.5	24-Sep-20	0	0	24-Oct-20	0	0
25-Apr-20			25-May-20	0	0	25-Jun-20	0	0	25-Jul-20	0	0	25-Aug-20	0.25	0	25-Sep-20	0	0	25-Oct-20	0	0
26-Apr-20			26-May-20	3.5	3.5	26-Jun-20	0	0	26-Jul-20	0	0	26-Aug-20	0	0	26-Sep-20	0	0	26-Oct-20	1	0.75
27-Apr-20			27-May-20	0.25	0.25	27-Jun-20	9.25	9.25	27-Jul-20	0	0	27-Aug-20	2	2.25	27-Sep-20	0	0	27-Oct-20	0.75	0.25
28-Apr-20			28-May-20	0	0	28-Jun-20	0	0	28-Jul-20	0	0	28-Aug-20	0	0	28-Sep-20			28-Oct-20	0	0
29-Apr-20			29-May-20	0	0	29-Jun-20	0	0	29-Jul-20	0	0	29-Aug-20	0	0	29-Sep-20			29-Oct-20	1.25	5
30-Apr-20	0	0	30-May-20	0	0	30-Jun-20	30	28.25	30-Jul-20	0.25	0	30-Aug-20	0	0	30-Sep-20			30-Oct-20		
			31-May-20	14.25	15				31-Jul-20	0	0	31-Aug-20	0	0				31-Oct-20		
Month Total	0	0		78	81		99	104		54	101		93	87		11	17		9	12
	21	Rainfall exceeding 10 mm																		

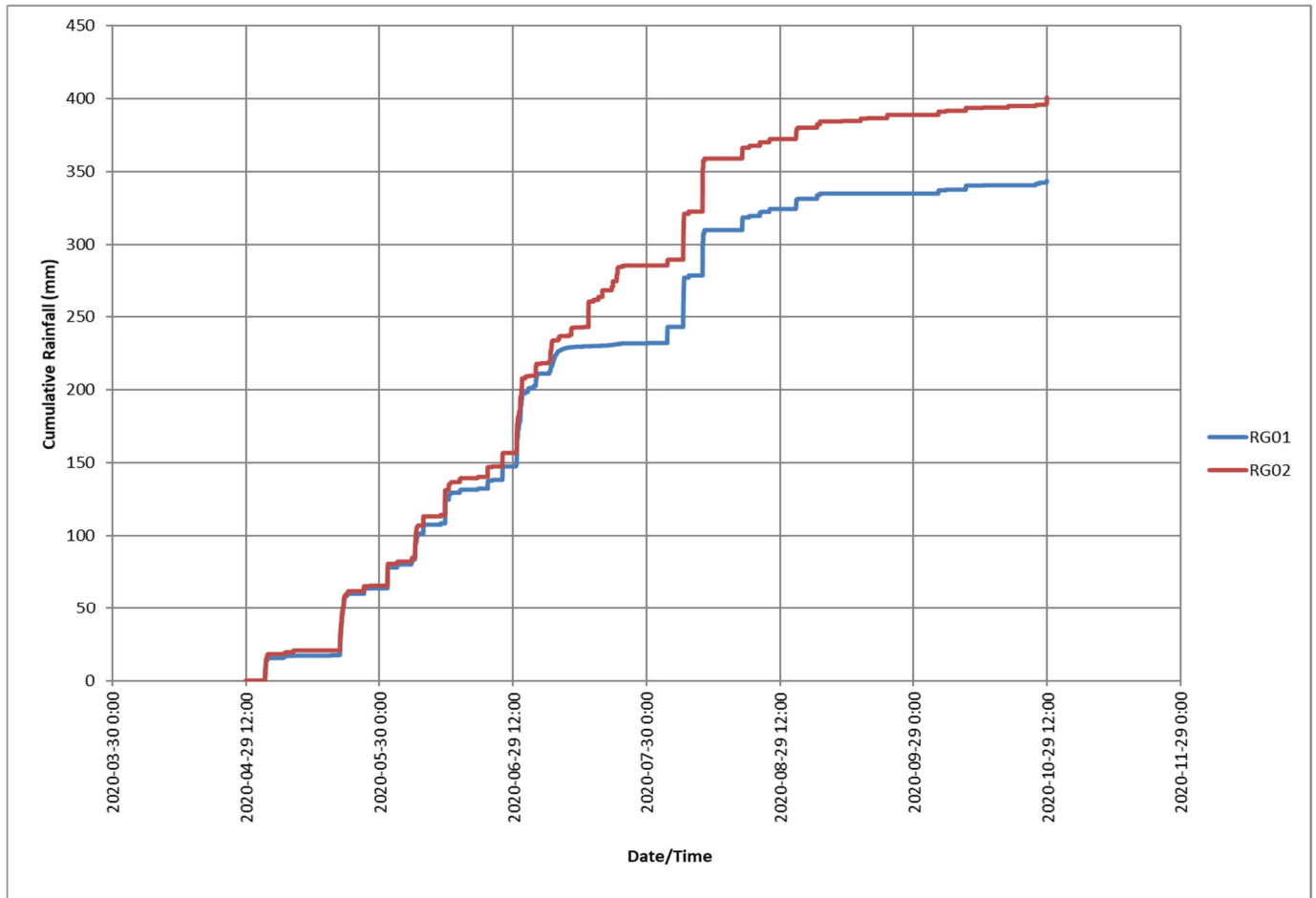


Figure 4-5
Wetaskiwin Sanitary Flow Monitoring Cumulative Rainfall 2020

4.4.3 Data Analysis

Upon completion of the flow and rain data processing, the flow data was combined with the rainfall data with a statistical approach using a spreadsheet tool designed and developed by Associated Engineering. The final data was analyzed to verify the flow data, to provide a better understanding of the variation of the sanitary flows during a storm event (i.e. inflow/infiltration), and to define parameters for the sanitary model calibration and validation.

The statistical analysis stage involves the following steps:

- The spreadsheet tool uses the reviewed flow data to generate a base flow for dry weather periods and plots it with the measured flow and rainfall data. This plot is used to identify the wet weather events.
- The most relevant storm events are selected and plotted to show the base flow, monitored flow, and rainfall during the wet weather event. The flows of interest are those where the monitored total flow is significantly affected during a storm event (i.e. conspicuous increase of total flow from the beginning to the end of the storm event). **Figure 4-6** shows an example of the plot for Flow Monitor 6 during the August 11, 2020 storm event. This event indicates a peak flow rate of 11 L/s which is twice the average base flow of 5 L/s.
- A plot is made to compare the peak rainfall intensity over various durations for each storm event to the historical IDF curves (2018 EPCOR data). This process was used to assess the magnitude of each storm event. A comparison of the IDF profiles for the City of Edmonton (EPCOR, 2018) and the observed storm events are presented in **Figure 4-7**. The magnitude of the rainfall events which occurred in 2020 were not significant; therefore, this provides a limitation to the model calibration and validation. This is discussed further in **Section 5**.
- Rainfall depths, runoff rates, and volumes are correlated to define the relationship between I/I and rainfall depths. The line of best-fit was used to determine the relationship mathematically (regression equation). For example, **Figure 4-8** illustrates an example of the relationship between I/I rate and the 1-hour rainfall depths for Flow Monitor 6. The Index of Determination (R^2) value (0.26) is a measure of the strength of correlation and confidence in the results. An R^2 value of 0 indicates no relationship while 1 indicates perfect agreement. The rainfall duration that provides the strongest correlation with the peak flow rate is identified through this analysis.
- The regression equation with the highest R^2 value is then applied to the statistical, historical, rainfall depths for each return period as defined in the IDF curve (EPCOR, 2018). **Figure 4-9** shows the design storm curve for Flow Monitor 6 indicating an I/I flow rate of 0.19 L/s/ha during the 1:25-Year design storm event for this site. Note, the design flows are preliminary estimates based on only one year of data and should be used with caution.
- Average dry weather flows (ADWF) in L/s/ha and Peak Factors (PFs) were also estimated from the monitored flow data. The PF is defined as the ratio of Peak DWF (PDWF) to the ADWF.

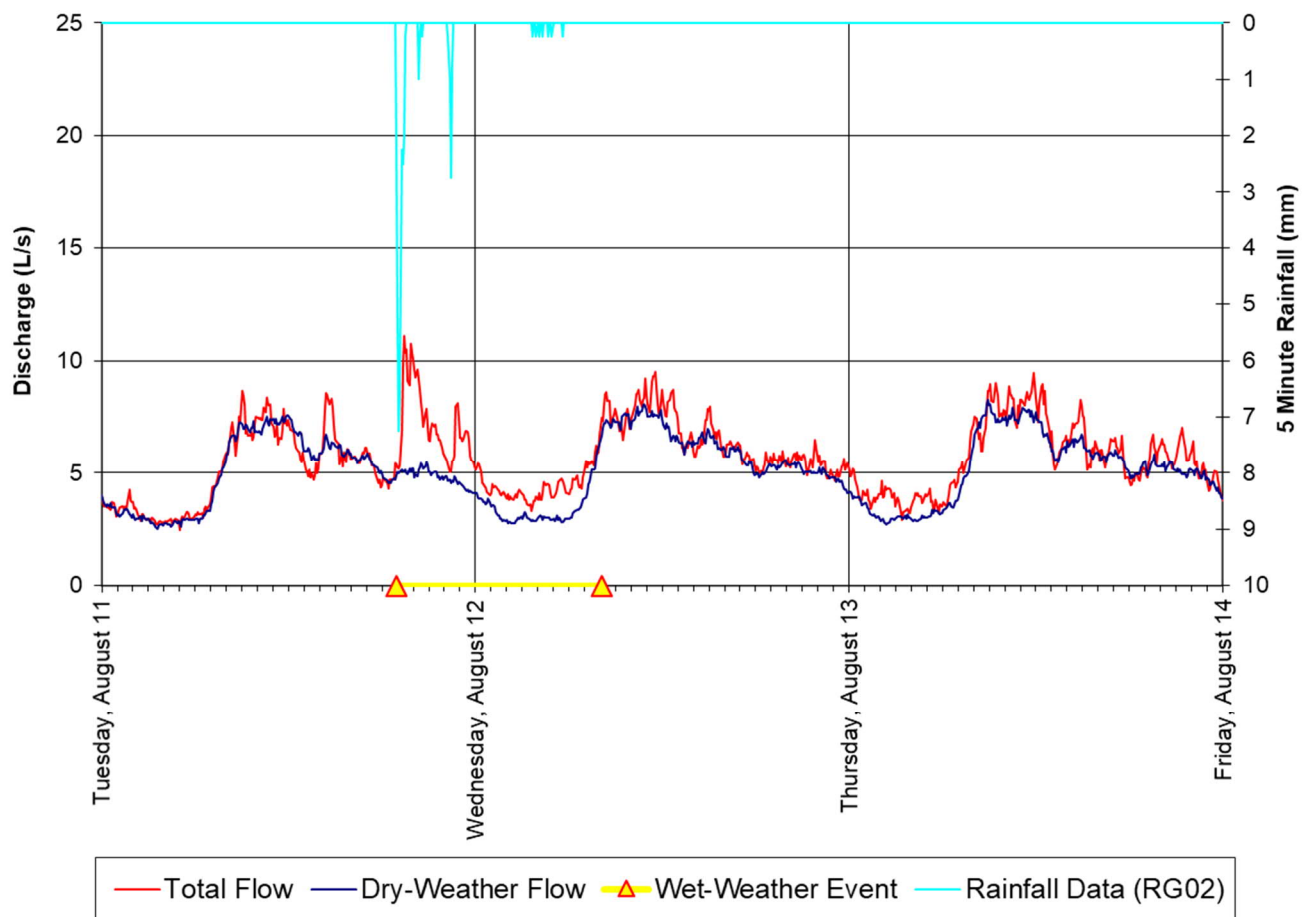


Figure 4-6
Measured Total Flow – Flow Monitor 6 – August 11, 2020

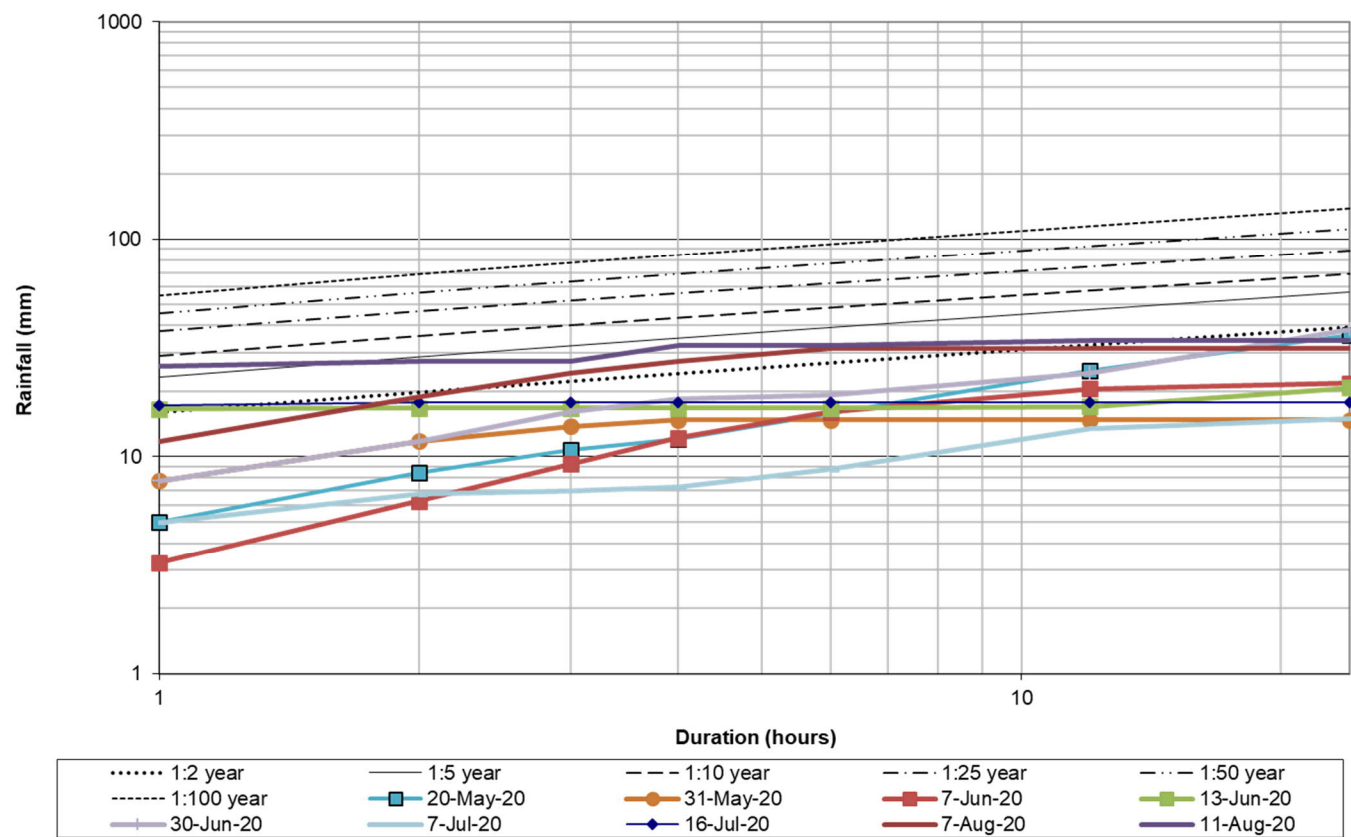


Figure 4-7
Storm IDF Profiles (RG02)

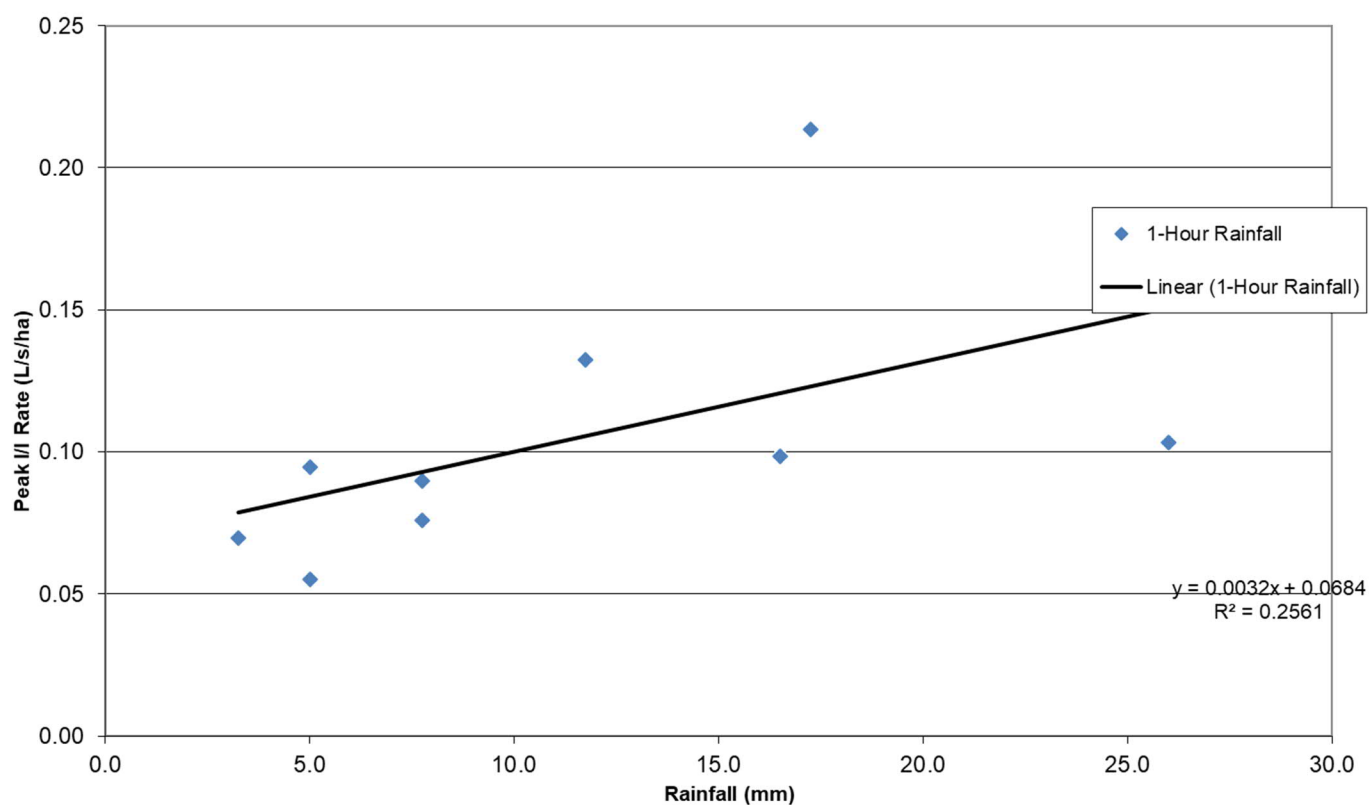


Figure 4-8
Regression Plot – Flow Monitor 6 and Rain Gauge 02

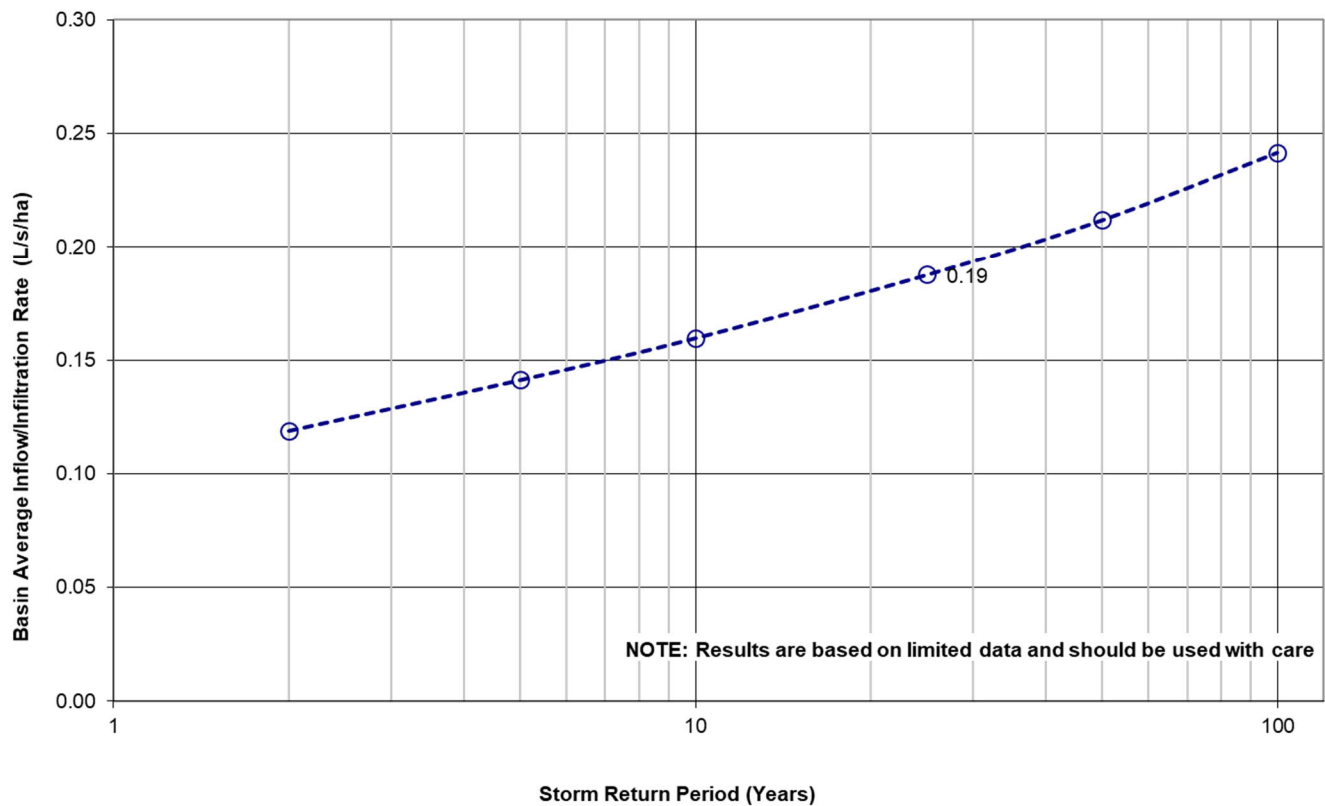


Figure 4-9
Projected Design Curve – Flow Monitor 6 with Rain Gauge 02

4.4.4 Data Summary

Table 4-3 summarizes the results from the 2020 Flow Monitoring Program. The results indicate the following:

- The storm events which occurred within the City of Wetaskiwin during the 2020 monitoring period were of a small in magnitude and short in duration, on average.
- The statistical analysis conducted for each return period at all sites had low R^2 values. This was most likely due to limited available monitoring data (one year). It is recommended that further flow monitoring is conducted to increase the confidence level in the data analysis.
- The 1:25-Year I/I rates range from 0.19 L/s/ha in Catchment 6 to 0.96 L/s/ha in Catchment 5. This indicates that high I/I is occurring within the City's industrial area.
- The 1:100-Year I/I rates are between 20% and 50% higher than the 1:25-Year I/I rate which reflects the statistical characteristics of rainfall.
- The peaking factors range between 1.29 and 3.36 which are lower than those usually computed using the equation provided within the City's Municipal Engineering Standards.
- I/I rates are all higher than the standard 0.28 L/s/ha, with the exception of the mixed land use value computed at Flow Monitor 6.

- Our approach used a scatterplot comparison of depth and velocity readings to check for consistency and stability. In addition, velocity dropouts were substituted during the monitoring period. However, the final flow data at Flow Monitor 2 and 3 includes dropouts which could not be substituted due to poor data quality during low flow periods.

The compiled flow and rainfall data was used to calibrate and validate the updated sanitary sewer system model as described in [Section 5](#). The estimates of I/I derived above from the analysis of the flow and rainfall data were verified during the model calibration and validation phase of this study.

The final reviewed flow and rainfall data has been submitted to the City as part of this Master Plan Update.

**Table 4-3
Data Summary**

Monitor	Total Catchment Area (ha)	Percent I/I	I/I Peak Flow		ADWF (L/s)	PDWF (L/s)	Peaking Factor
			1:25Y (L/s/ha)	1:100Y (L/s/ha)			
1	399.5	4.9%	0.68	0.94	44.26	57.07	1.29
2	330.9	2.4%	0.32	0.44	17.80	25.54	1.44
3	12.9	1.0%	0.48	0.64	1.38	3.54	2.56
4	21.8	3.7%	0.52	0.63	3.51	4.87	1.39
5	17.6	1.9%	0.96	1.43	1.43	4.82	3.36
6	58.7	1.0%	0.19	0.24	5.00	8.27	1.65

5 MODEL CALIBRATION AND VALIDATION

Calibration and validation of a hydrologic and hydraulic model is imperative to provide results with confidence and reliability. Sanitary models must calibrate and validate to both DWF and WWF events in order to accurately predict sewer hydraulics. The updated PCSWMM model was simulated for two periods with no rainfall as well as three chosen storm events to provide calibration and validation of the sanitary sewer network.

5.1 Dry Weather Flow Calibration

DWF in the sanitary sewer system is the domestic component of sewer flow generated by household activities. It is measured during times of no precipitation when it comprises the total flow (absent any infiltration or stormwater inflow).

PCSWMM uses the following parameters to model the dry weather flow:

- Average dry weather flow rate to each manhole; and
- Diurnal curve depicting the typical variation of sewer flow throughout the day.

Distinct diurnal curves and average dry weather flow rates for each land use class were estimated from the 2020 flow monitoring data and compared to previous patterns included within the 2005 XPSWMM model.

Residential diurnal patterns typically have two peaks during the weekday - one in the morning when people are starting their day and the other in the evening when people come home from school/work. The weekend peak tends to be higher and start later in the day. Commercial, institutional, and industrial diurnal weekday patterns tend to vary depending on the type of land use, but generally have higher flow during business hours and reduced flows outside of business hours. The weekend pattern for commercial and institutional may vary from the weekday flow pattern while industrial weekend patterns are expected to be significantly reduced as workers take time off.

After processing and analyzing the flow monitoring data as described in [Section 4](#), diurnal patterns were produced for each monitored location. [Table 5-1](#) summarizes the land use areas and percentages for each monitoring location. As shown in the table, Flow Monitors 1, 2, 4, and 6 have a mixture of residential, commercial, industrial, and institutional land use. Flow Monitor 3 has a ratio of approximately 6:4 residential to commercial area, while Flow Monitor 5 has a principally industrial land use.

Table 5-1
Flow Monitor Land Use Areas

Flow Monitor	Total Area ¹ (ha)	Residential Area (ha)	Commercial Area (ha)	Industrial Area (ha)	Institutional Area (ha)
1	338.4	216.3	36.0	40.7	45.4
		(64%)	(11%)	(12%)	(13%)
2	309.1	73.0	40.6	94.6	100.9
		(24%)	(13%)	(31%)	(33%)
3	12.0	7.7	4.4	0.0	0.0
		(64%)	(36%)	(0%)	(0%)
4	17.1	9.2	4.2	0.3	3.5
		(54%)	(24%)	(1%)	(20%)
5	16.1	0.0	0.0	16.1	0.0
		(0%)	(0%)	(100%)	(0%)
6	53.1	32.2	1.0	7.1	12.8
		(61%)	(2%)	(13%)	(24%)

¹Not including road area

The weekday and weekend diurnal patterns for each Flow Monitor are illustrated in [Appendix B](#). Flow Monitors 1, 3, 4, and 6 were expected to exhibit a typical residential diurnal pattern as their catchment areas included greater than 50% residential land use. However, two distinct peaks were not directly visible at these locations. Flow Monitors 1, 2, 4, and 6 have one distinct peak in the late morning/early afternoon and similar weekday/weekend patterns. Flow Monitor 3 has a weekday peak later in the day which may be attributed to its 36% commercial land use. The industrial diurnal pattern developed for Flow Monitor 5 has a peak around lunchtime on weekdays and a consistently low pattern on weekends, as expected. Comparisons between the 2005 and 2020 diurnal patterns show the same general shape with slightly higher residential peaks and lower commercial peaks.

The year 2020 was an unprecedented year to monitor sanitary flow due to a COVID-19 pandemic. The pandemic led to rules and regulations being put in place, such as lockdowns and work-from-home orders. This could explain the missing peaks and separation between weekdays and weekends for mainly residential monitoring sites. The decrease in flows at commercial sites could also account for work from home policies.

The City of Wetaskiwin Sanitary Sewer Assessment (UMA, 2005) used a domestic sewer generation rate of 220 L/c/day and a non-residential rate of 4900 L/ha/day based on calibration. As discussed in [Section 2](#), the Municipal Engineering Standards recommends a per capita sewage contribution of 320 L/c/day and non-residential rates between 20,000 L/ha/day and 40,000 L/ha/day. These values resulted in overly-conservative simulated flows within the updated PCSWMM model. The calibrated values used in the model were as follows:

- Residential (low density) 200 L/c/day
- Residential (medium-high density) 125 L/c/day
- Commercial 5,250 L/ha/day
- Industrial 7,920 L/ha/day
- Institutional 4,000 L/ha/day

The calibrated residential sewage rates are 50% and 80% of the historical water consumption data for low and medium-to-high density land uses, respectively. Similarly, the calibrated commercial and industrial sewage rates are 50% and 90% of the water consumption data, respectively. Water consumption data was investigated as part of the City of Wetaskiwin Water Master Plan Update (Associated Engineering, 2020).

The diurnal curves for each monitored gauge location were assigned within the updated PCSWMM model. The diurnal curves were shifted ahead by one hour (on average) in order to achieve a better fit to the observed data.

The DWFs were modelled using the unit flows and diurnal curves discussed above. A close match between the modelled and observed values was found. [Figures 5-1](#) and [5-2](#) show the modelled and observed flows at Flow Monitors 1 and 4 for the DWF period of May 12 to 19, 2020. Calibration plots at each Flow Monitor are included in [Appendix C](#). Note, the final flow data was smoothed using a one-hour moving average in order to reduce noise and facilitate model/observed flow comparison.

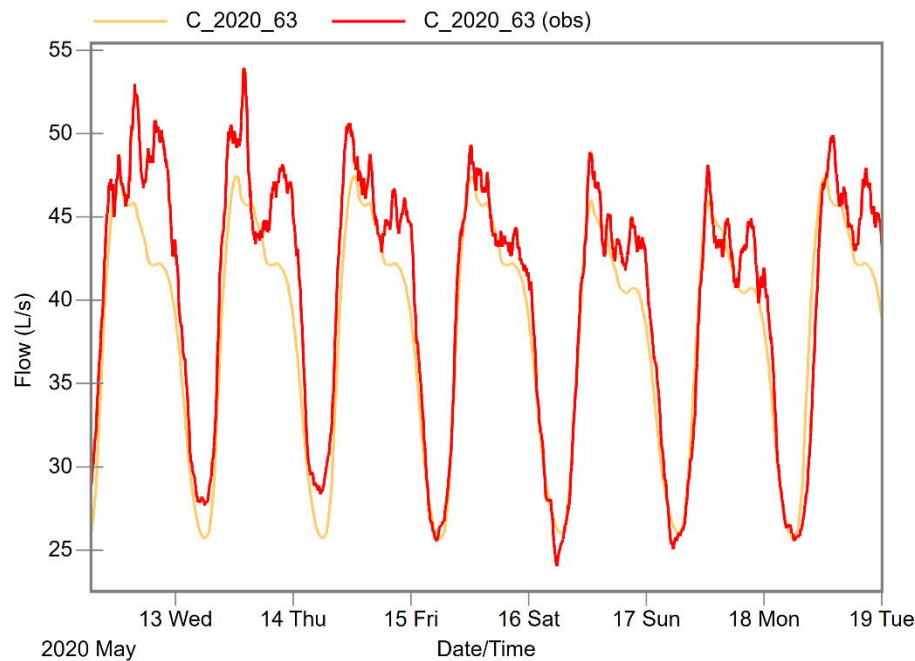


Figure 5-1
DWF Calibration Flow Monitor 1 – May 12 to 19, 2020

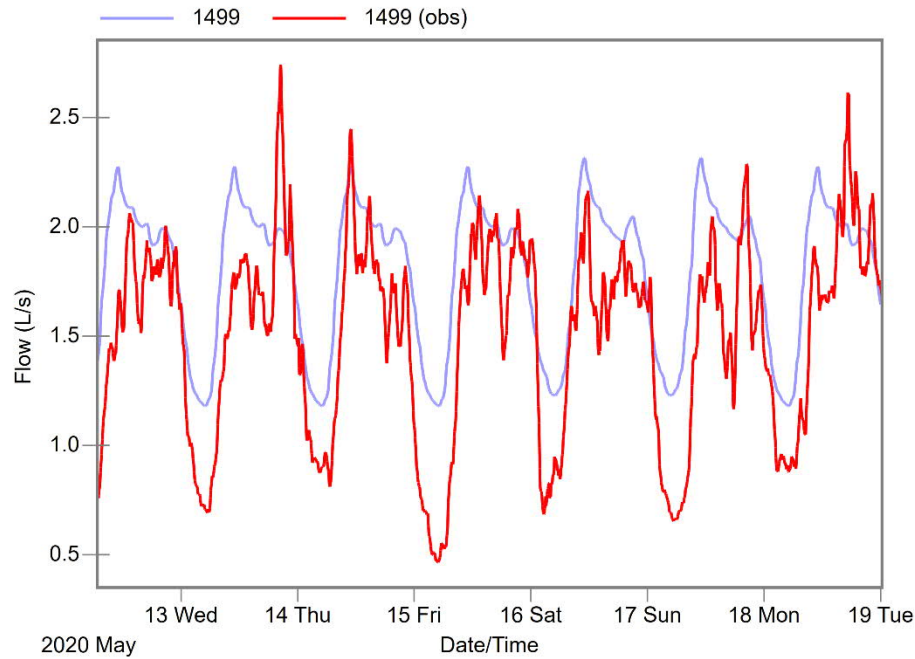


Figure 5-2
DWF Calibration Flow Monitor 4 – May 12 to 19, 2020

Modelled peak flows were found to be within 35% of observed flows, on average. [Table 5-2](#) summarizes the modelled and observed peak flow and volume during the DWF calibration event.

Table 5-2
Calibration Peak Flow and Volume

Flow Monitor	Volume (m ³)				Peak Flow (L/s)			
	Monitor	Model	Model/Monitor	% Error	Monitor	Model	Model/Monitor	% Error
1	23480	22390	0.95	5%	53.95	47.47	0.88	12%
2	5733	7511	1.31	31%	24.29	31.26	1.29	29%
3	579.5	574.6	0.99	1%	2.663	1.7	0.64	36%
4	876.5	1051	1.20	20%	2.742	2.316	0.84	16%
5	828.3	875.1	1.06	6%	3.57	3.403	0.95	5%
6	1586	4701	2.96	196%	5.776	12.15	2.10	110%

Modelled flows at Flow Monitor sites 2 and 6 were higher than observed flows for this period. The predominant land use within the Flow Monitor 2 catchment area is industrial. DWFs may be slightly conservative in these areas as large parcels of land may only have one or two buildings which generate sewage. However, this site is on average approximately 30% conservative, which was deemed acceptable.

The modelled results for Flow Monitor 6 are overly conservative when compared to other flow monitors. This might be due to the lack of consistency between the City's cadastre GIS layer and the parcel outlines (high-density residential land use vs. lower density buildings). The Flow Monitor 1 comparison was very close to observed values. This monitor site is located downstream of Flow Monitor 6, indicating that the high flows simulated at Flow Monitor 6 do not impact the overall Flow Monitor 1 catchment. It is recommended that the City confirm and validate their cadastre GIS layer for future use.

Note, DWF catchment areas were assigned within the model based on the City's cadastre GIS layer which represents each parcel. Parcels with no current development were excluded so that dry weather flow calculations were not over-conservative. In addition, residential average sewage generation rates were grouped according to either low density or medium-high density values. These factors contributed to the deviation between the observed flows and modelled results. Overall, the calibration results were reasonably good and are acceptable for the purposes of this study.

5.2 Dry Weather Flow Validation

The model was simulated for a DWF period between July 27 and August 3, 2020 to validate the DWF calibration. Note, some rainfall occurred prior to this DWF period; therefore, observed flows were slightly higher than the modelled flows at the beginning of the period. Results showed that modelled and observed flows matched reasonably well at each monitoring site taking this observed flow increase into account. On average, peak flows were found to be within 40% of observed flows. Based on these values, the model was considered slightly conservative with reasonable validation for DWF parameters. Validation plots at each Flow Monitor are included in [Appendix C](#).

5.3 Wet Weather Flow Calibration

The second component of flow within a sanitary sewer system is the rainwater inflow during a storm event. The rainwater inflow is commonly referred to as I/I, Rainwater-Dependent Inflow (RDI), or Rainwater-Dependent Inflow and Infiltration (RDII). Typically, it is significantly larger than the DWF (in terms of peak flow) but is much more difficult to quantify accurately. This is because the rainwater inflow varies substantially from place to place and with rainfall intensity.

The rainwater inflow includes the following:

- **General I/I** – the fast response to rainfall which includes flows entering through manhole covers or direct stormwater connections. It is affected by the nature and magnitude of the surface runoff; therefore, by rainfall intensity.
- **Weeping Tile Inflow** – this occurs where weeping tiles are connected to the sanitary sewers, which was the standard practice prior to 2005 in Wetaskiwin. It is generated by rainwater inflow but is less direct and slower to respond than the direct inflow component described above. It is influenced by lot grading and roof downspout connections, storm rainfall intensity and volume, and to a lesser extent, by groundwater levels.
- **Groundwater Infiltration** – this is a slow-responding component that generally includes flows entering through cracked manholes, cracked pipes, open joints, and the long-term response of weeping tile flow to groundwater levels. Infiltration is governed by groundwater levels that tend to be relatively stable over time but can rise during prolonged periods of heavy rainfall increasing ground saturation.

PCSWMM uses the unit hydrograph method to estimate RDI from a given rainfall input. There are up to three hydrographs, one for short-term response, one for the intermediate-term response, and one for the slower, long-term response. Each unit hydrograph is defined by three parameters:

- **R:** the fraction of rainfall volume that enters the sewer system.
- **T:** the time from the onset of rainfall to the peak of the unit hydrograph in hours.
- **K:** the ratio of time to recession of the unit hydrograph to the time to peak.

There can also be an initial abstraction parameter associated with each unit hydrograph, which determines how much rainfall is lost to interception and depression storage before any runoff is generated. The initial abstraction is described by three parameters:

- **D_{max}** is the maximum depth of depression storage (mm).
- **D_{rec}** is the rate of recovery of the depression storage during dry periods (mm/day).
- **D_o** is the starting depth (mm).

These parameters provide considerable flexibility in simulating the I/I process but also create significant challenges in calibration of the model due to the large number of possible parameter combinations. In practice, this means that a substantial amount of monitored flow and rainfall data is required to achieve an adequate calibration.

Associated Engineering used the flow monitoring data collected during the 2020 monitoring program to calibrate the WWF parameters based on comparison of modelled and observed flows at the six monitoring locations. The rainfall data collected during the 2020 Flow Monitoring Program was reviewed, as per [Section 4](#). [Table 5-3](#) provides a summary of the rainfall characteristics for three of the largest storm events that occurred over the 2020 season (April to October) based on data obtained from Rain Gauge 02.

Table 5-3
Calibration/Validation Storm Events Summary

Date of Storm Event	Rainfall Depth (mm)	Peak Intensity (mm/hr)	Approximate Duration (hours)	Approximate Design Storm Event Return Period (years)
June 30 - July 1, 2020 ^V	51.0	42	33	2
August 7, 2020 ^C	31.5	36	6	2
August 11, 2020 ^C	34.5	87	4	5

C – Calibration Simulation

V – Validation Simulation

The largest storm event during the flow monitoring period occurred on August 11, 2020. This event was chosen for the calibration of the updated model. This storm was approximately equivalent to a 1:5-Year design storm event. However, due to the spatial variability of rainfall over an area, some Flow Monitors did not respond during this storm event. Therefore, the August 7, 2020 event was used as a second calibration event. This storm was approximately equivalent to a 1:2-Year design storm event. Both events were simulated, and model parameters were adjusted through an iterative process to achieve the best match between modelled and observed results. [Table 5-4](#) provides a summary of the calibrated model parameters for I/I.

A close match between the modelled and observed values was also found during WWF calibration. [Figures 5-3 to 5-6](#) show the modelled and observed flows at Flow Monitors 1 and 4 for the WWF periods of August 6-9 and August 11-13, 2020. Calibration plots for both storm events at each Flow Monitor are included in [Appendix C](#). Note, the final flow data was smoothed using a one-hour moving average in order to reduce data noise and facilitate model/observed flow comparison.

Table 5-4
Summary of Calibrated Model Parameters

	R	T	K	D _{max}	D _{rec}	D _o
Catchment 1						
Short Term	0.013	0.5	4	5	0.5	0
Medium Term	0.01	0.8	6	4	0	0
Long Term	0.04	4.5	9	3	0	0
Catchment 2						
Short Term	0.002	0.1	3	6	1	0
Medium Term	0.003	0.6	3	3	0	0
Long Term	0.01	2.7	3	1	0	0
Catchment 3						
Short Term	0.006	0.4	3	5	1	0
Medium Term	0.004	0.8	5	3	0	0
Long Term	0.03	5.7	8	3	0	0
Catchment 4						
Short Term	0.008	0.4	3	5	0	0
Medium Term	0.004	0.9	5	3	0	0
Long Term	0.02	4.4	8	3	0	0
Catchment 5						
Short Term	0.012	0.4	4	6	1.5	0
Medium Term	0.02	3.8	4	5	0	0
Long Term	0	0	0	0	0	0
Catchment 6						
Short Term	0.0012	0.3	4	6	1	0
Medium Term	0.0006	0.6	4	3	0	0
Long Term	0.0009	3	6	2	0	0

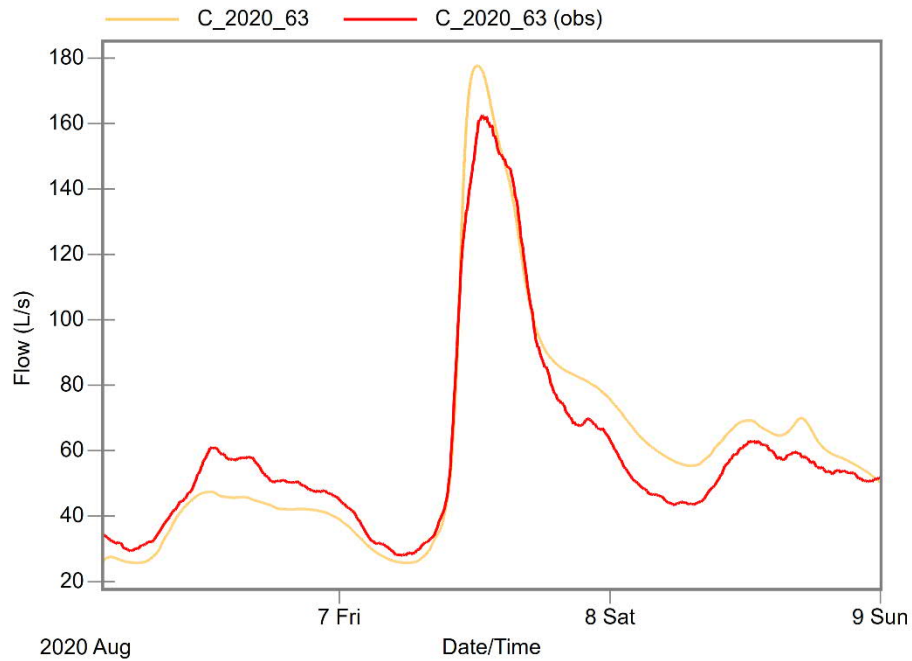


Figure 5-3
WWF Calibration Flow Monitor 1 - August 6-9, 2020

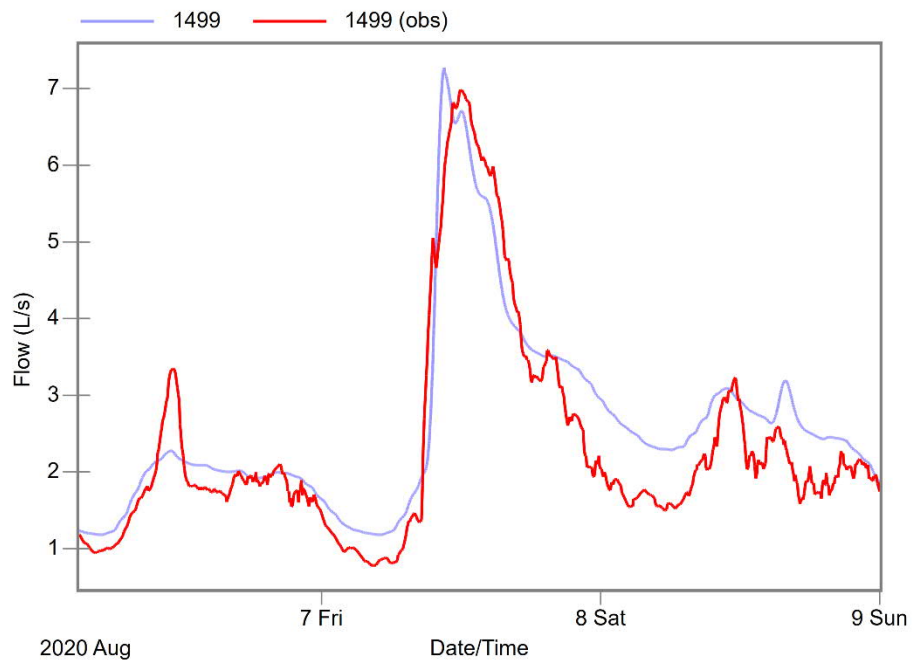


Figure 5-4
WWF Calibration Flow Monitor 4 - August 6-9, 2020

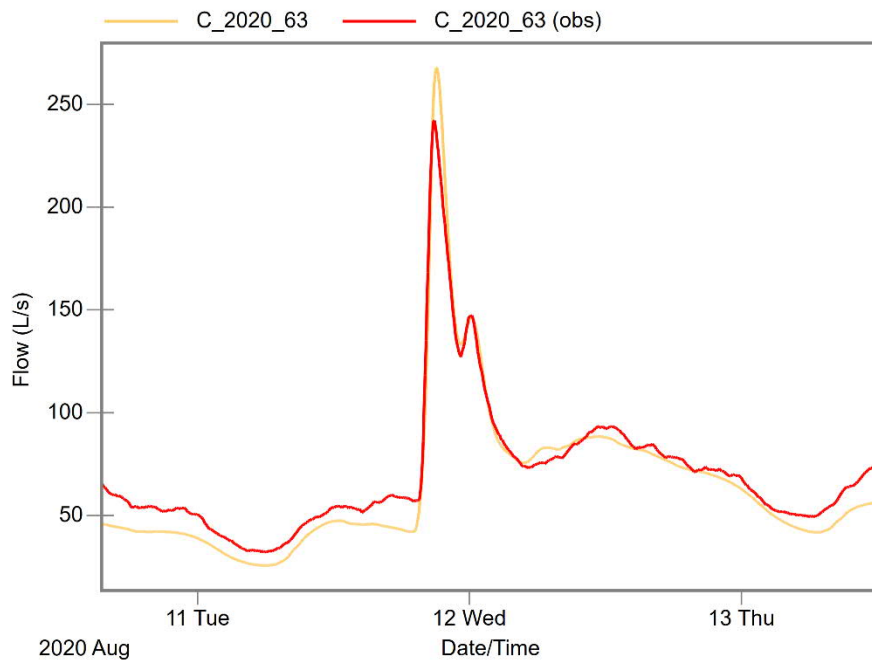


Figure 5-5
WWF Calibration Flow Monitor 1 - August 10-13,2020

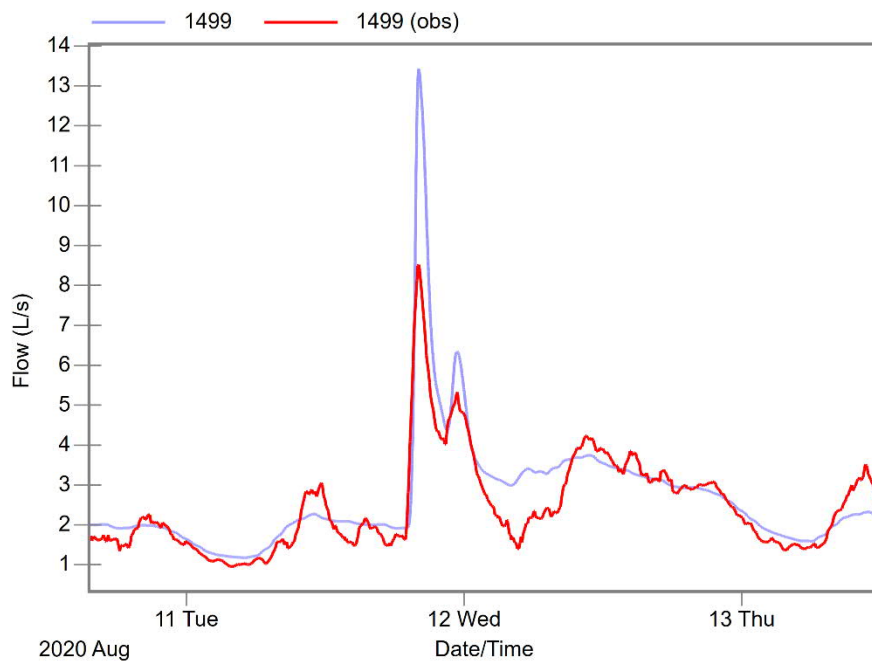


Figure 5-6
WWF Calibration Flow Monitor 4 - August 10-13, 2020

Modelled peak flows were found to be within 10% of observed flows during the August 7 event and 50% of observed flows during the August 11 event, on average. **Tables 5-5** and **5-6** summarize the modelled and observed peak flow and volume during the WWF calibration events.

Table 5-5
Calibration Peak Flow and Volume – August 7, 2020

Flow Monitor	Volume (m ³)							
	Monitor	Model	Model/Monitor	% Error	Monitor	Model	Model/Monitor	% Error
1	8467	9446	1.12	12%	162.4	177.6	1.09	9%
2	3029	4257	1.41	41%	60.67	82.56	1.36	36%
3	224.7	233.7	1.04	4%	3.763	3.628	0.96	4%
4	354.4	388.9	1.10	10%	6.985	7.272	1.04	4%
5	257.6	316.6	1.23	23%	7.804	7.615	0.98	2%
6	812.2	970.9	1.20	20%	14.67	14.32	0.98	2%

Table 5-6
Calibration Peak Flow and Volume – August 11, 2020

Flow Monitor	Volume (m ³)							
	Monitor	Model	Model/Monitor	% Error	Monitor	Model	Model/Monitor	% Error
1	4715	4782	1.01	1%	242.2	267.8	1.11	11%
2	2835	2369	0.84	16%	90.83	89.3	0.98	2%
3	66.96	98.97	1.48	48%	3.766	7.358	1.95	95%
4	148.7	189.4	1.27	27%	8.518	13.43	1.58	58%
5	113.2	169.4	1.50	50%	7.614	13.07	1.72	72%
6	218.9	286.4	1.31	31%	9.943	13.65	1.37	37%

Additional calibration is recommended due to the limited data collected (one monitoring season) and the minor storm events which occurred ($\leq 1:5$ -Year event).

5.4 Wet Weather Flow Validation

The model was validated with the June 30-July 1, 2020 storm event. This storm event was approximately equivalent to a 1:2-Year design storm event. Results showed that modelled and observed flows matched reasonably well at each monitoring site. On average, peak flows were found to be within 15% of the observed flows. Based on this, the model was considered validated for WWF parameters. Validation plots at each Flow Monitor are included in [Appendix C](#).

5.5 Summary

Overall, considering the limited flow monitoring data and variability in rainfall conditions over time and space, the model was deemed to provide an adequate estimate of peak dry weather and wet weather flows for the system assessment that follows. Perfect agreement is not realistic at all locations due to the spatial variability of rainfall intensities, model approximations, and limitations. Associated Engineering recommends additional calibration and validation as more observed data becomes available. Therefore, it is recommended that the City implement a continuous flow monitoring program.

6 EXISTING SYSTEM PERFORMANCE

Following calibration and validation of the model, the following design storm events were simulated using the 2018 EPCOR IDF curves for the City of Edmonton:

- 1:5-Year 4-Hour Chicago Distribution.
- 1:10-Year 4-Hour Chicago Distribution.
- 1:10-Year 24-Hour Huff Distribution.
- 1:25-Year 4-Hour Chicago Distribution.
- 1:100-Year 4-Hour Chicago Distribution.

These storm events were used to assess the existing sanitary system during wet weather flow events. In addition, a dry weather flow period with no rainfall was also simulated.

The model results for each node (manhole) were converted into Grade Line Factors (GLF) to illustrate surcharge levels. The GLF indicates the Hydraulic Grade Line (HGL) within each manhole, expressed in metres below ground. Areas where the system is surcharged to within 2.5 m of ground elevation have the potential risk of basement flooding due to sanitary sewer backup. Shallow manholes were noted where the total depth from rim to invert elevation is less than or equal to 2.5 m. Therefore, basement flooding is a possibility, but is not necessarily more likely at these locations.

The model results for each sanitary pipe were converted into Theoretical Loading Factors (TLF) to illustrate the ratio of peak flow to pipeful capacity. Values greater than 1.0 indicate the pipe is carrying more than its design flow. Note that pipes can be overloaded locally due to flat gradients without significantly affecting the overall performance of the system.

The following is a summary of the existing system performance under each design storm event. **Figures 6-1 to 6-6** present the sanitary model results.

DWF Existing System (Figure 6-1)

- A number of shallow manholes are located within the City boundaries, primarily in the following subdivisions: City Centre, Central, Jubilee, McMurdo, Parkdale, Recside, Lynalta, and Southeast Industrial Park. Two of the shallowest manholes with a depth of less than 1 m are within the McMurdo and North Centennial subdivisions.
- Nine manholes are identified with their GLF within 2.5 m of ground elevation and depths ranging from 2.51 to 2.53 m, indicating shallow manholes.
- The existing pipe system has spare capacity during DWF conditions.

1:5-Year 4-Hour Chicago Distribution (Figure 6-2)

- There are 18 manholes (mostly located within the Central, City Centre, and Southeast Industrial Park subdivisions) with GLF within 2.5 m of ground elevation. However, the depths of these manholes are between 2.51 and 2.86 m, which may be considered shallow manholes.
- Seventeen pipes, located mainly within the central part of the City (south of McMurdo, Centennial and City Centre subdivisions), are flowing at or above capacity. Three of these conduits are flowing over twice their capacity. The trunk along 47 Street flowing north and east at 56 Avenue is the most capacity challenged. However, these local constraints do not significantly impact the rest of the system.

1:10-Year 4-Hour Chicago Distribution (Figure 6-3)

- Results from this simulation are similar to the 1:5-Year 4-Hour event with a total of 19 shallow manholes with GLF within 2.5 m of ground elevation.
- Twenty-three centrally located pipes are flowing at or above capacity. Five of these conduits are flowing over twice their capacity. Loading at 47 Street/56 Avenue was increased.

1:10-Year 24-Hour Huff Distribution (Figure 6-4)

- Peak flows and surcharge levels are lower compared to the 1:10-Year 4-Hour design storm event results.
- There are 17 manholes that have GLF within 2.5 m of ground elevation which are also shallow manholes.
- Pipes flowing at or above capacity are decreased to 10 (located mainly in the East Centennial, East Central and City Central – East subdivisions) with two of them flowing over two times their capacity.

1:25-Year 4-Hour Chicago Distribution (Figure 6-5)

- There are 23 manholes with GLF within 2.5 m of ground elevation. They are located within the Lynalta, Northmount, and Central Industrial Park subdivisions. These manholes have depths of less than 3 m.
- Thirty-four pipes are flowing at or above capacity. Eight pipes are flowing greater than twice their capacity.

1:100-Year 4-Hour Chicago Distribution (Figure 6-6)

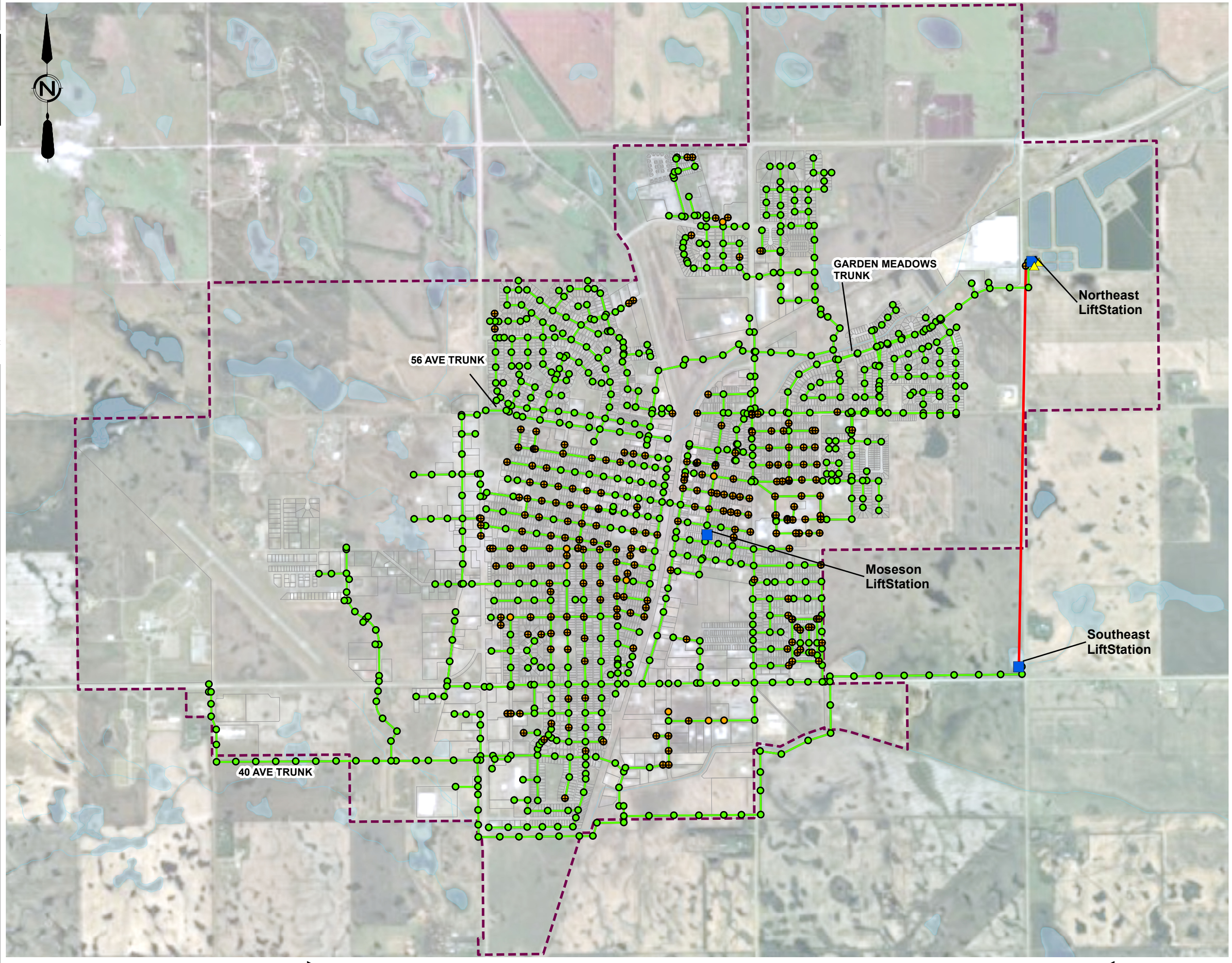
- There is an increase to 47 manholes with GLF within 2.5 m of ground elevation in similar areas highlighted during the 1:25-Year 4-Hour design storm event results. These manholes are less than 4 m in depth. Nine manholes within the City Centre and Central subdivision and one manhole in the Jubilee subdivision have GLF within 1.5 m of ground elevation.
- Pipes flowing at or above capacity more than double to 75, when compared to the 1:25-Year, 4-Hour design storm event results. These pipes extend into the Highway-North/South, Annexation-92, Glendale, Garden Meadows, and South Centennial subdivisions.

The 2005 Sanitary Sewer Assessment proposed construction of a new trunk on the west side of the City to mitigate the addition of large flows entering into the downtown area sanitary system which was flowing full or above capacity during the 1:10- and 1:25-Year design storm events. This trunk was constructed in 2009 and was included in the updated model. Model results were very similar to results presented within the 2005 report, particularly within the City Centre-East subdivision and the 47 Street/56 Avenue trunk.

Overall, the existing sanitary sewer system provides close to a 1:100-Year level of service with no surcharge to ground. However, localized sections of pipes are over capacity for design storm events equal to or greater than the 1:5-Year 4-Hour storm, specifically, the 47 Street/56 Avenue trunk. The TLF of pipes and manhole GLFs increase with larger design storm intensities. Shallow manholes exist within the central part of the City (City Centre and Central subdivisions), which could lead to basement flooding during a more severe storm. It is recommended that further model calibration is completed to increase confidence in the representation of large, high intensity design storm event results. Existing system upgrades to achieve a 1:100-Year level of service are discussed in [Section 7](#). This provides a robust system to mitigate the impacts of climate change which increases the frequency of storm events within our region.

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IF NOT 25 mm ASJUST SCALES
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE



Legend

- Sanitary Lagoon
- Sanitary Lift Station
- Sanitary Forcemain
- Grade Line Factors**
 - <0
 - 0 - 2.5
 - >2.5
 - ⊕ Shallow (Depth < 2.5m)
- Theoretical Loading Factors (Qmax/Qf)**
 - 0 to <1.0
 - 1 to <1.5
 - 1.5 to <2.0
 - >2.0
- City of Wetaskiwin

FIGURE 6-1

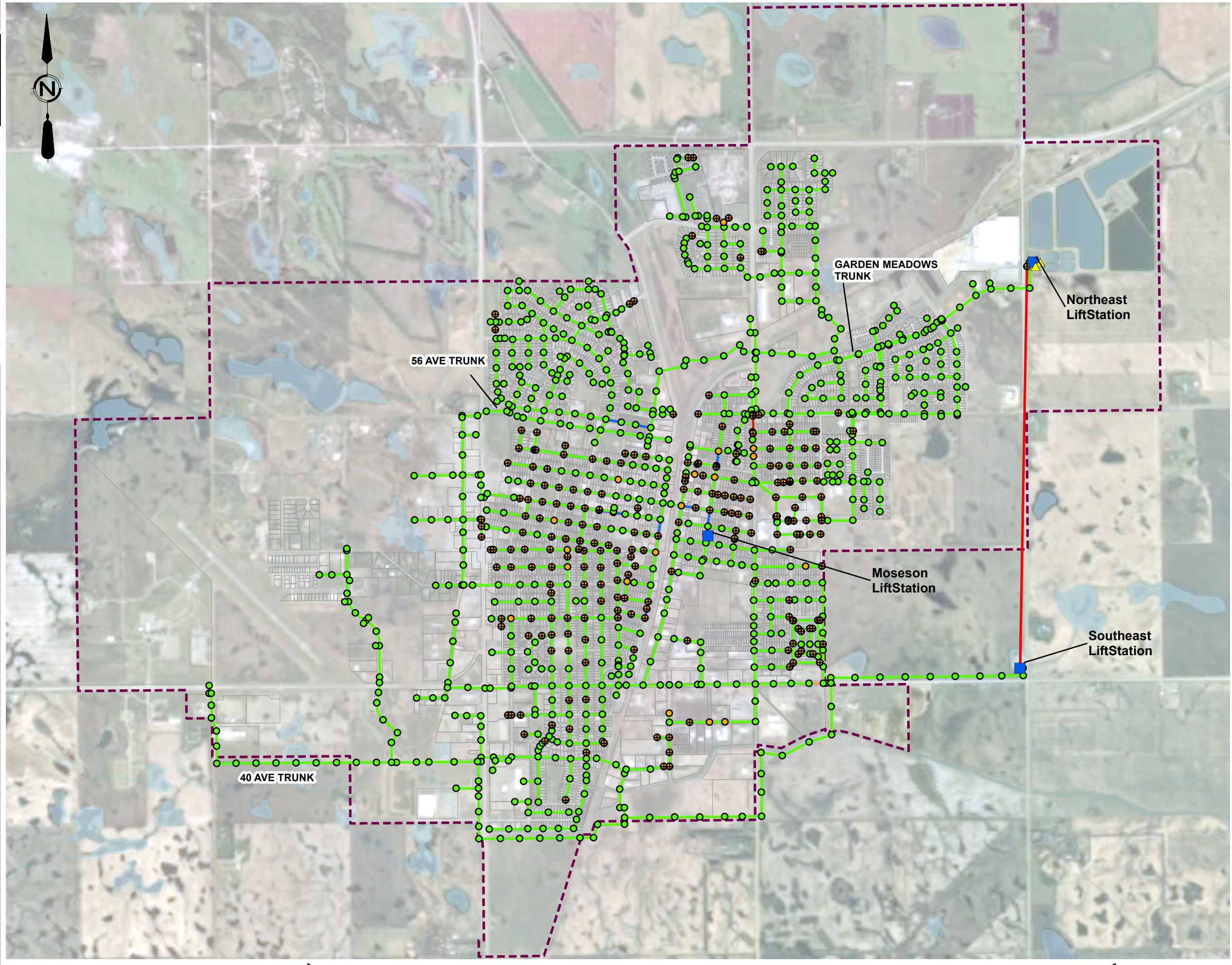
CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

EXISTING SYSTEM RESULTS - DWF

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APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL

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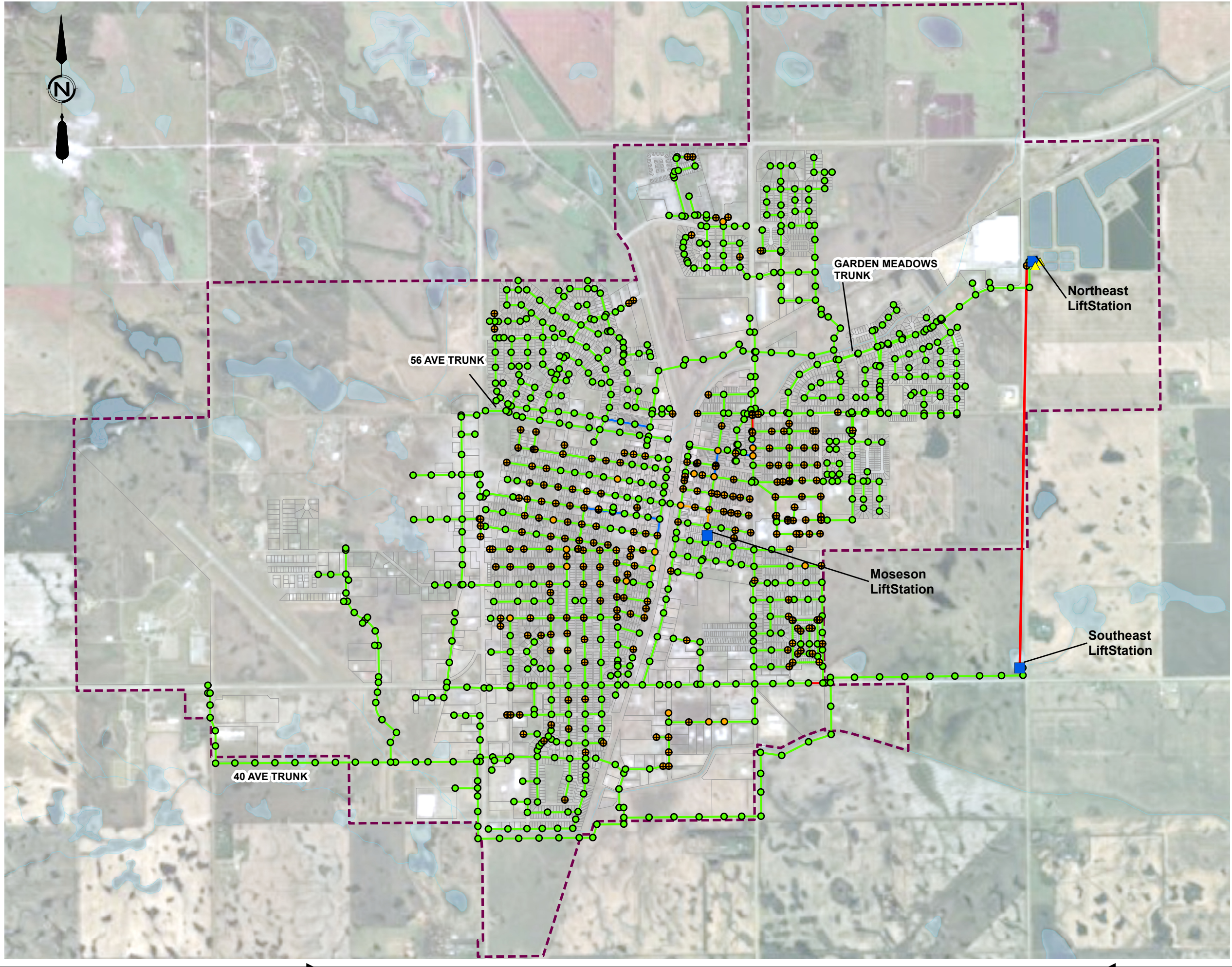
IF NOT 25 mm ASJUST SCALES
SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE



- Legend**
- Sanitary Lagoon
 - Sanitary Lift Station
 - Sanitary Forcemain
- Grade Line Factors**
- <0
 - 0 - 2.5
 - >2.5
 - ⊕ Shallow (Depth < 2.5m)
- Theoretical Loading Factors (Qmax/Qf)**
- 0 to <1.0
 - 1 to <1.5
 - 1.5 to <2.0
 - >2.0
 - City of Wetaskiwin

FIGURE 6-2
CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE
EXISTING SYSTEM RESULTS - 1:5 YEAR 4-HOUR

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SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL



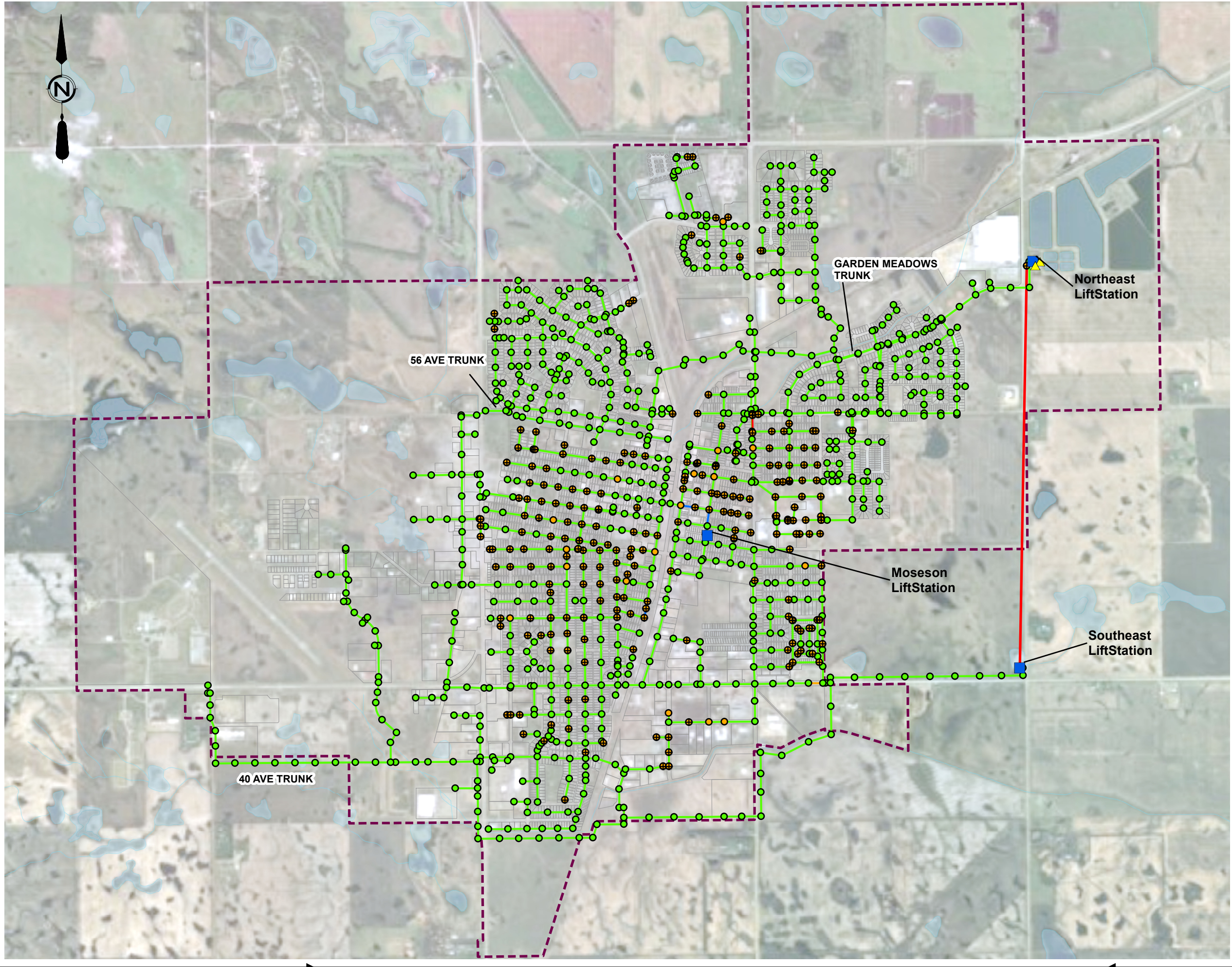
- Legend**
- Sanitary Lagoon
 - Sanitary Lift Station
 - Sanitary Forcemain
- Grade Line Factors**
- <0
 - 0 - 2.5
 - >2.5
 - ⊕ Shallow (Depth < 2.5m)
- Theoretical Loading Factors (Qmax/Qf)**
- 0 to <1.0
 - 1 to <1.5
 - 1.5 to <2.0
 - >2.0
 - City of Wetaskiwin

FIGURE 6-3

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

EXISTING SYSTEM RESULTS - 1:10-YEAR, 4-HOUR

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL



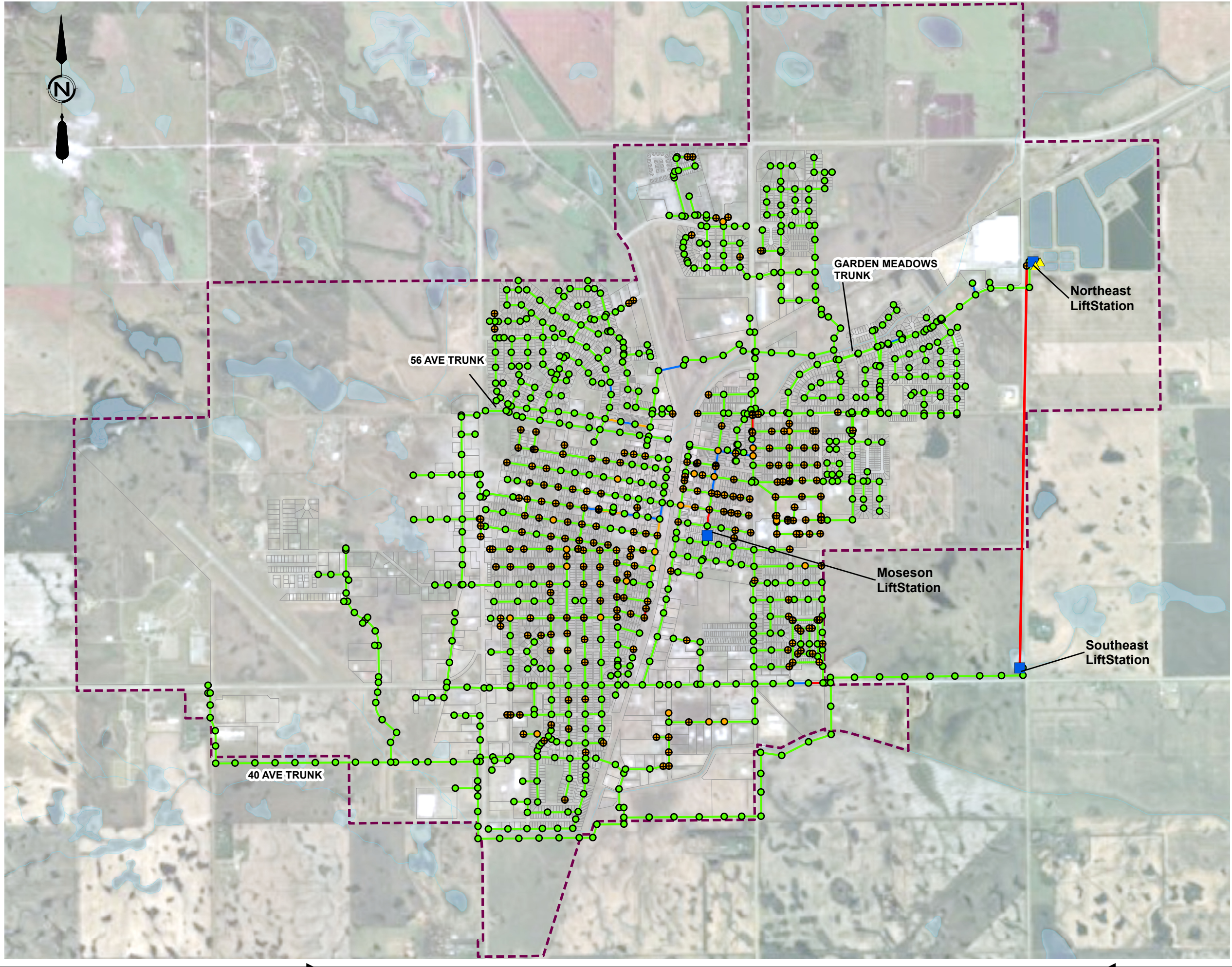
- Legend**
- Sanitary Lagoon
 - Sanitary Lift Station
 - Sanitary Forcemain
- Grade Line Factors**
- <0
 - 0 - 2.5
 - >2.5
 - ⊕ Shallow (Depth < 2.5m)
- Theoretical Loading Factors (Qmax/Qf)**
- 0 to <1.0
 - 1 to <1.5
 - 1.5 to <2.0
 - >2.0
 - City of Wetaskiwin

FIGURE 6-4

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

EXISTING SYSTEM RESULTS - 1:10-YEAR, 24-HOUR

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APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL



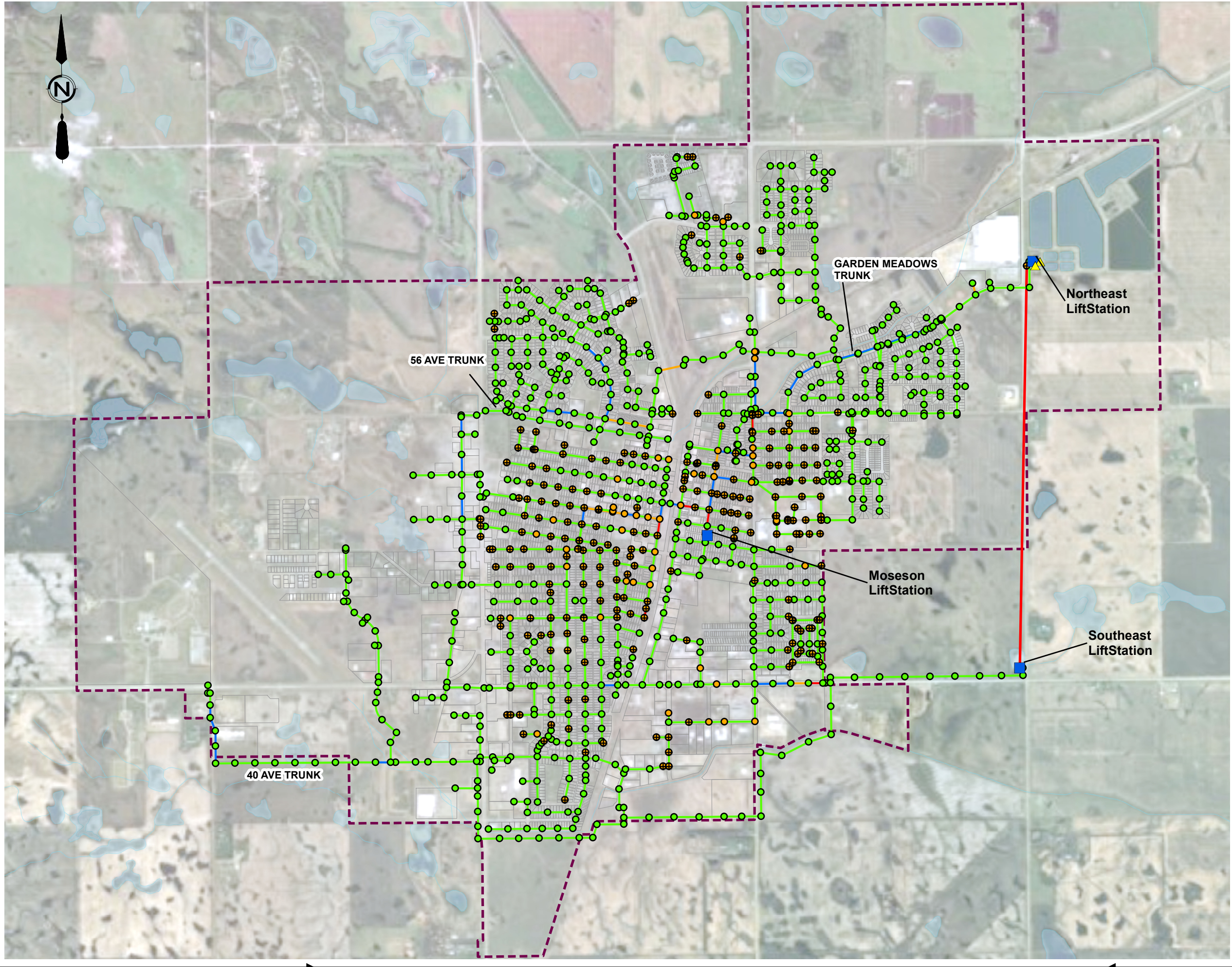
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- Sanitary Lagoon
 - Sanitary Lift Station
 - Sanitary Forcemain
- Grade Line Factors**
- <0
 - 0 - 2.5
 - >2.5
 - ⊕ Shallow (Depth < 2.5m)
- Theoretical Loading Factors (Qmax/Qf)**
- 0 to <1.0
 - 1 to <1.5
 - 1.5 to <2.0
 - >2.0
 - City of Wetaskiwin

FIGURE 6-5

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

EXISTING SYSTEM RESULTS - 1:25-YEAR, 4-HOUR

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL



- Legend**
- Sanitary Lagoon
 - Sanitary Lift Station
 - Sanitary Forcemain
- Grade Line Factors**
- <0
 - 0 - 2.5
 - >2.5
 - ⊕ Shallow (Depth < 2.5m)
- Theoretical Loading Factors (Qmax/Qf)**
- 0 to <1.0
 - 1 to <1.5
 - 1.5 to <2.0
 - >2.0
 - City of Wetaskiwin

FIGURE 6-6

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

EXISTING SYSTEM RESULTS - 1:100-YEAR, 4-HOUR

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL

7 EXISTING SYSTEM UPGRADES

Prior to 2020, several upgrades were completed within the sanitary system according to previous studies summarized in [Section 1.6](#). These include upgrades along Garden Meadows Drive, Cypress Drive, Norwood Close, Monterey Estates, Park Grove, Northgate Crescent, Inglewood Drive, Wildrose Garden Estates, and the southwest trunk (running from 47 Avenue to 40 Avenue, along 60 Street). These upgrades have increased sewer capacity and have been included in the 2020 PCSWMM model update.

Associated Engineering identified several required upgrades to the existing sanitary system based on the system's performance during a 1:100-Year, 4-Hour design storm event. Proposed upgrades were focused on increasing pipe capacity, changing pipe grades with zero or negative slopes, and lowering surcharge levels within shallow manholes. Four trunks, denoted UP1 – UP4, were identified for upgrades. Their locations are illustrated in [Figure 7-1](#) and are summarized below:

- **UP1:** upgrades required along 48 Street between 48 Avenue and 49 Avenue as well as along 54 Avenue and 47 Street, to the intersection of 56 Avenue and 47 Street.
- **UP2:** upgrades required along 50 Street between 42 Avenue and 50 Avenue, as well as along 50 Avenue between 50 Street and 48 Street.
- **UP3:** upgrades required between 53 Street and 48 Avenue, along 49 Avenue between 53 Street and 50 Street, as well as along 50 Avenue between 50 Street and 49 Street.
- **UP4:** upgrades required along 55 Avenue from 53 Street/Centennial Drive to 51 Street.

Model results including proposed upgrades during the 1:100-Year, 4-Hour design storm event indicate that hydraulic conditions were improved within the City Centre subdivisions.

Detailed results showing the hydraulic grade line profiles of the existing and proposed systems under the 1:100-Year 4-Hour design storm event are presented in [Appendix D. Table D-1](#) to [Table D-4](#) summarize the existing and proposed pipe configurations. Results indicate that the proposed upgrades increase pipe capacity and decrease surcharge levels. [Figures D-1](#) to [D-4](#) show the simulated peak flows and surcharge levels of UP1 – UP4 during the 1:100-Year 4-Hour design storm event for the existing system.

[Figures D-5](#) to [D-8](#) show the simulated hydraulic grade line profiles under the 1:100-Year 4-Hour design storm event with the proposed upgrades in place. It should be noted that the Garden Meadows Trunk will be overcapacity due to eliminating the bottleneck on UP1 – UP3. However, the manholes will have sufficient freeboard for surcharge. Similarly, pipes along 40th Avenue, from 45 to 47 Street, are overcapacity, constricted by a mild pipe slope. However, the HGL is greater than 2.5 m below ground elevation. This location should be improved when projects occur within this area and budgets allow. Proposed sections of regraded pipe satisfy the City's minimum slope criteria, as outlined in [Section 2](#).

Further refinement of each recommended upgrade should be completed based on the final development plans and site assessment during the preliminary design. The upgrades for each location should be based upon site constraints, construction method (open-cut, trenchless), budget, etc. An estimate of construction costs for each proposed upgrade is presented in [Section 9](#).

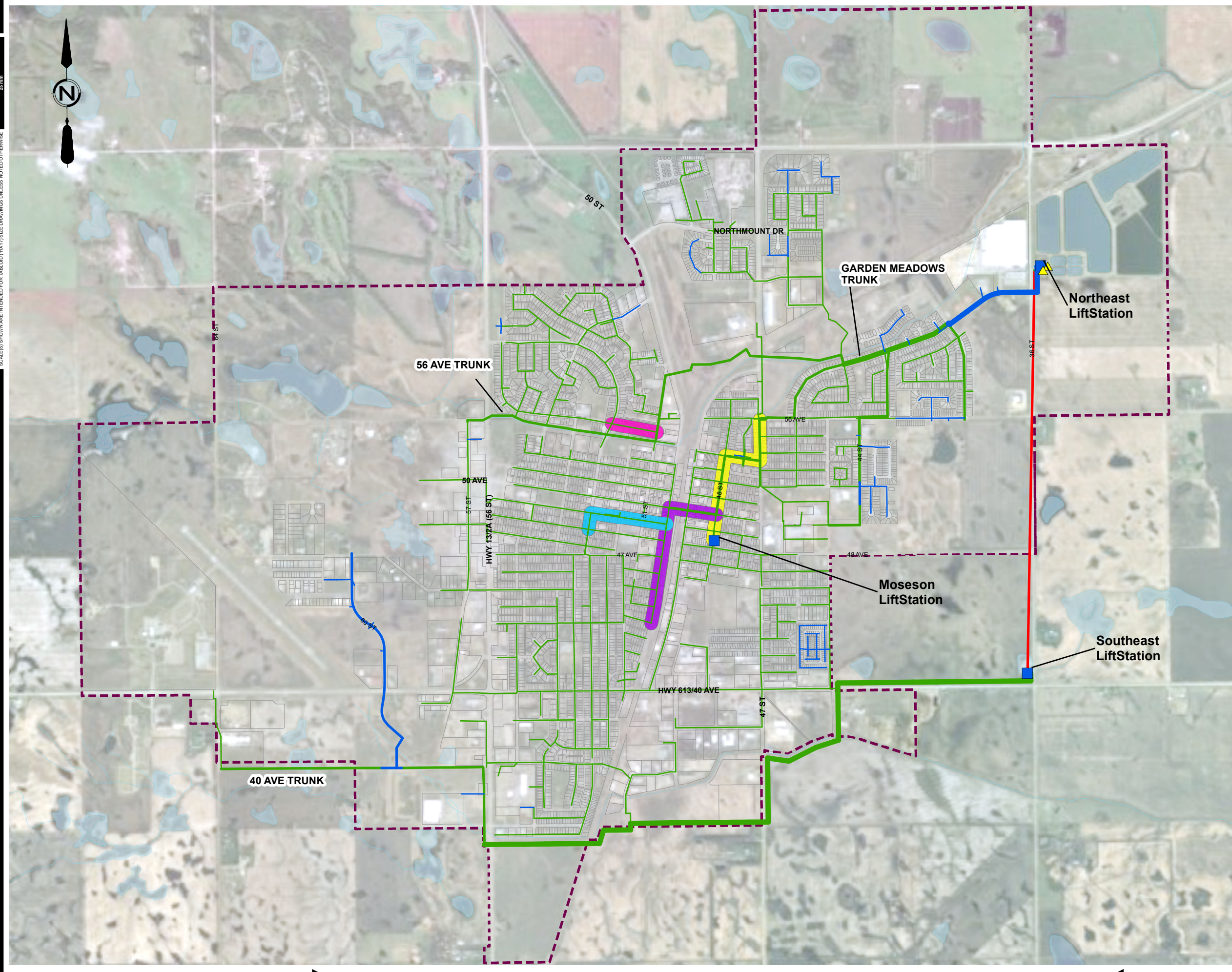


FIGURE 7-1

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

PROPOSED EXISTING SYSTEM UPGRADES

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL

8 FUTURE SYSTEM EXPANSION

Figure 8-1 presents the proposed future staged growth areas for the City of Wetaskiwin. These areas were determined through consultation with the City. The future sanitary sewer system concept is presented in four phases: Stages 1 through 3 and Ultimate Development. Area Structure Plans (ASPs) were reviewed where available and are reflected in the future sanitary concept where appropriate.

Sanitary flows from these future development areas were estimated using the design criteria detailed in **Table 2-1**. Population density for residential land use was assumed to be R3 Zoning (230 persons/ha). In addition, an average sewage generation rate of 40,000 L/h/day was assumed for non-residential land use.

The existing PCSWMM model was expanded for each development phase to include the estimated future flows from each growth area under the 1:100-Year, 4-Hour design storm event. Several upgrades were determined to be required to provide capacity within the City's existing sanitary sewer for future development stages. Pipe upgrades for each implementation stage are presented in **Figure 8-2** and summarized in **Appendix D (Table D-5 to D-8)**. Minimum pipe slopes, based on **Table 2-2**, should be applied during implementation of upgrades to mitigate bottlenecks within the system.

The proposed upgrades required to mitigate potential basement flooding in residential areas are as follows:

- **Aspen Ridge Subdivision:** Upgrades within the Aspen Ridge Subdivision are required to provide capacity for Stage 1 development. This upgrade consists of 250 mm diameter pipe, twin 525 mm diameter trunks, and includes a 900 mm crossing of the Canadian Pacific Railway rail line.
- **Glendale – Garden Meadows – Parkside Subdivisions:** This upgrade will be required to provide capacity for Stage 2 development and consists of 900 mm and 1200 mm diameter pipes.
- **Annexation-92 and Highway-North Subdivisions:** Trunk upgrades will be required southwest of the Annexation-92 and Highway-North Subdivisions to provide capacity for Ultimate Development. The upgrades consist of 375 mm and 450 mm diameter pipes.

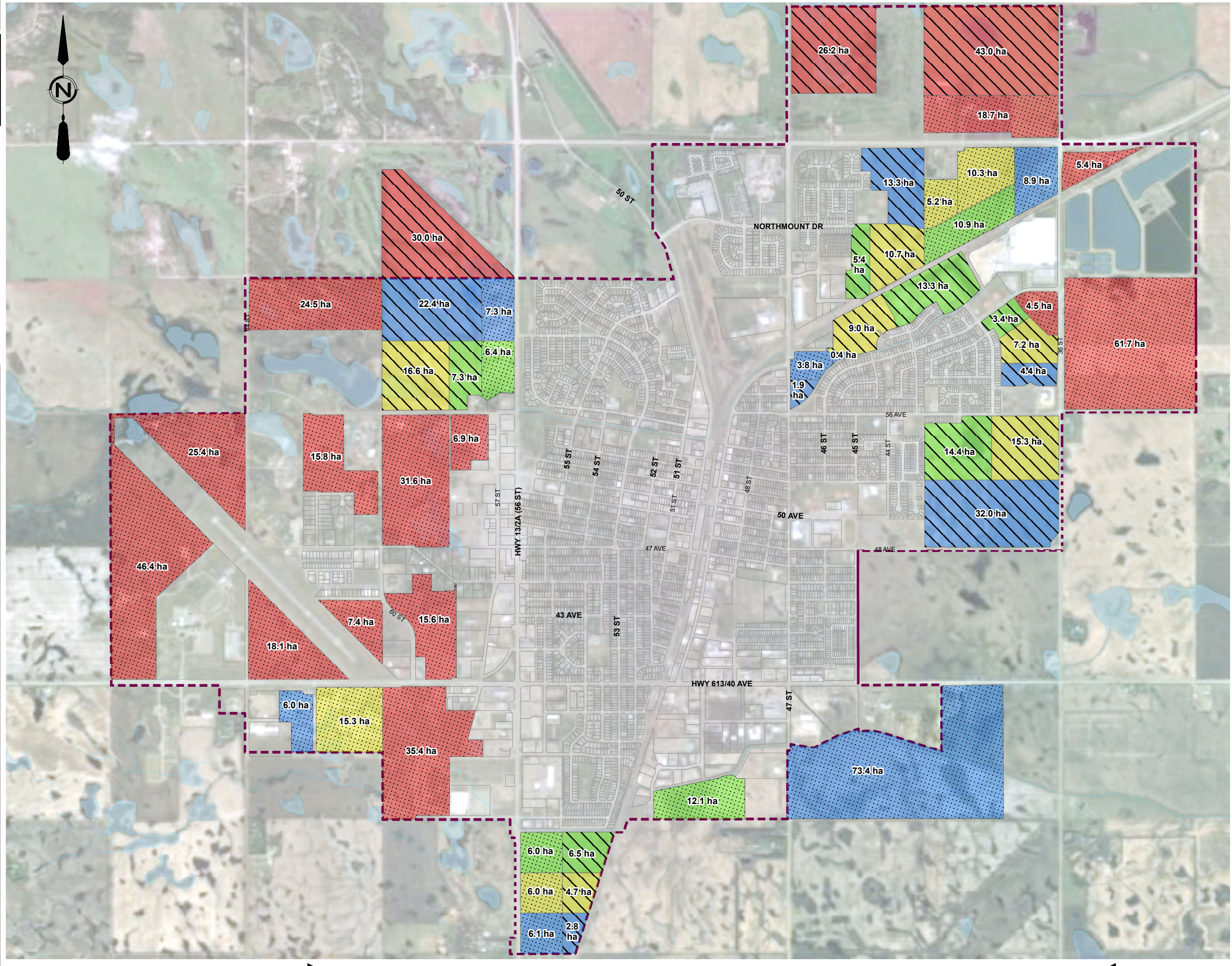
Based on the information available to date, additional pumping capacity will be required at both the Northeast and Southeast Lift Stations for future development. The Northeast Lift Station is estimated to require an increase in the pumping capacity for Stage 1 development. In addition, the Southeast Lift Station will require an increase to the pumping capacity for ultimate development. It is recommended that a more detailed analysis of the required pumping capacities be undertaken prior to lift station upgrades. This should include confirming pump curves, pump control rules, and wet well dimensions.

Figure 8-2 illustrates the recommended Ultimate Sanitary Servicing Concept for the City of Wetaskiwin. Trunk sizing will vary based on final slopes and pipe lengths which should be determined during feasibility and preliminary design stages. In addition, costs for the required upgrades to the existing system to provide capacity for the ultimate servicing concept are presented in **Section 9**. Costs including conceptual trunks have not been prepared; however, unit costs are included in **Appendix E**.

It is recommended that the Ultimate Sanitary Servicing Concept be followed as development within the City progresses. Development should progress in an orderly manner with discouragement of “leap-frogging”.

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DRAWING PATH: \\s-eon-fs-01\working\2020-3787-00\gsArcMap\Figs-1_ProjectedStageGrowthAreas.mxd
DATA SOURCE: :

SCALE(S) SHOWN ARE INTENDED FOR TABLOID (11X17) SIZE DRAWINGS UNLESS NOTED OTHERWISE
IF NOT 25 mm ASJUST SCALES



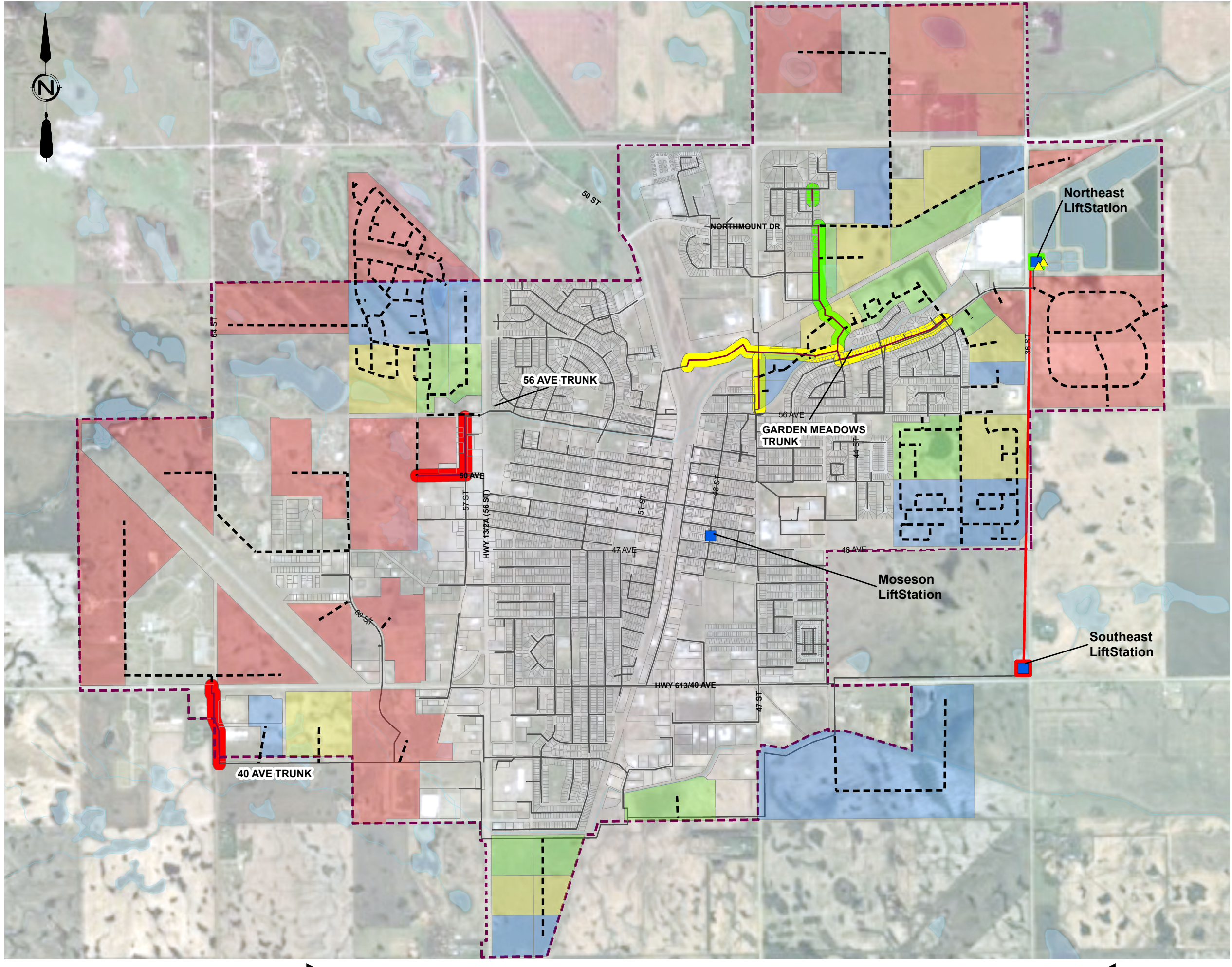
- Legend**
- City of Wetaskawin
 - Projected Future Development Area**
 - Stage 1
 - Stage 2
 - Stage 3
 - Ultimate
 - Residential
 - Non-Residential

FIGURE 8-1

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

PROJECTED STAGE GROWTH AREAS

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL



- Legend
-  Sanitary Lagoon

 Sanitary Lift Station

 Stage 1 Pipe Upgrade

 Stage 2 Pipe Upgrade

 Ultimate Pipe Upgrade

 Conceptual Sanitary Pipe

 Existing Sanitary Pipe

 Sanitary Forcemain

 Stage 1 Lift Station Upgrade

 Ultimate Lift Station Upgrade

 City of Wetaskawin
- Projected Future
Development Area
-  Stage 1

 Stage 2

 Stage 3

 Ultimate

FIGURE 8-2

CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

ULTIMATE SANITARY SERVICING CONCEPT

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL

9 COST ESTIMATES

A summary of capital cost estimates is provided in **Table 9-1** for the proposed upgrades to the existing sanitary system for existing and future system expansion. The estimates include an allowance for engineering (15%) and contingency (15%), but do not include GST. All costs are presented in 2021 dollars. A breakdown of unit costs is included in **Appendix E**.

Table 9-1
Existing System Upgrades Capital Cost Estimate

Upgrades to Existing System	
Upgrades	Costs
UP1	\$2,923,000
UP2	\$1,850,000
UP3	\$1,966,000
UP4	\$672,000
Total	\$7,411,000
Upgrades to Existing for Ultimate Development	
Development Stage	Costs
Stage 1	\$2,771,000
Stage 2	\$8,598,000
Stage 3	\$ 0
Ultimate	\$2,859,000
Total	\$14,228,000
Total Upgrades to Existing	\$21,639,000

10 CONCLUSIONS

Following are the key findings of the Sanitary Master Plan Update:

- The topography of The City of Wetaskiwin generally falls toward the east with the highest elevations occurring in the west portion of the City and the lowest elevations located in the northeast near the wastewater lagoons.
- The City has an urban wastewater collection system including gravity sewers ranging in size from 100 to 1200 mm in diameter, manholes, lift stations and forcemains.
- Weeping tiles, roof leaders, and other stormwater connections are not permitted to tie-in to the sanitary sewer system. However, prior to 2001, house weeping tiles were typically connected to the sanitary sewer system.
- In general, the data obtained from the flow monitoring program was found to be of good quality. Associated Engineering completed extensive quality control reviews and adjusted flow data as described in [Section 4](#). No data adjustments were required for the rainfall data.
- Distinct diurnal curves and average dry weather flow rates for each land use class were estimated from the 2020 flow monitoring data. The calibrated residential sewage rates were 50% and 80% of the historical water consumption data for low and medium-high density land uses, respectively. Similarly, the calibrated commercial and industrial sewage rates were 50% and 90% of the water consumption data, respectively.
- The updated model was simulated for two week-long DWF periods to calibrate and validate modelled flows. Modelled peak flows were found to be within 35% of observed flows during calibration, on average. On average, peak flows were found to be within 40% of observed flows during validation. Based on this, the model was considered slightly conservative and validated for DWF parameters.
- Storm events occurred on June 30-July 1, August 7, and August 11 during the 2020 Flow Monitoring program and were chosen for WWF calibration and validation events. The updated model was simulated for these three storm events. The largest event occurred on August 11, 2020 and was approximately equivalent to a 1:5-Year design storm event. The events on August 7 and June 30-July 1 were approximately equal to 1:2-Year design storm events.
- The largest storm event during the flow monitoring period occurred on August 11, 2020. This event was chosen for the WWF calibration of the updated model. However, due to the spatial variability of rainfall over an area, some Flow Monitors did not respond during this storm event. Therefore, the August 7, 2020 event was used as a second calibration event. Modelled peak flows were found to be within 10% of observed flows during the August 7 event and 50% of observed flows during the August 11 event, on average.
- The model was validated with the June 30-July 1, 2020 storm event. On average, peak flows were found to be within 15% of observed flows. Based on this, the model was considered validated for WWF parameters.
- Overall, the existing sanitary sewer system provides close to a 1:100-Year level of service with no surcharge to ground. However, localized sections of pipes are over capacity for design storm events equal to or greater than the 1:5-Year 4-Hour design storm event.
- Shallow manholes exist within the central part of the City (City Centre and Central subdivisions), which could lead to basement flooding during a more severe storm.

- Several upgrades were proposed to address pipe capacity issues within the City's existing sanitary sewer system during the 1:100-Year design storm event. This provides a robust system to mitigate the impacts of climate change which increases the frequency of storm events within our region.
- Based on the information available to date, additional pumping capacity will be required at both the Northeast and Southeast Lift Stations for future development. The Northeast Lift Station is estimated to require an increase in the pumping capacity for Stage 1 development. The Southeast Lift Station will require an increase to the pumping capacity for ultimate development.
- Proposed future staged growth areas for the City of Wetaskiwin were determined through consultation with the City during the Water Master Plan Update in 2019. The future sanitary system concept is presented in four phases: Stages 1 through 3 and Ultimate Development.

11 RECOMMENDATIONS

Associated Engineering recommends the following:

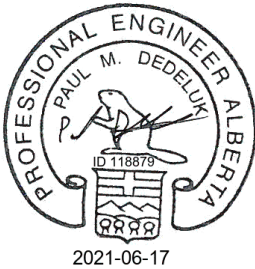
- The City update their Municipal Engineering Standards to include the use of the 2018 EPCOR IDF curves to provide consistency for modelling purposes and align with the Stormwater Master Plan Update (Associated Engineering, 2020).
- The City of Wetaskiwin Municipal Engineering Standards continue to be used by developers for design purposes of all new local and lateral sewers.
- Additional calibration and validation of the updated PCSWMM model will be required as more observed data becomes available. This will increase the confidence in the representation of the system during various design storm events.
- The City implement a continuous sanitary sewer flow monitoring program.
- It is recommended that the City confirm and validate their cadastre GIS layer for future use.
- Further refinement of each recommended upgrade should be completed based on the final development plans and site assessment during the preliminary design. The upgrades for each location should be based upon site constraints, construction method (open-cut, trenchless), budget, etc.
- A more detailed analysis of pumping capacity be undertaken at both the Northeast and Southeast Lift Stations prior to lift station upgrades.
- The Ultimate Sanitary Servicing Concept be followed as development within the City progresses. Development should progress in an orderly manner with discouragement of “leap-frogging”.

CLOSURE

This report was prepared for the City of Wetaskiwin to complete an update to the City's Sanitary Master Plan.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Engineering Alberta Ltd.

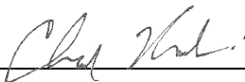


Paul Dedeluk, P.Eng.
Project Manager



Laurel Richards, P.Eng.
Water Resources Engineer

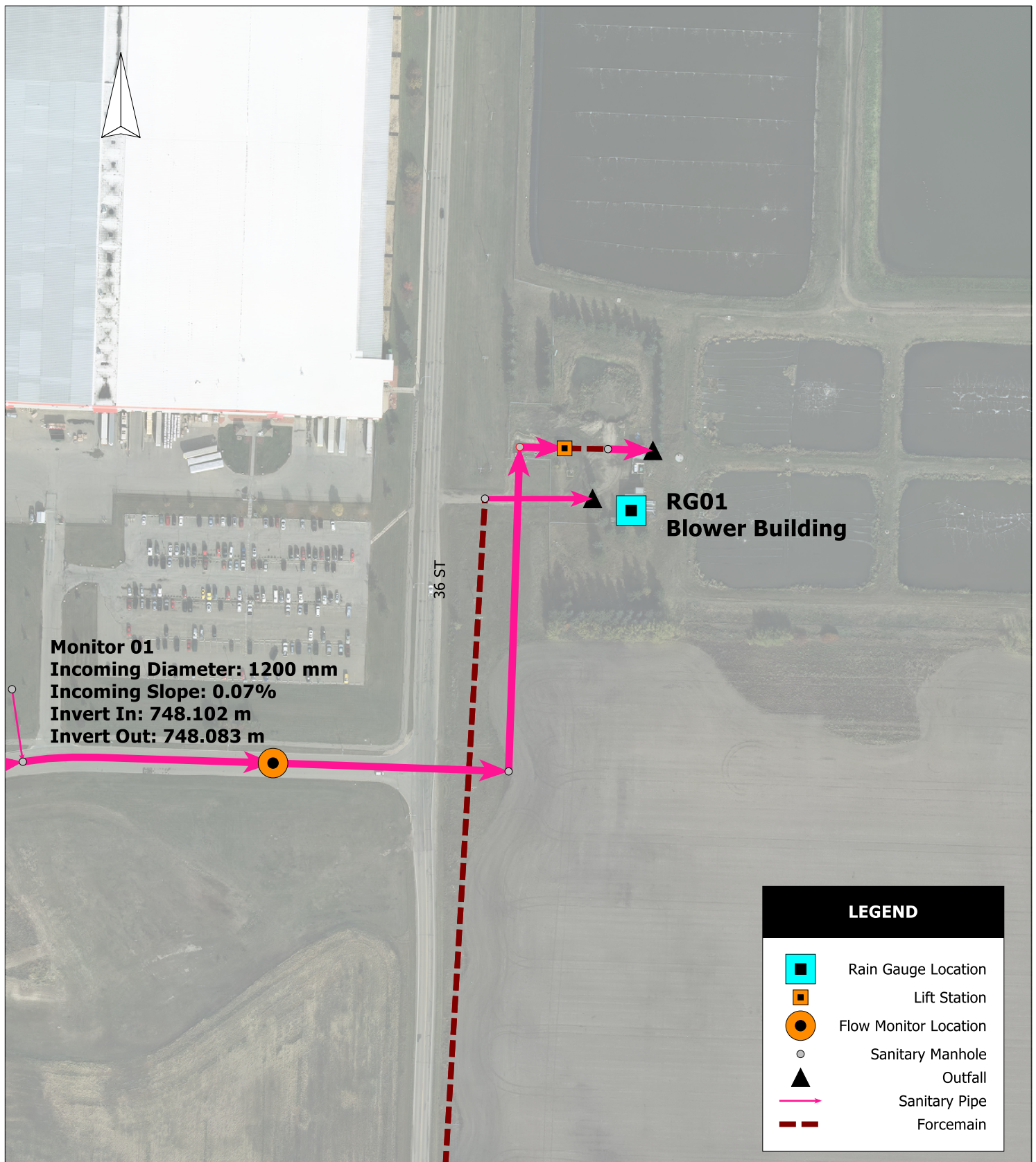
**PERMIT TO PRACTICE
ASSOCIATED ENGINEERING ALBERTA LTD.**

Signature 
ID: 84469 2021-06-18

PERMIT NUMBER: P 03979

The Association of Professional Engineers
and Geoscientists of Alberta

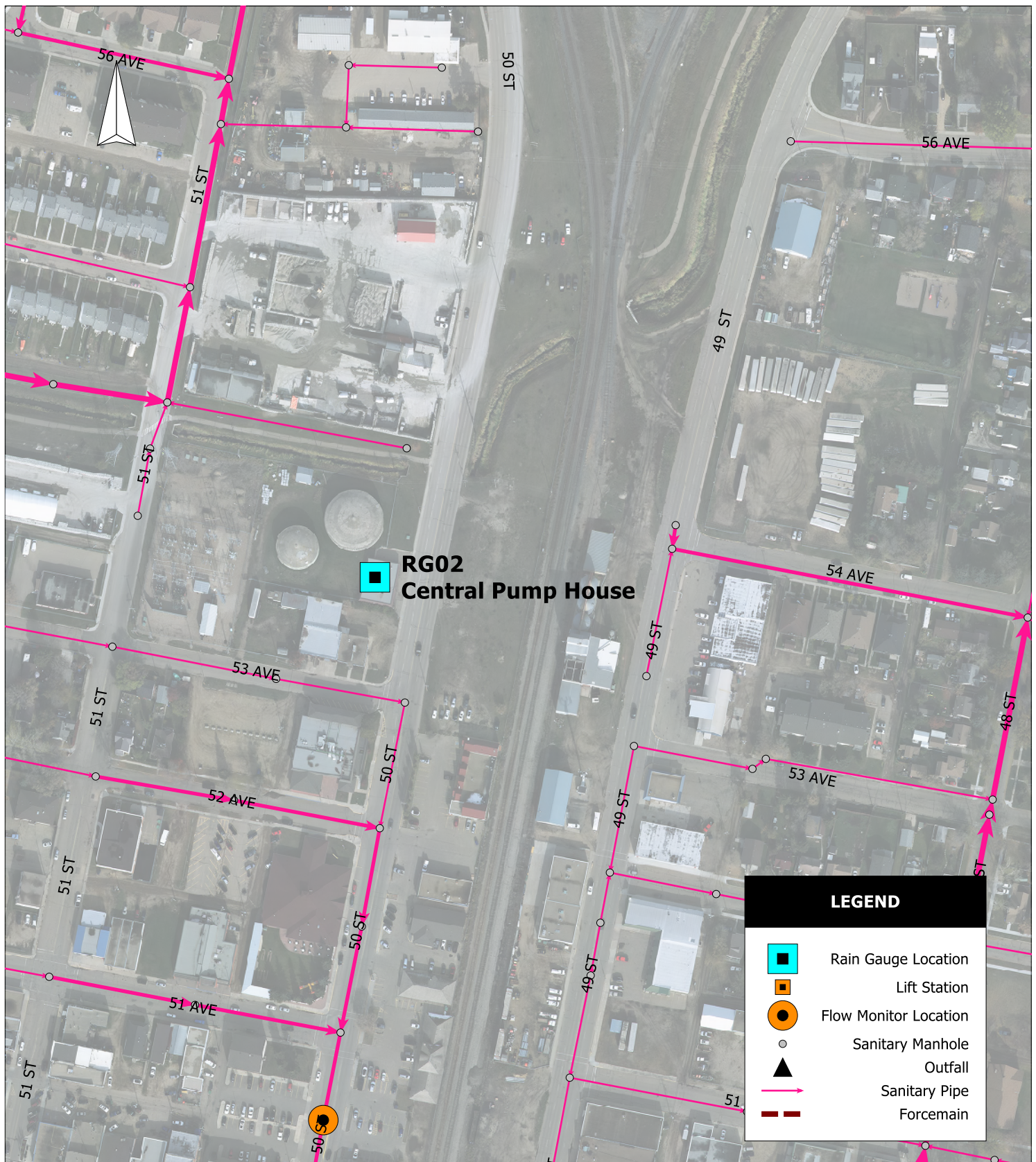
APPENDIX A - FLOW MONITOR SITE MAPS



SANITARY SEWER FLOW MONITORING PROGRAM

Rain Gauge Site 01

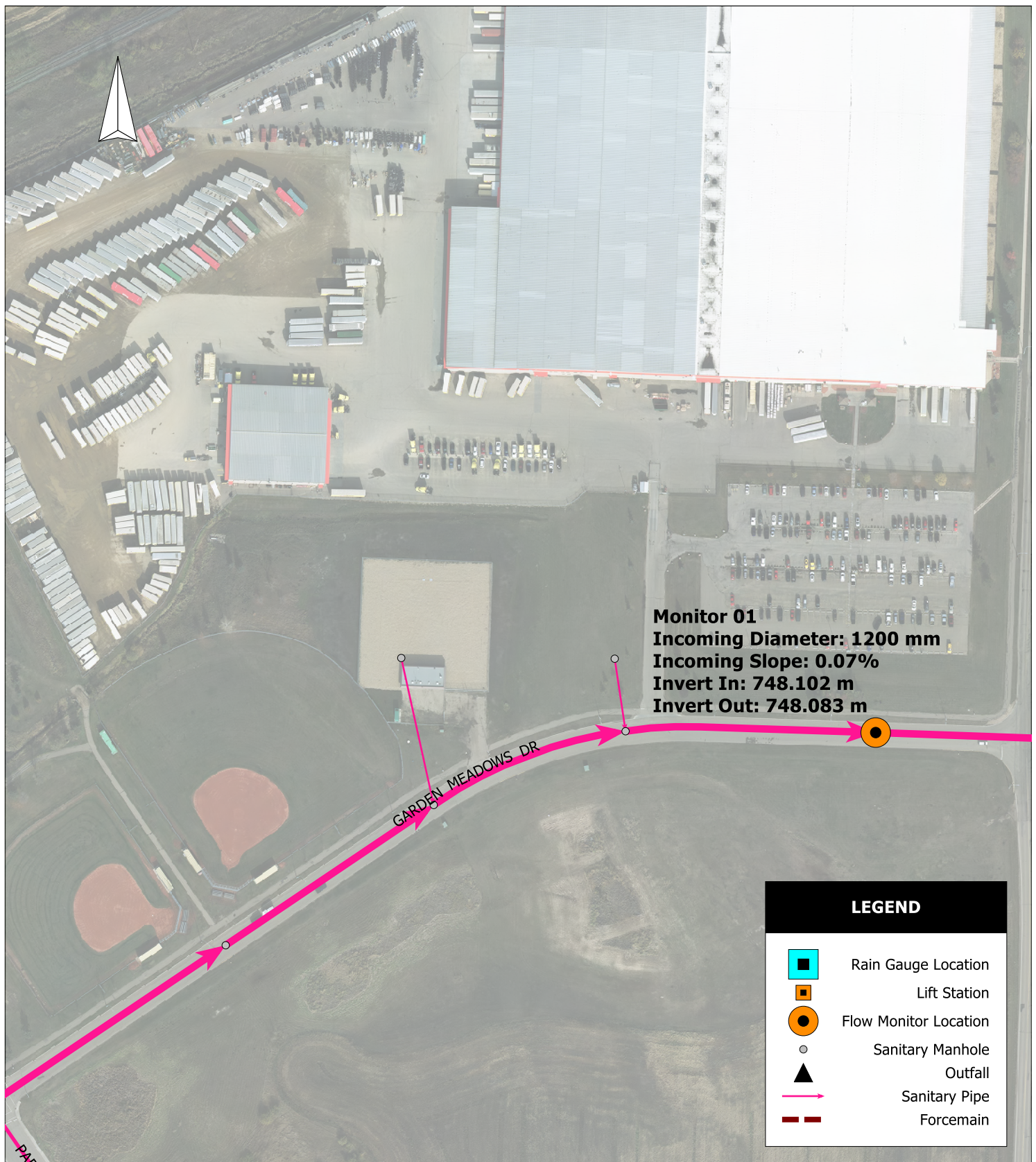
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SANITARY SEWER FLOW MONITORING PROGRAM

Rain Gauge Site 02

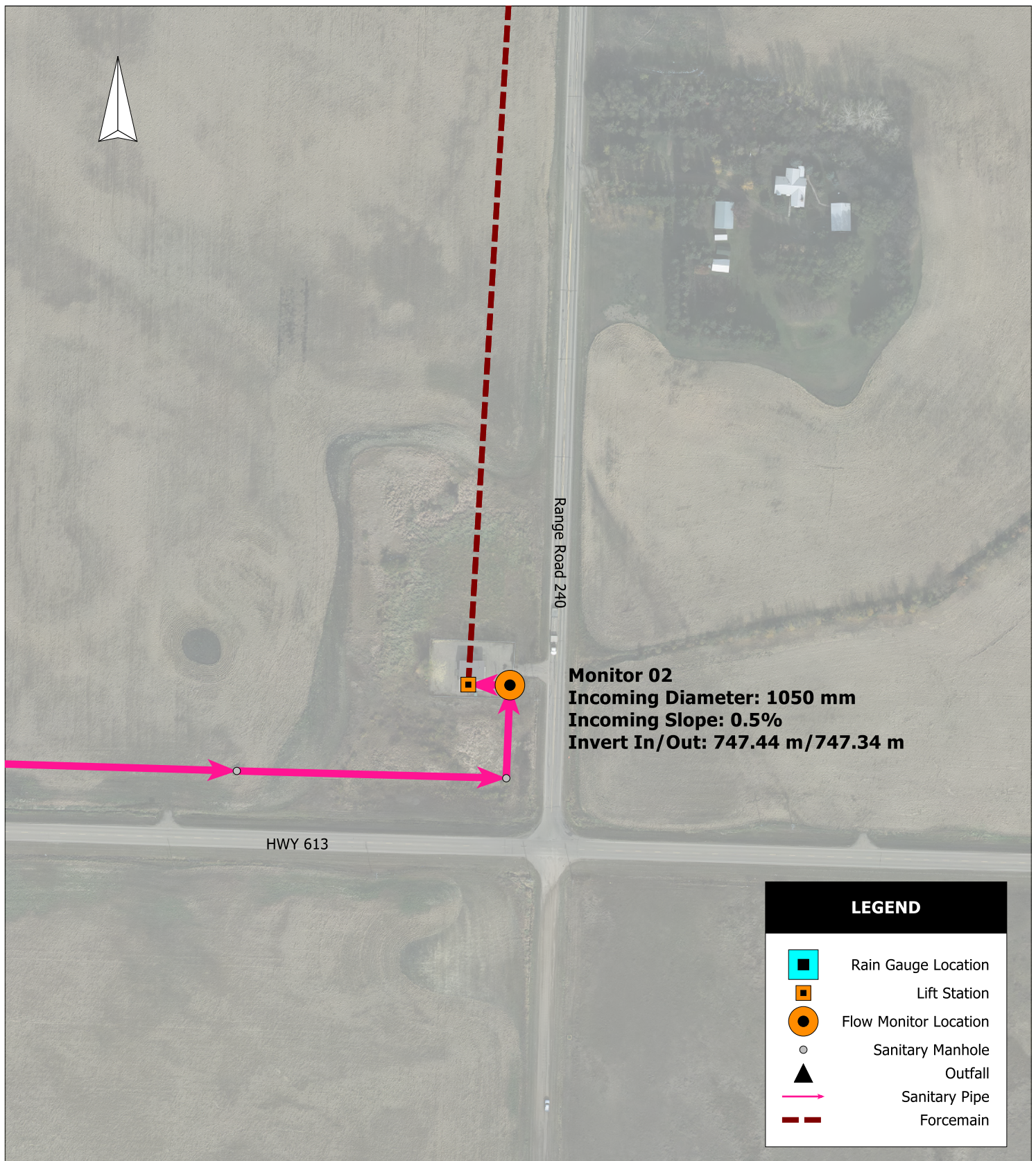
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SANITARY SEWER FLOW MONITORING PROGRAM

Flow Meter Site 01

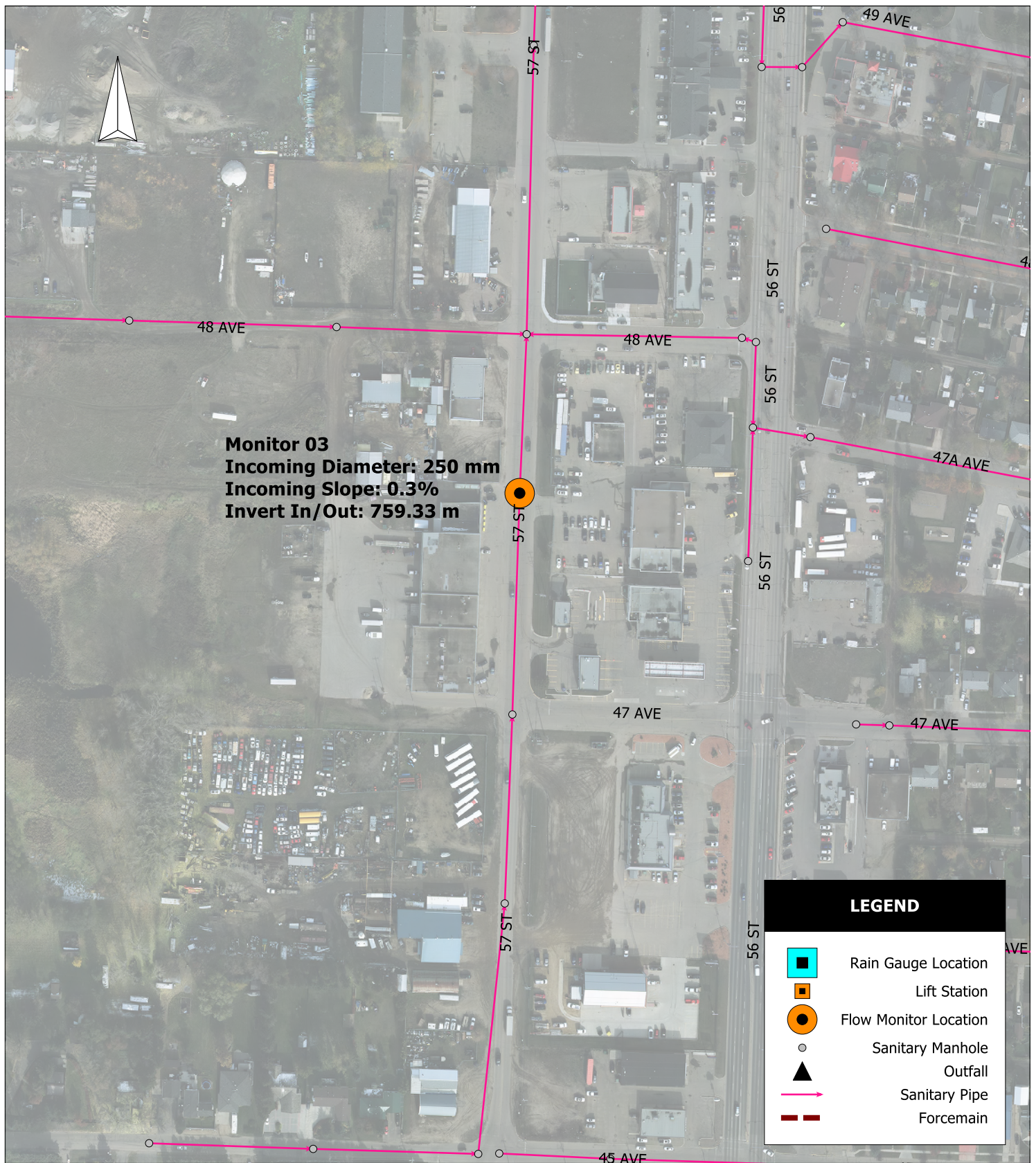
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SANITARY SEWER FLOW MONITORING PROGRAM

Flow Meter Site 02

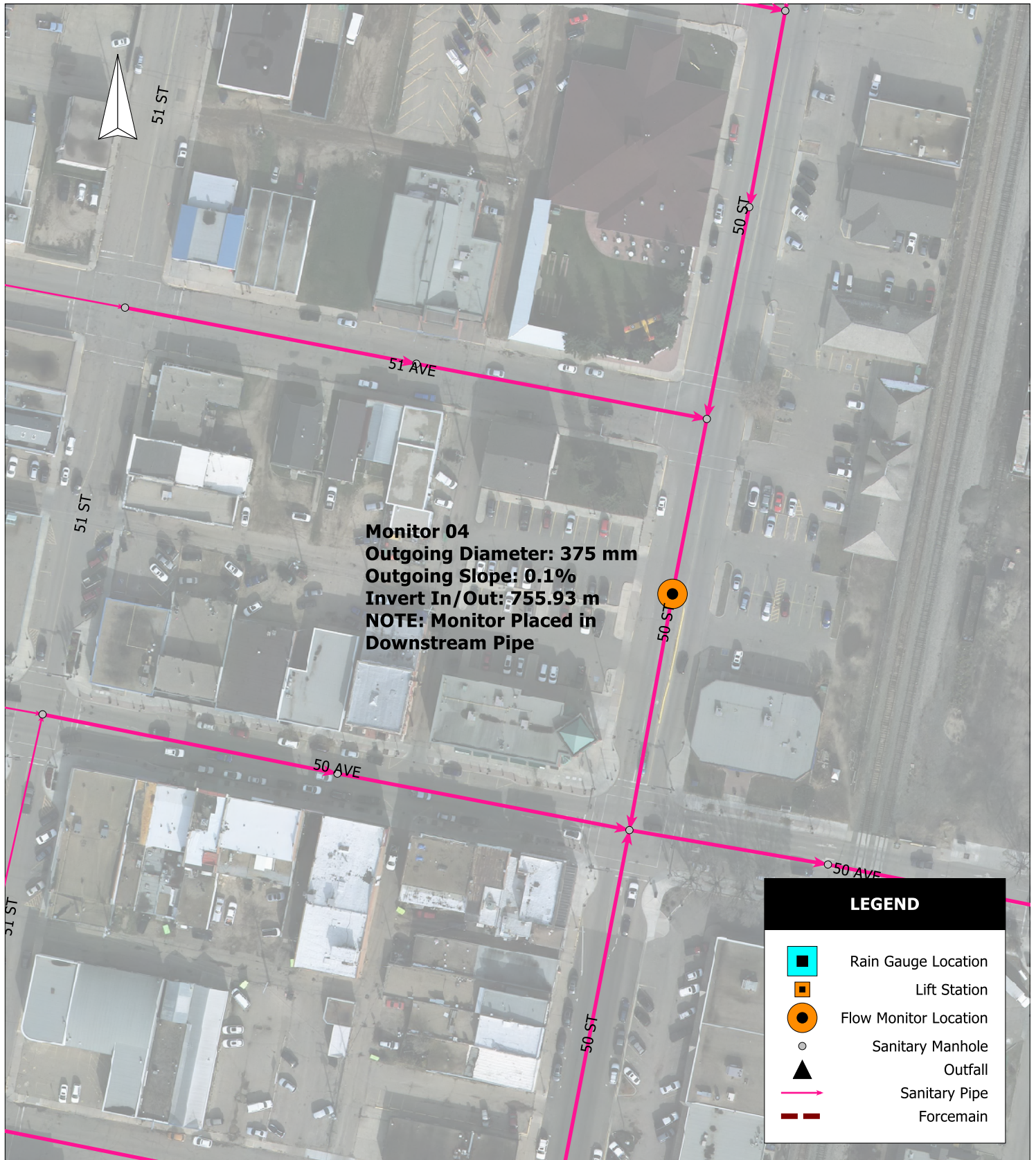
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SANITARY SEWER FLOW MONITORING PROGRAM

Flow Meter Site 03

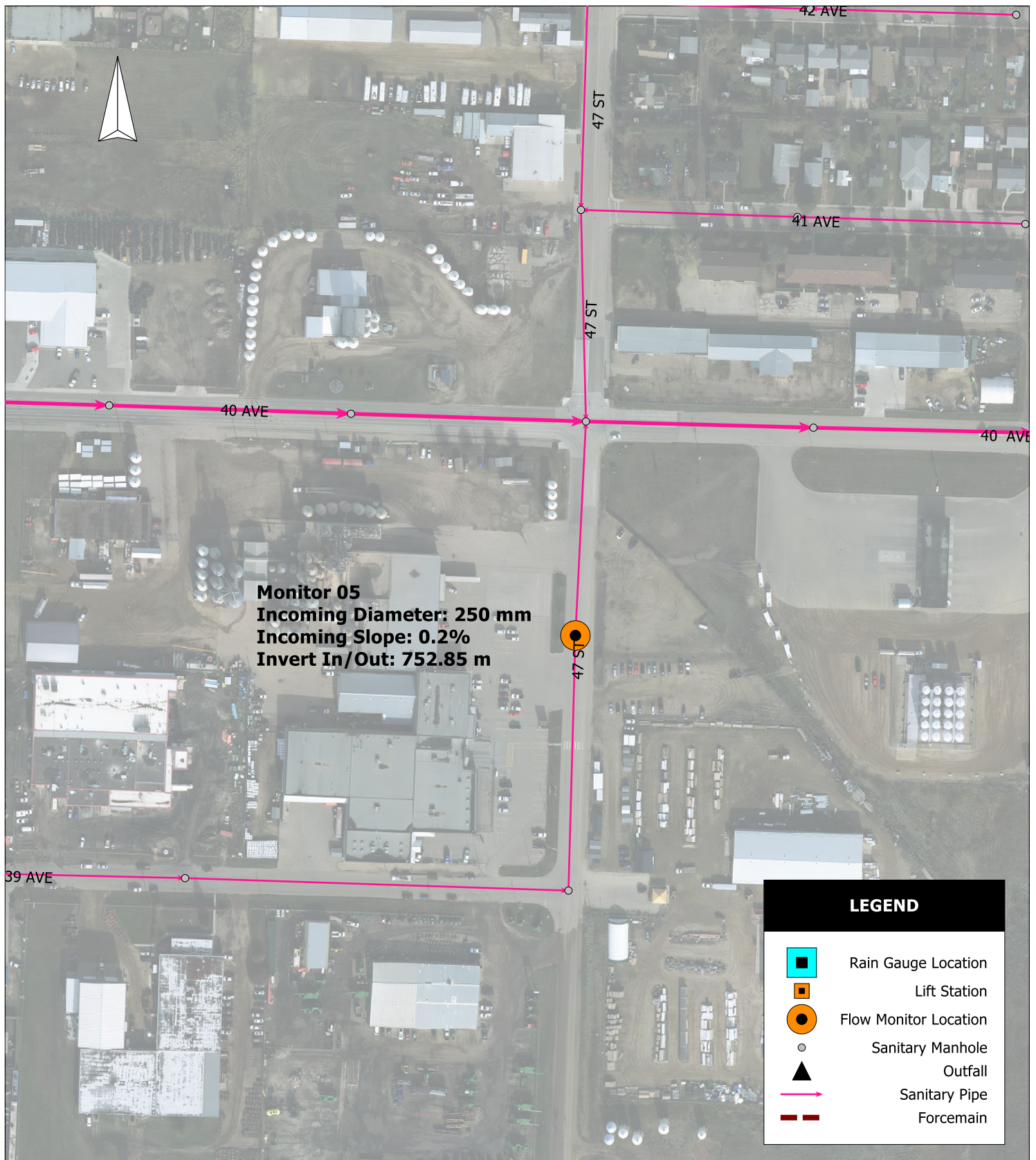
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SANITARY SEWER FLOW MONITORING PROGRAM

Flow Meter Site 04

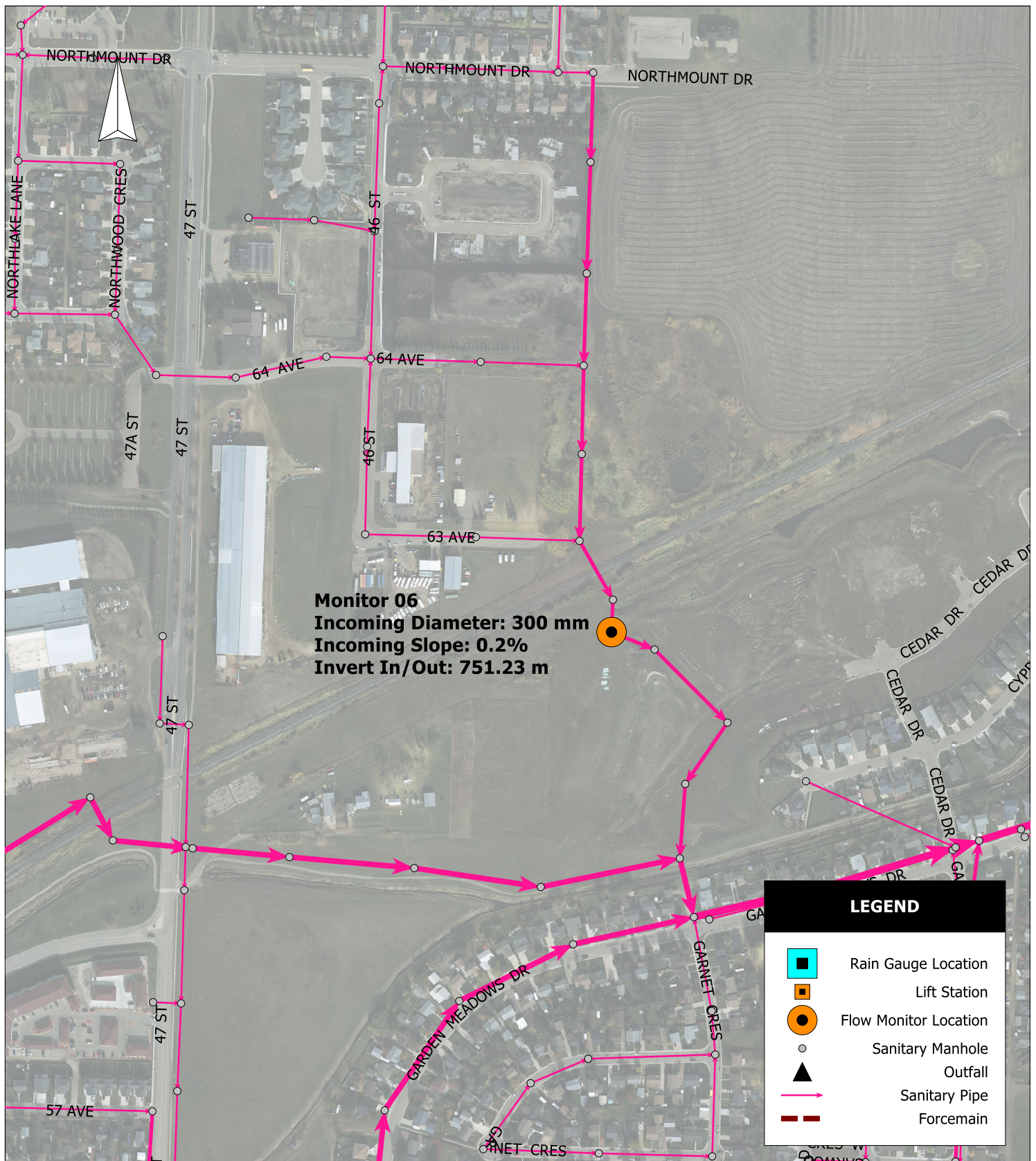
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SANITARY SEWER FLOW MONITORING PROGRAM

Flow Meter Site 05

Scale 1:2,500



SANITARY SEWER FLOW MONITORING PROGRAM

Flow Meter Site 06

Scale 1:5,000

APPENDIX B - DIURNAL PATTERNS

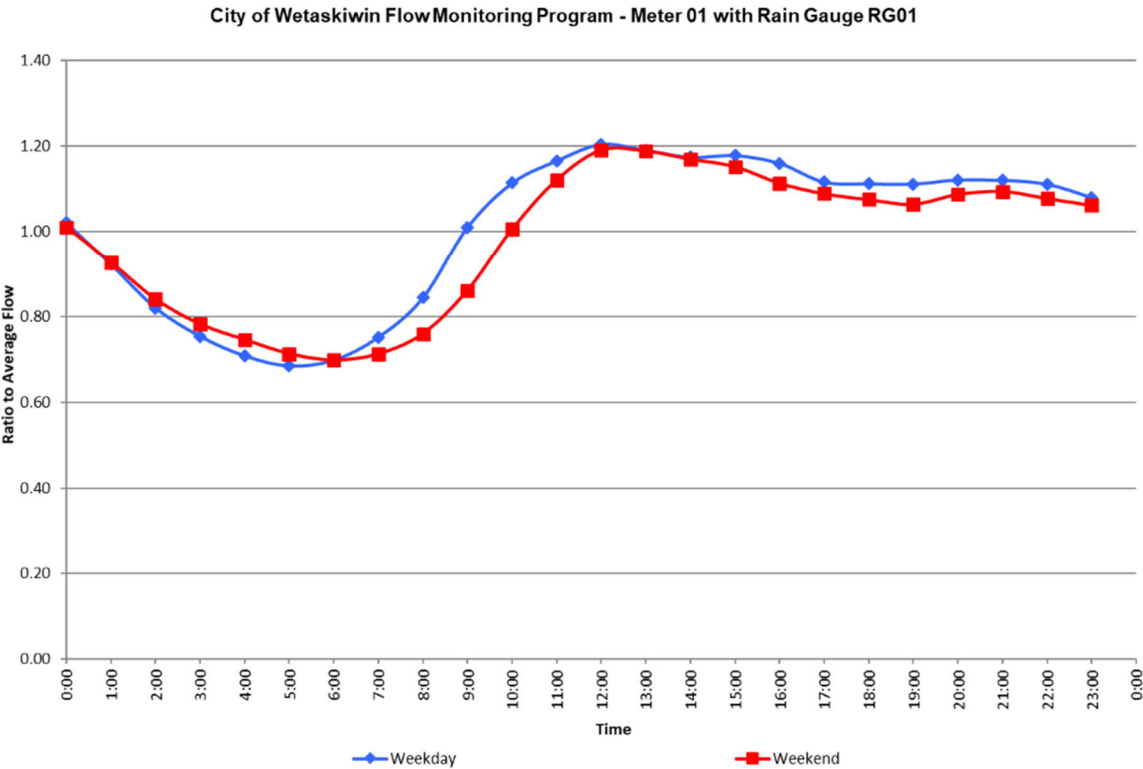


Figure B-1: Flow Monitor 1 Diurnal Patterns

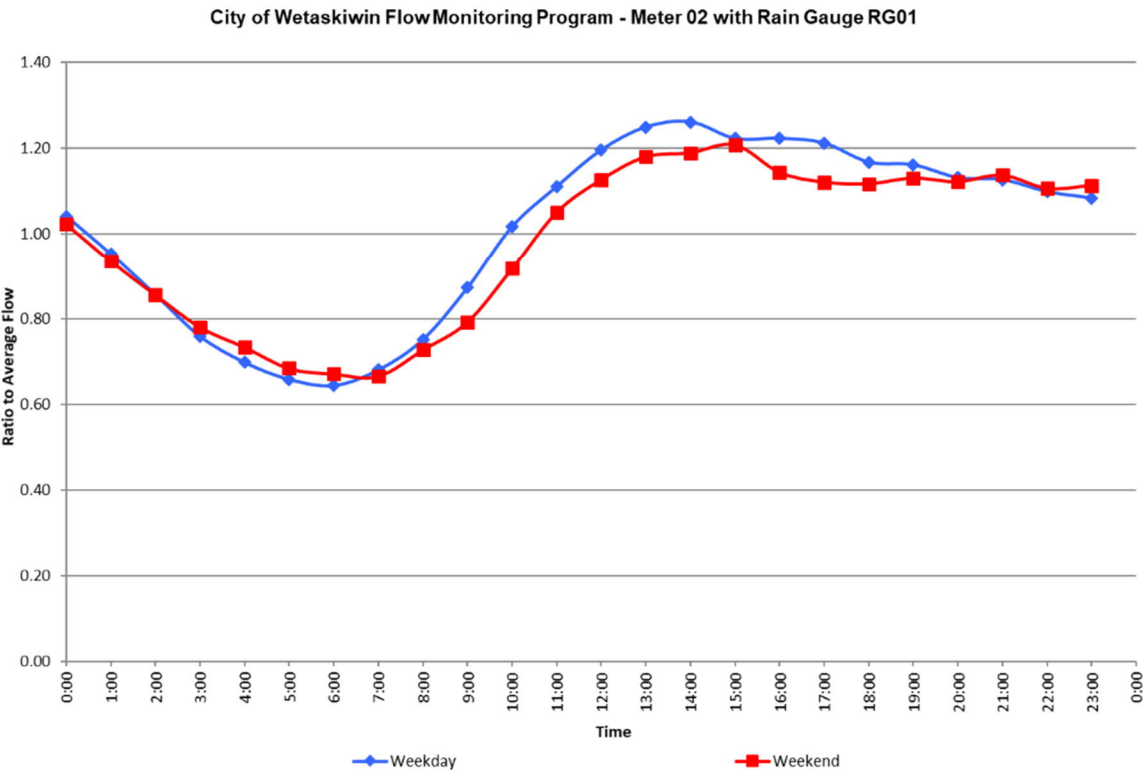


Figure B-2: Flow Monitor 2 Diurnal Patterns

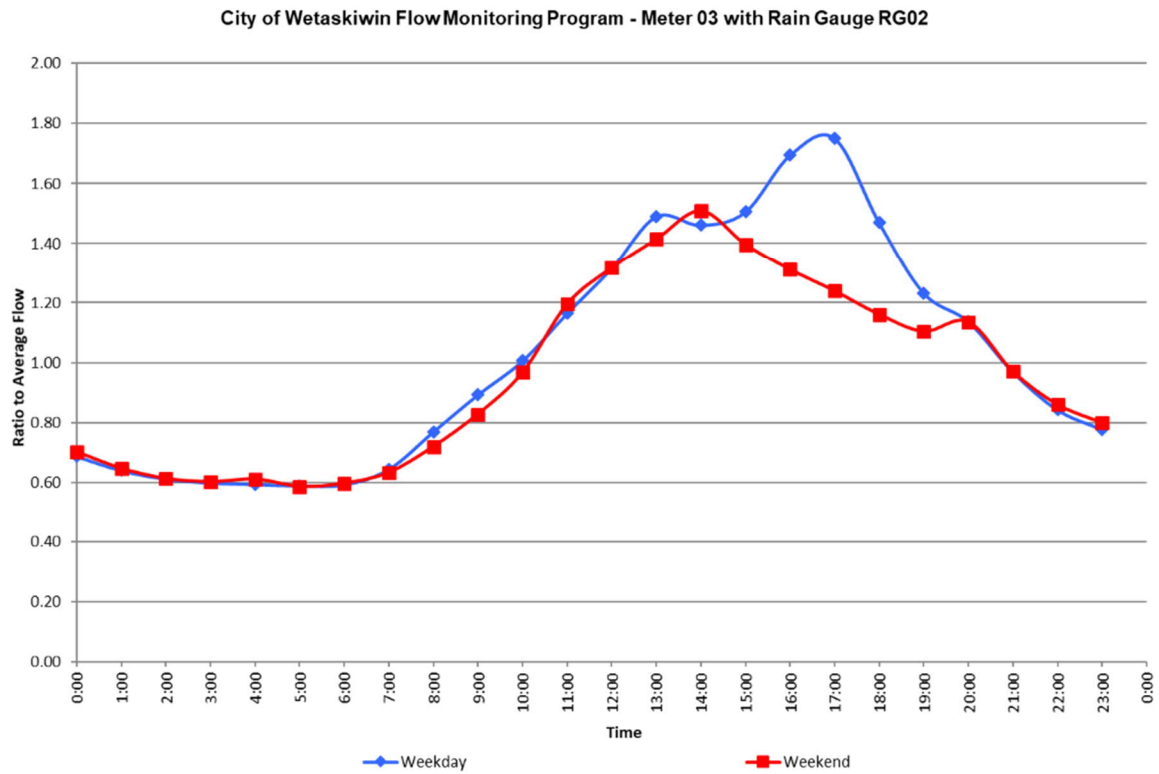


Figure B-3: Flow Monitor 3 Diurnal Patterns

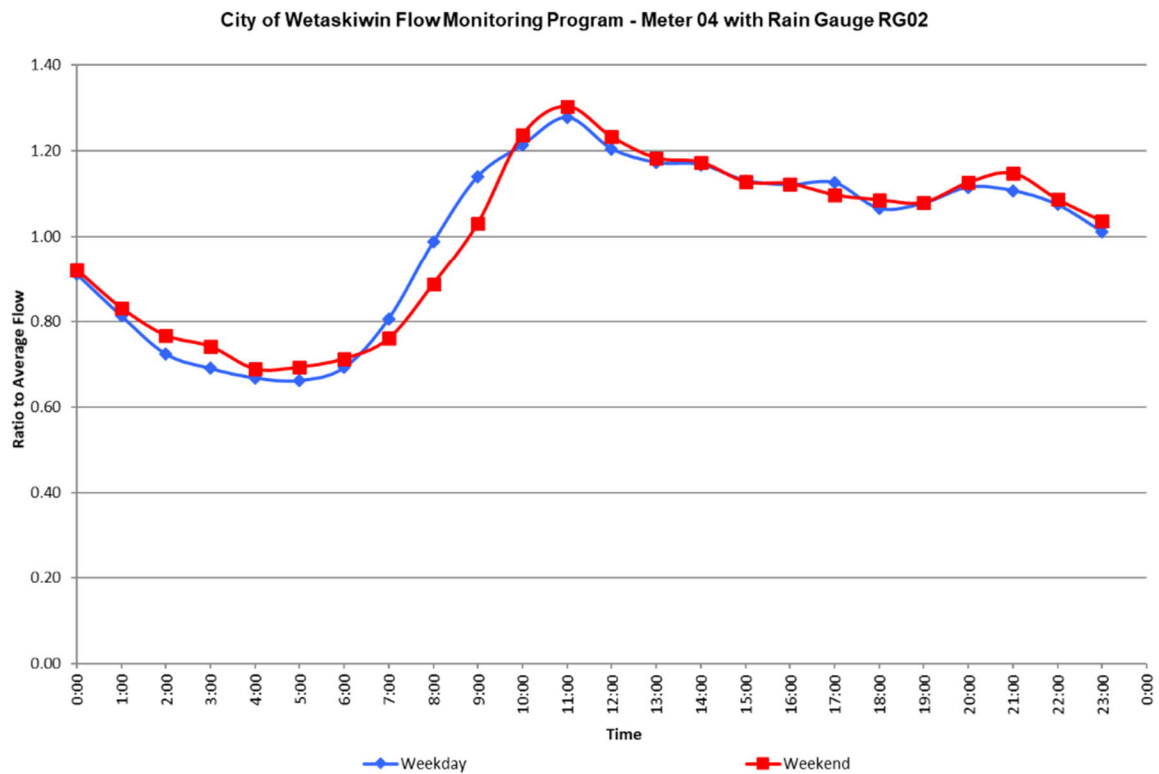


Figure B-4: Flow Monitor 4 Diurnal Patterns

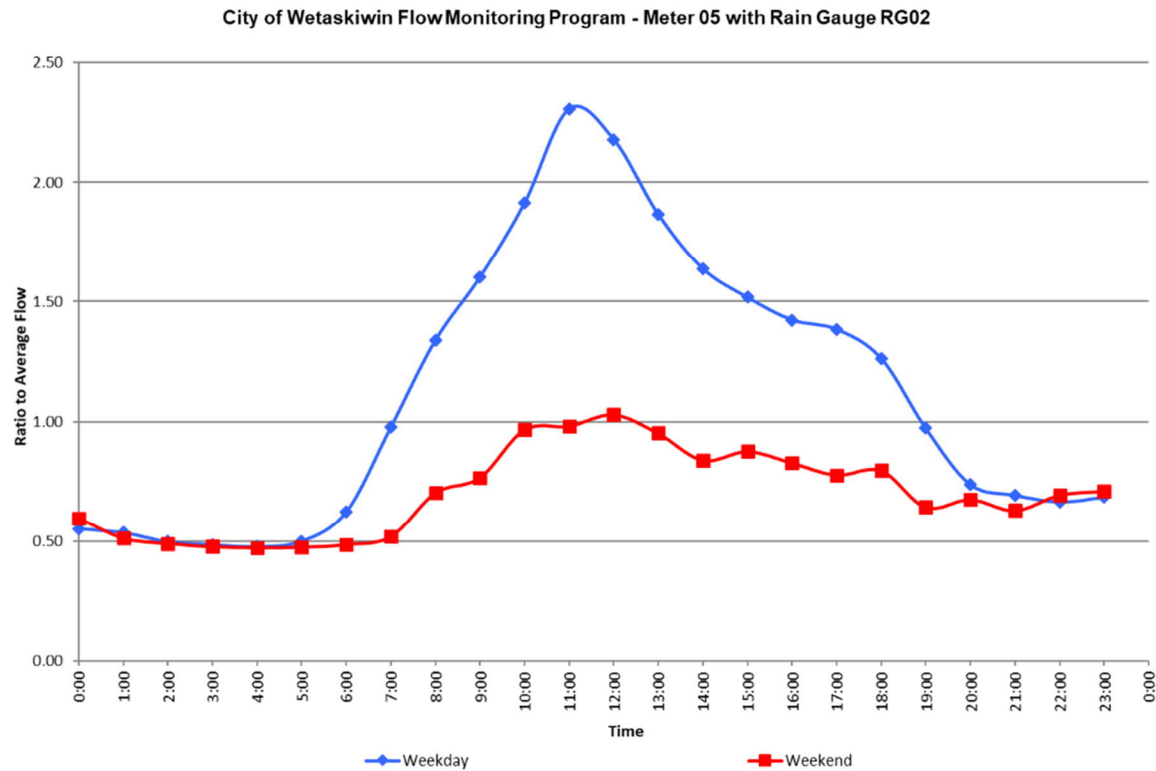


Figure B-5: Flow Monitor 5 Diurnal Patterns

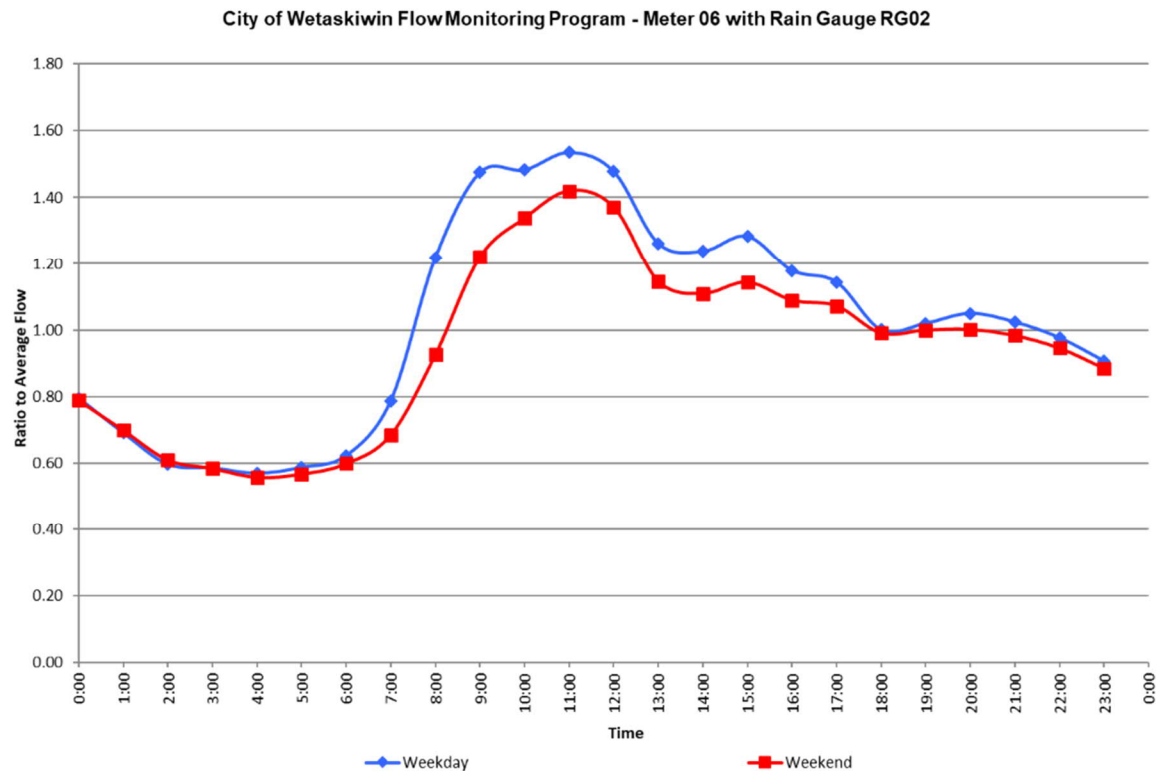
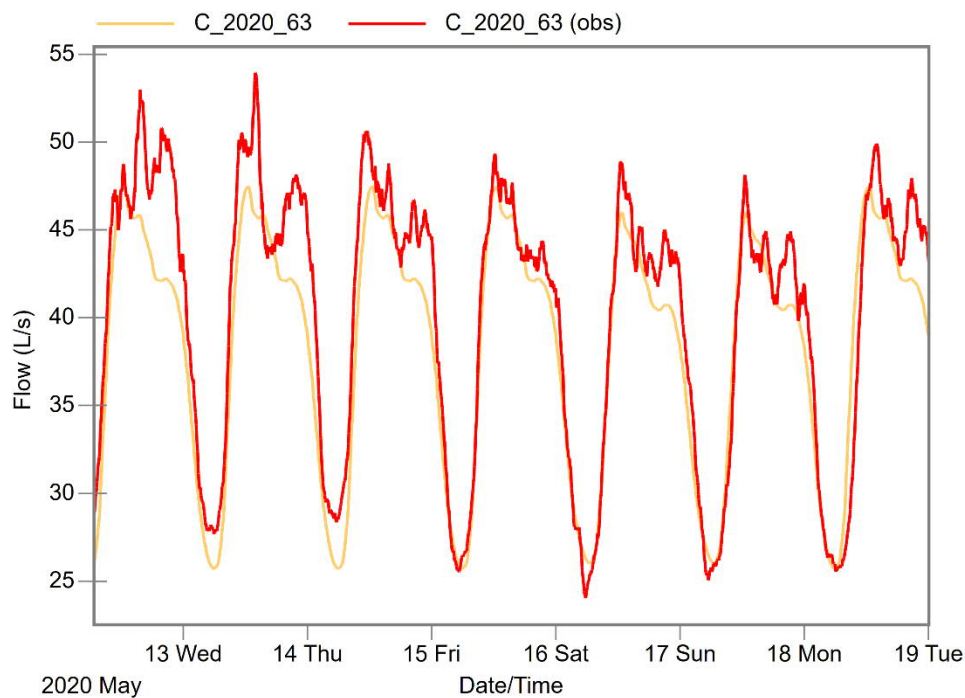


Figure B-6: Flow Monitor 6 Diurnal Patterns

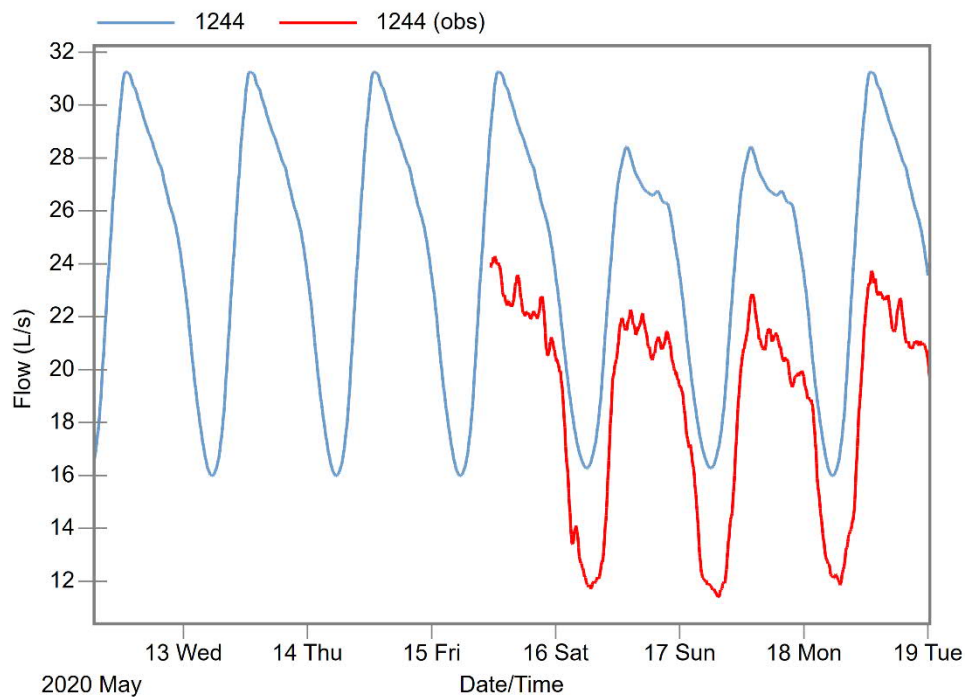
APPENDIX C - CALIBRATION AND VALIDATION PLOTS

DRY WEATHER FLOW CALIBRATION

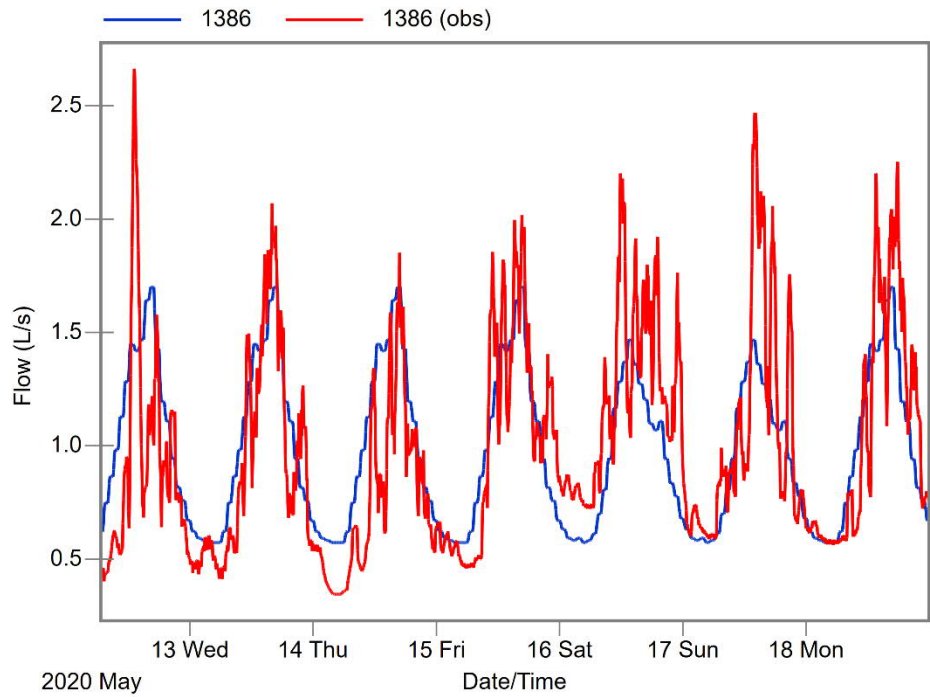
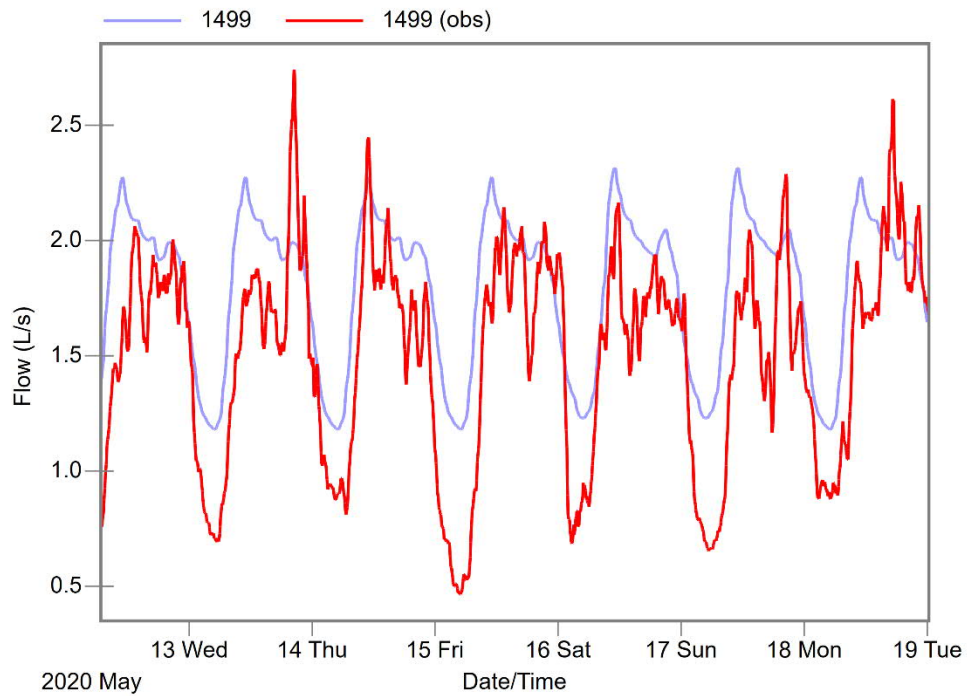
MAY 12, 2020 - MAY 19, 2020

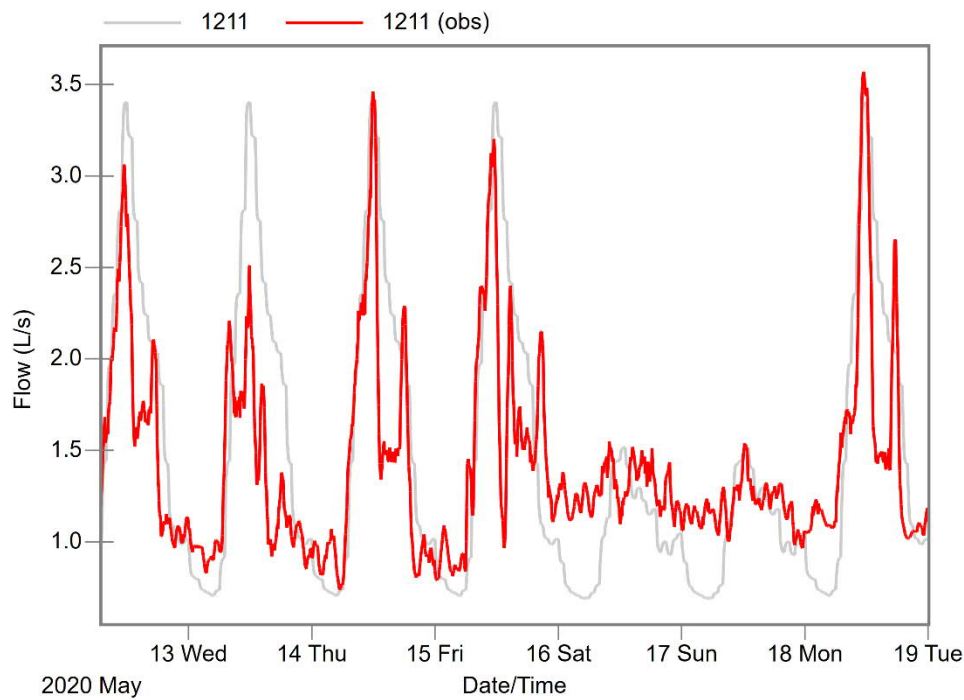


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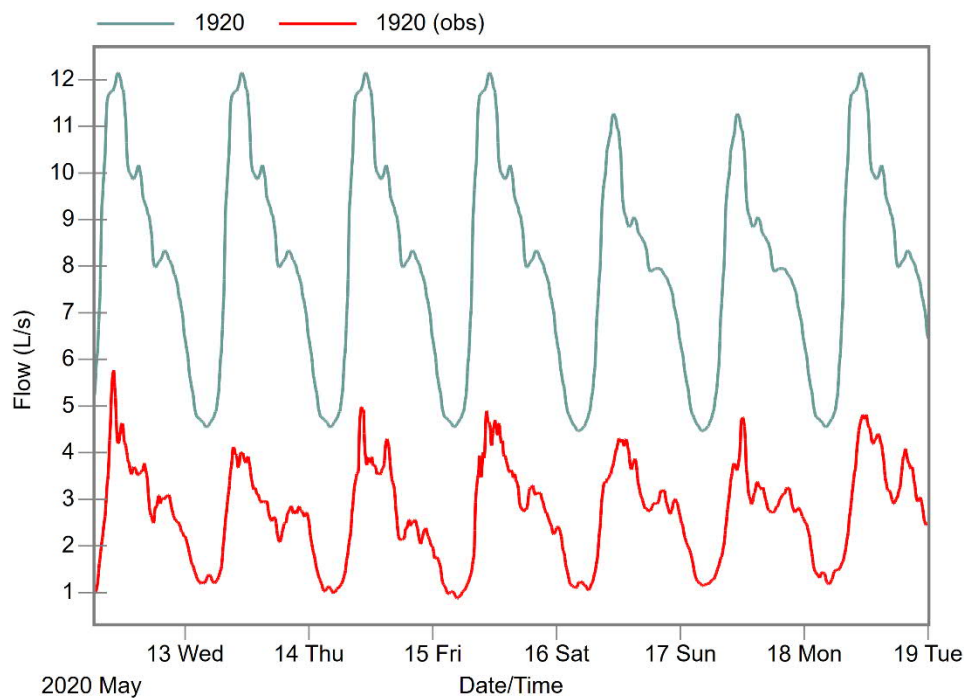


Flow Monitor 2

**Flow Monitor 3****Flow Monitor 4**

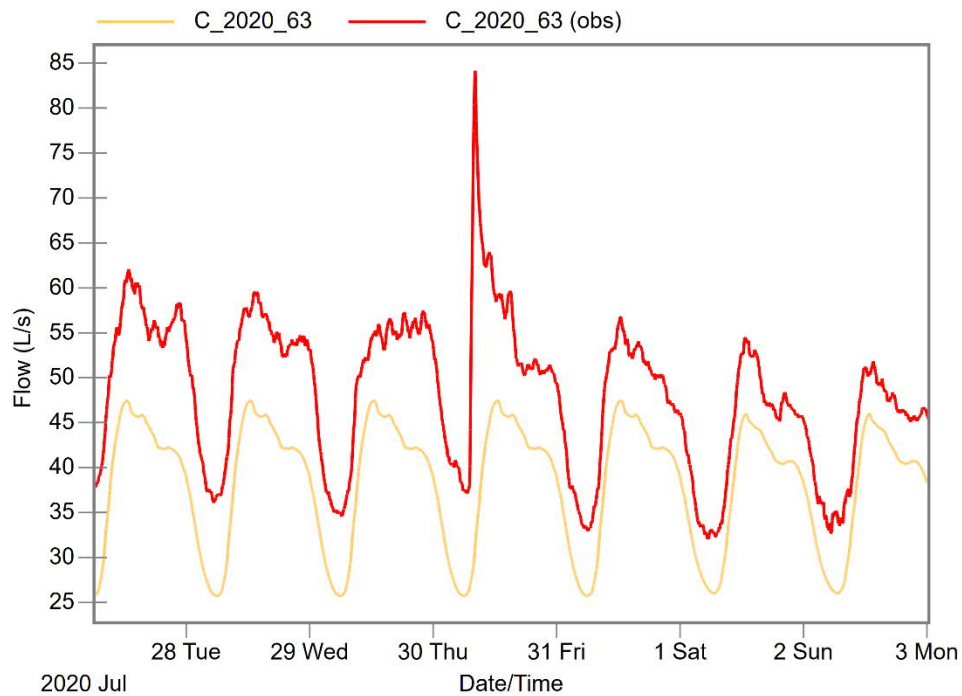


Flow Monitor 5

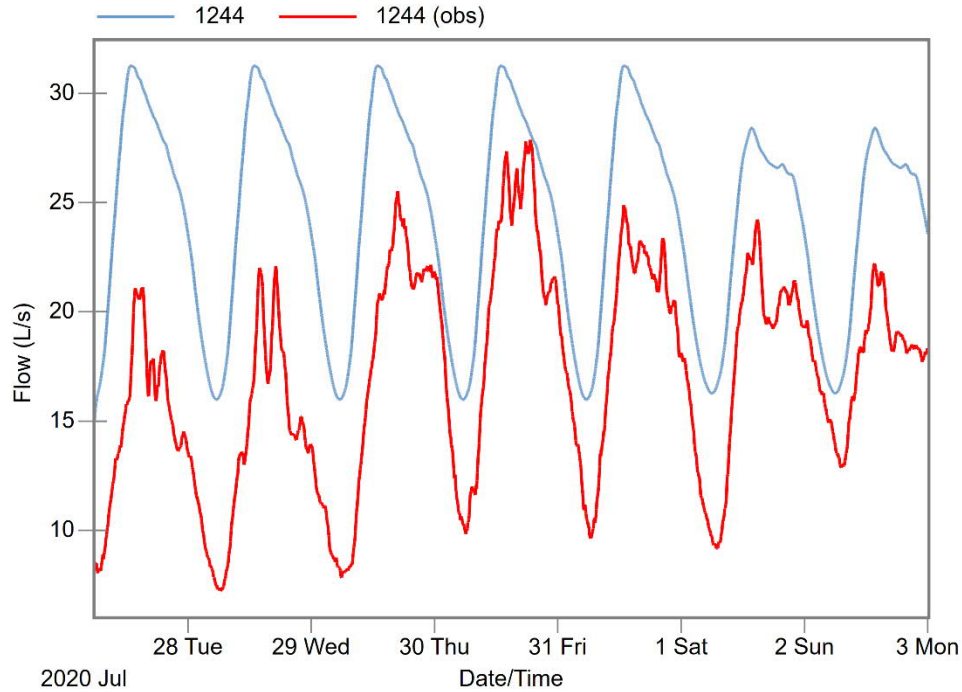


Flow Monitor 6

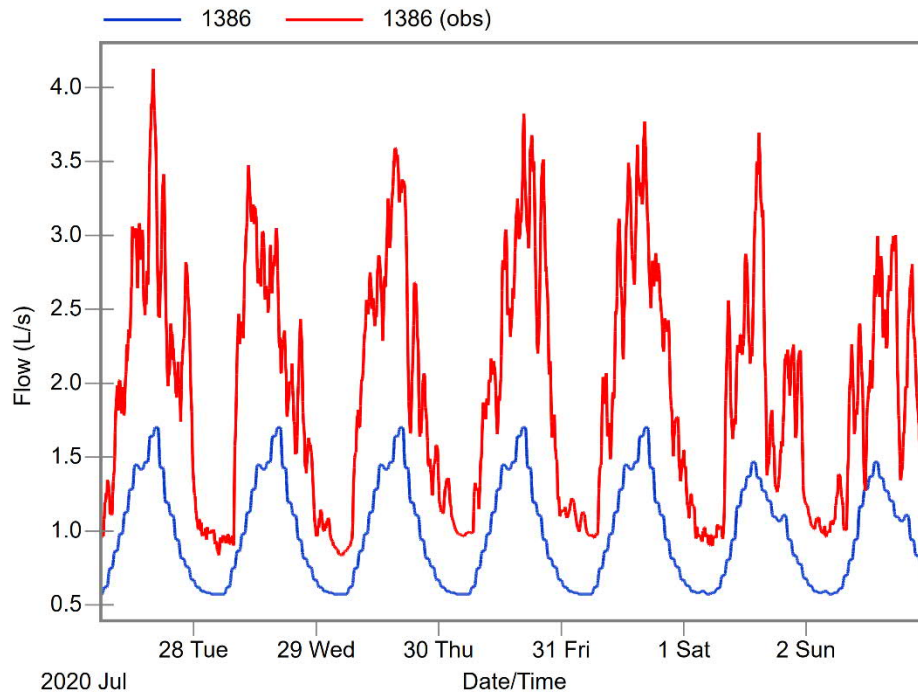
DRY WEATHER FLOW VALIDATION
JULY 27, 2020 - AUGUST 3, 2020



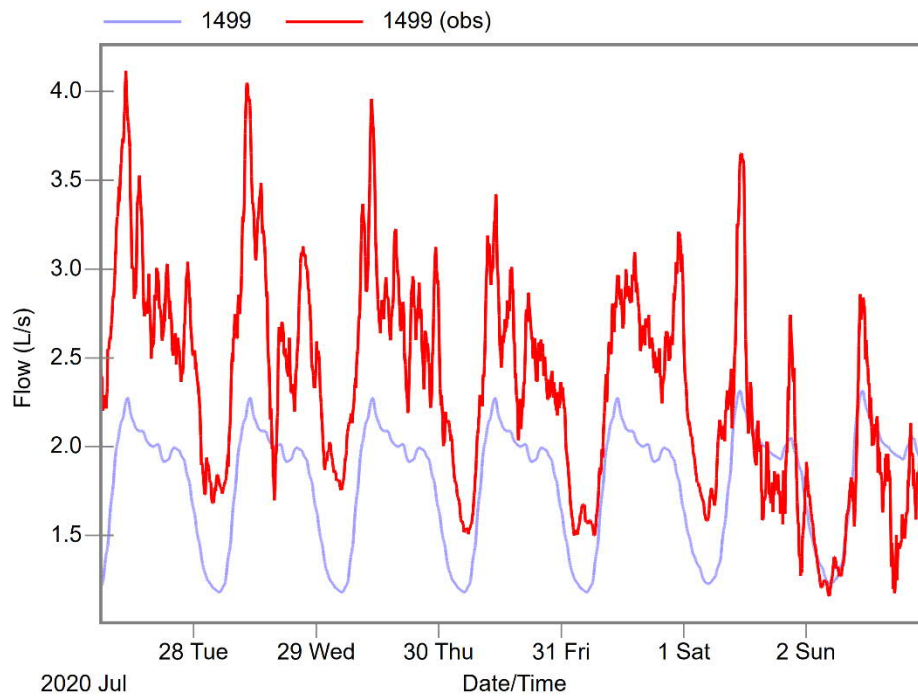
Flow Monitor 1



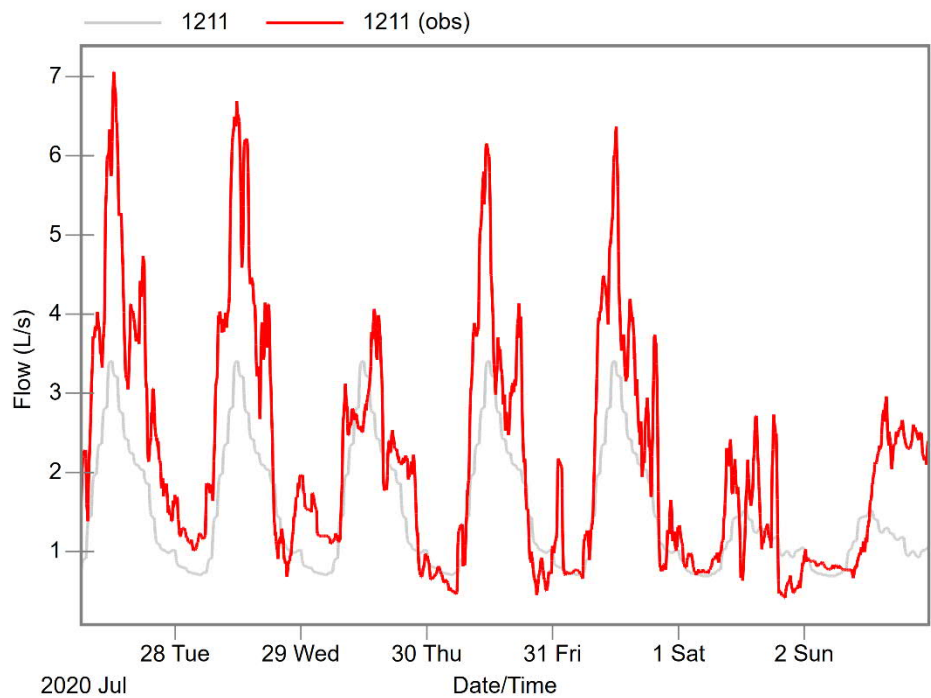
Flow Monitor 2



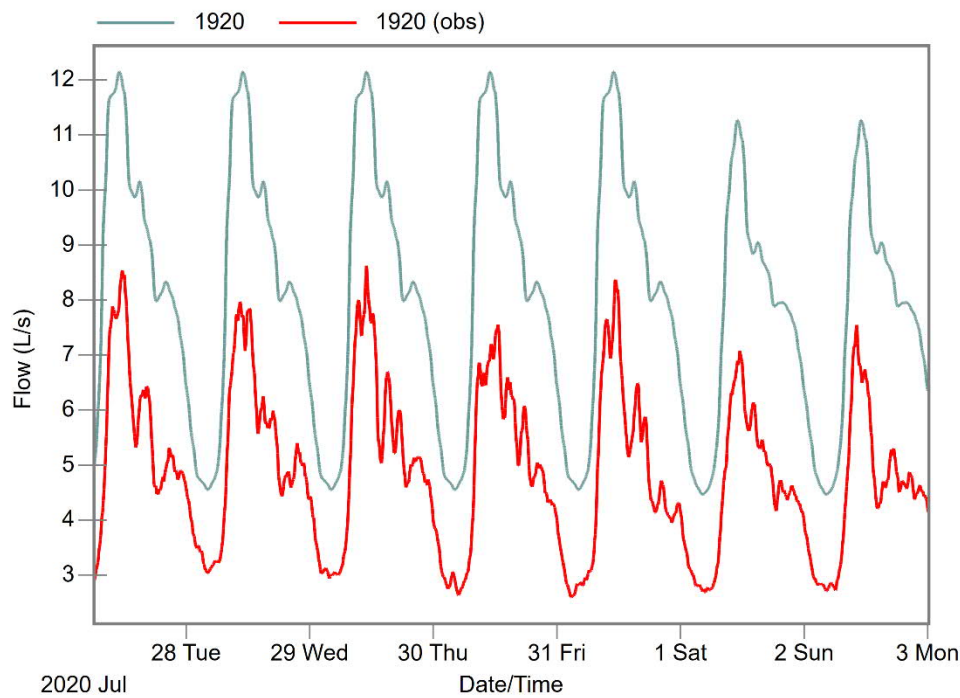
Flow Monitor 3



Flow Monitor 4

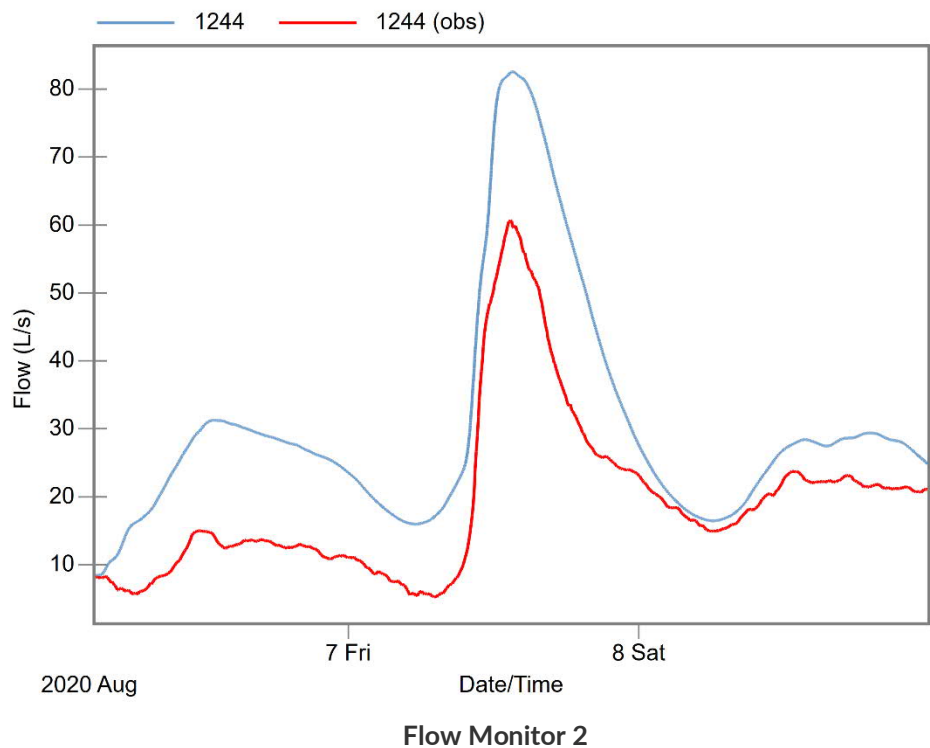
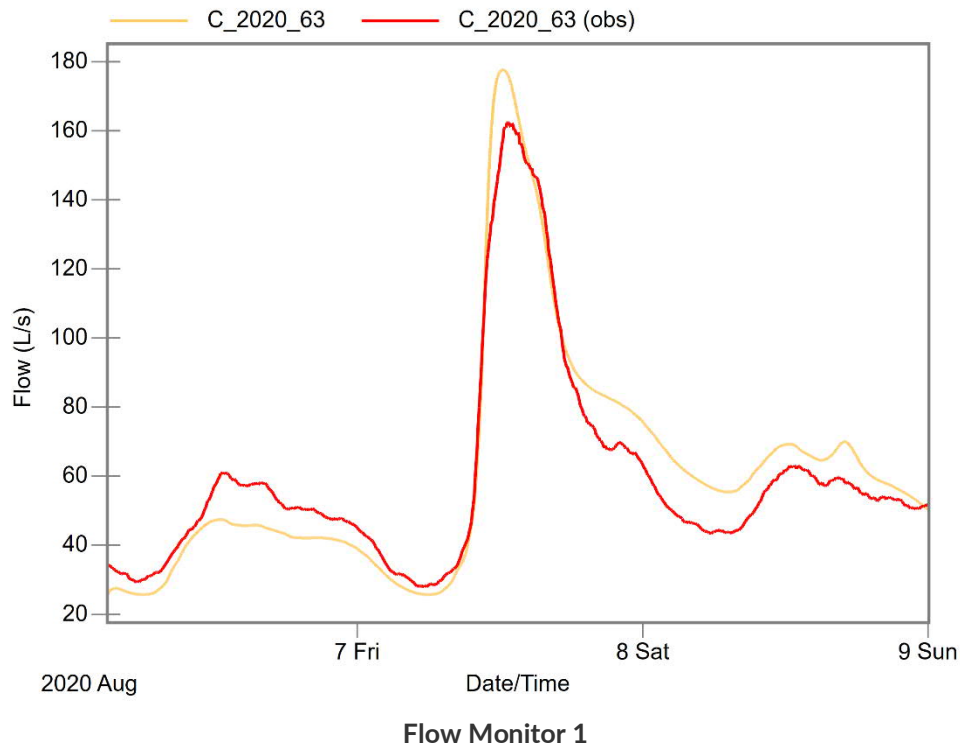


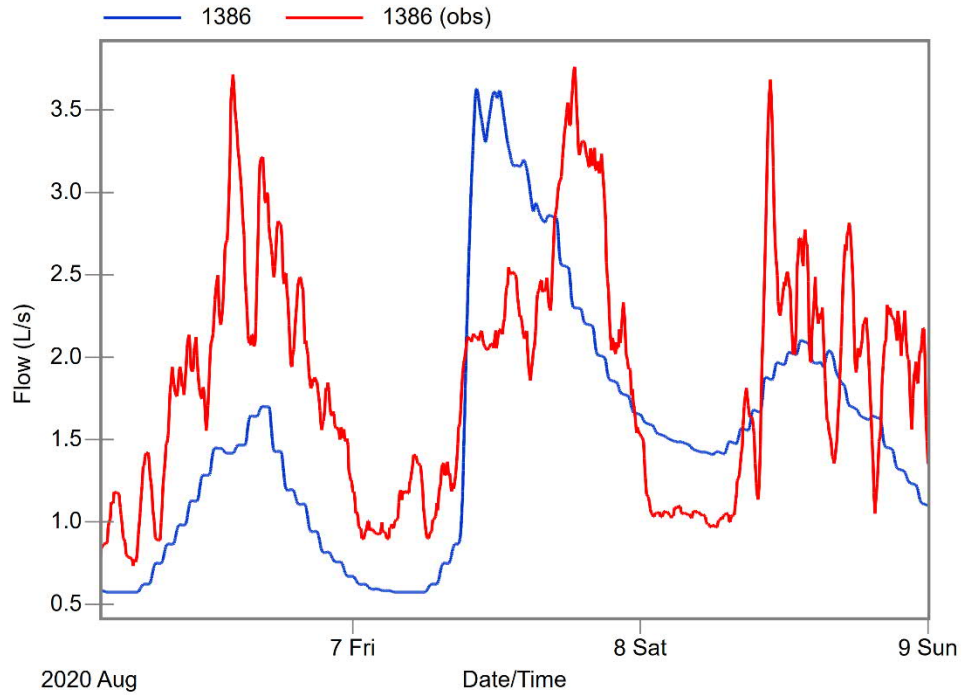
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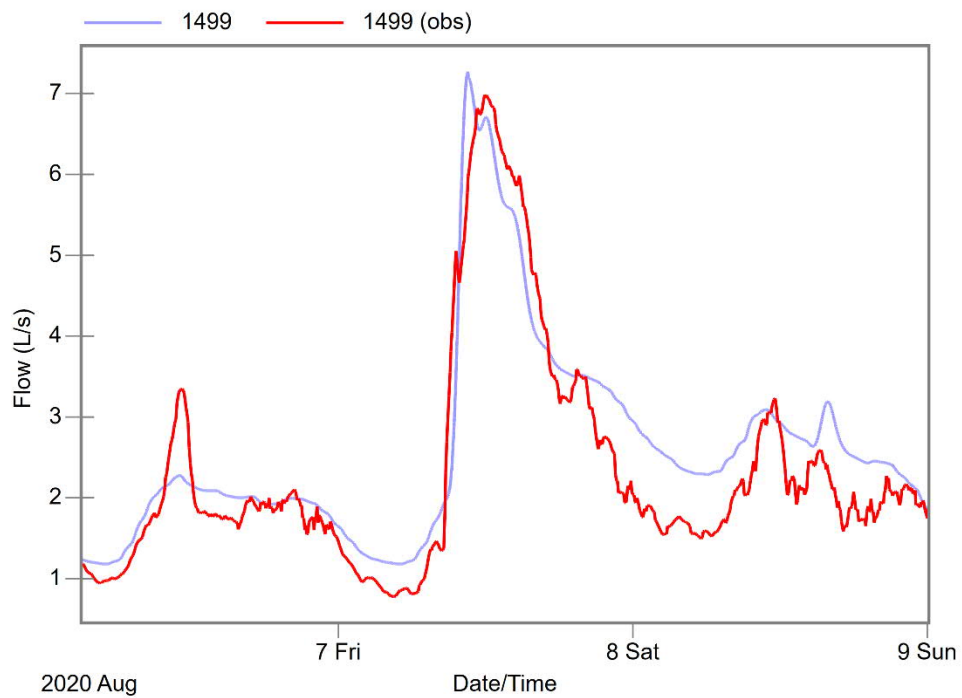
Flow Monitor 6

**WET WEATHER FLOW CALIBRATION
AUGUST 6, 2020 – AUGUST 9, 2020**

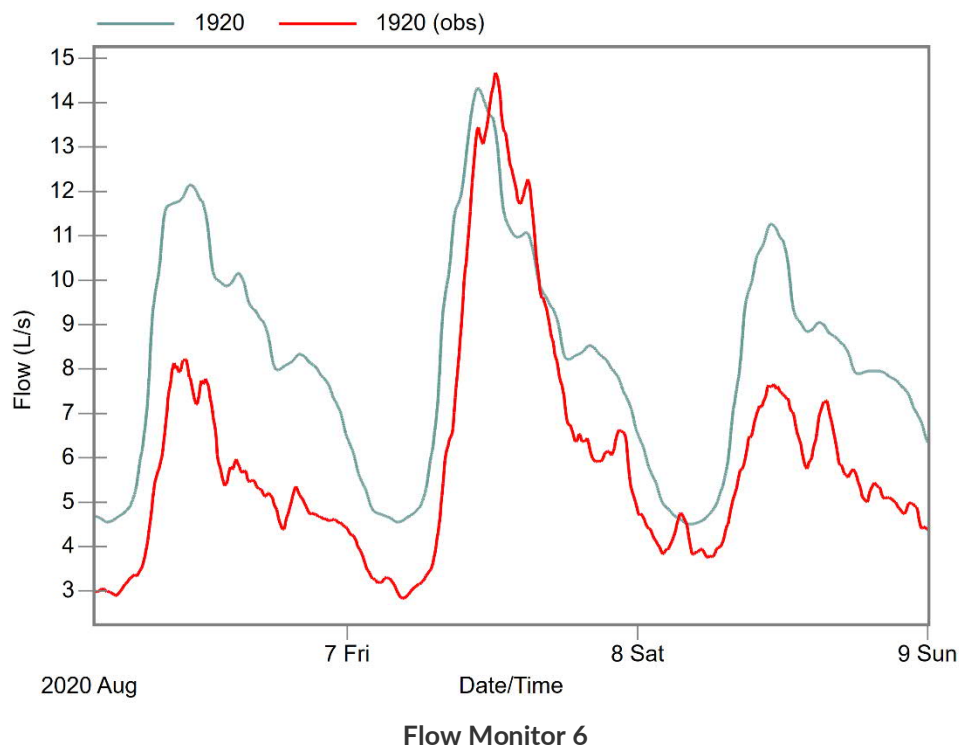
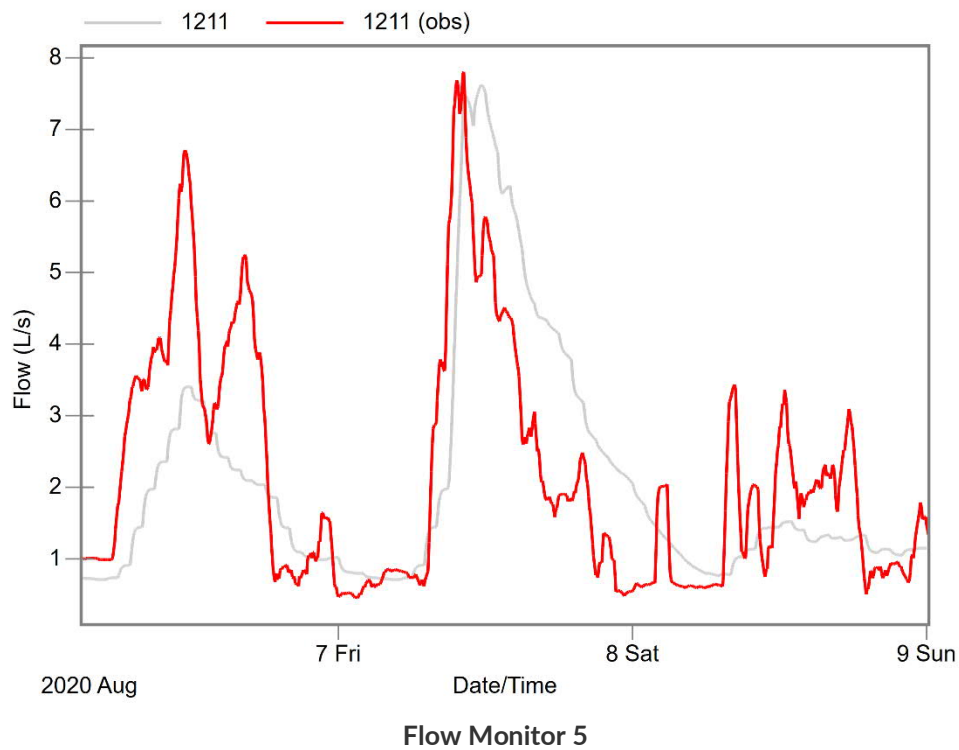




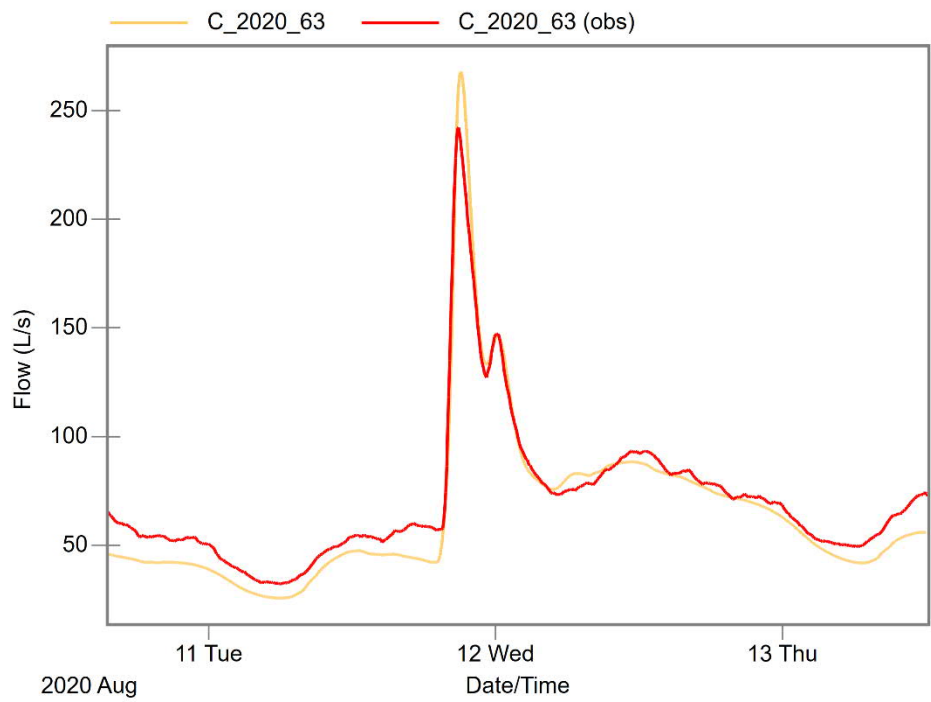
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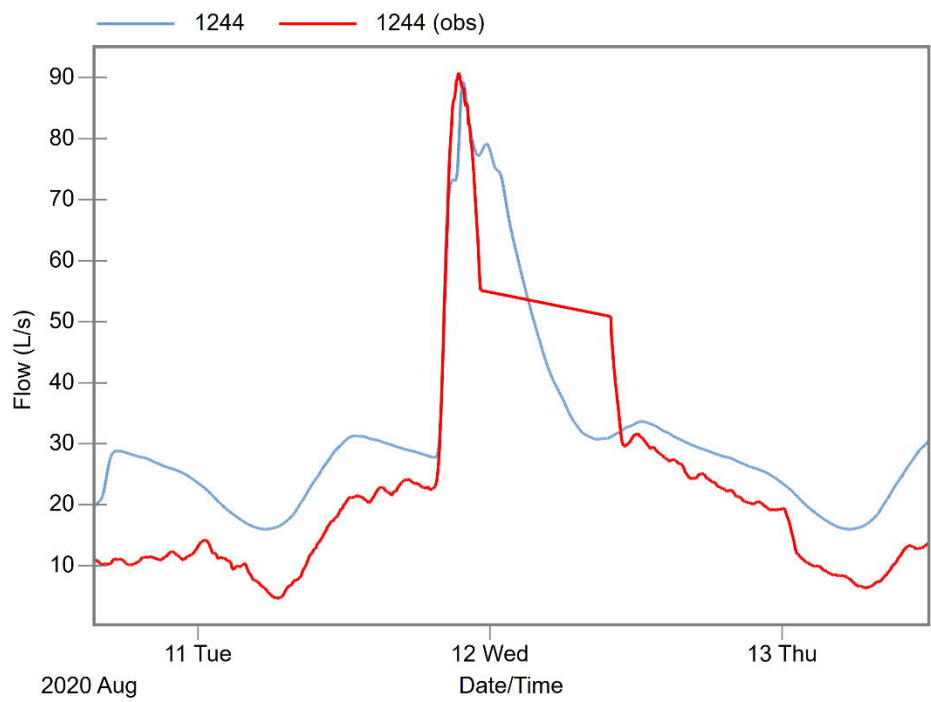
Flow Monitor 4



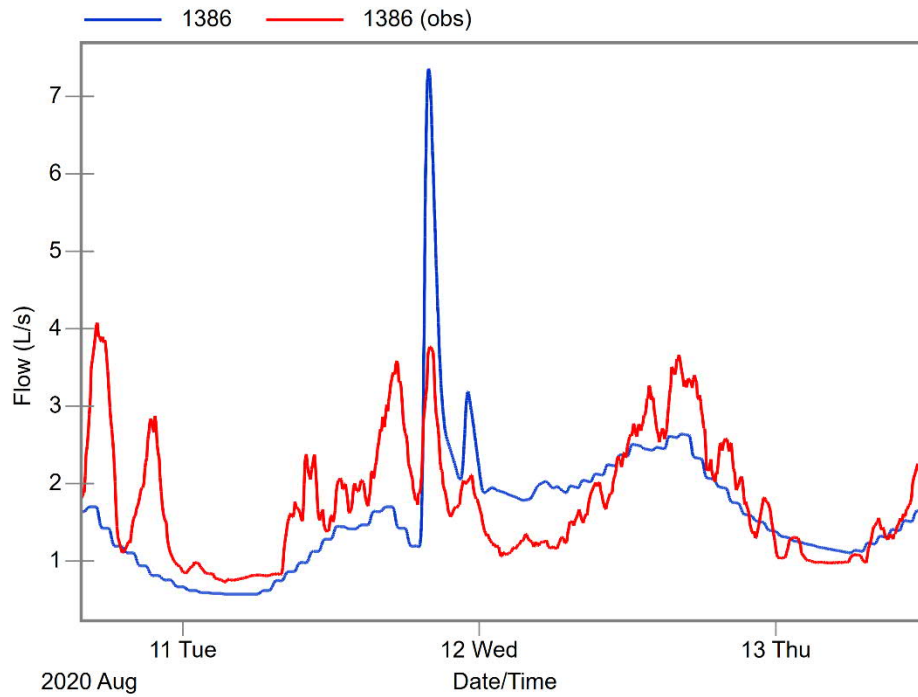
**WET WEATHER FLOW CALIBRATION
AUGUST 10, 2020 – AUGUST 13, 2020**



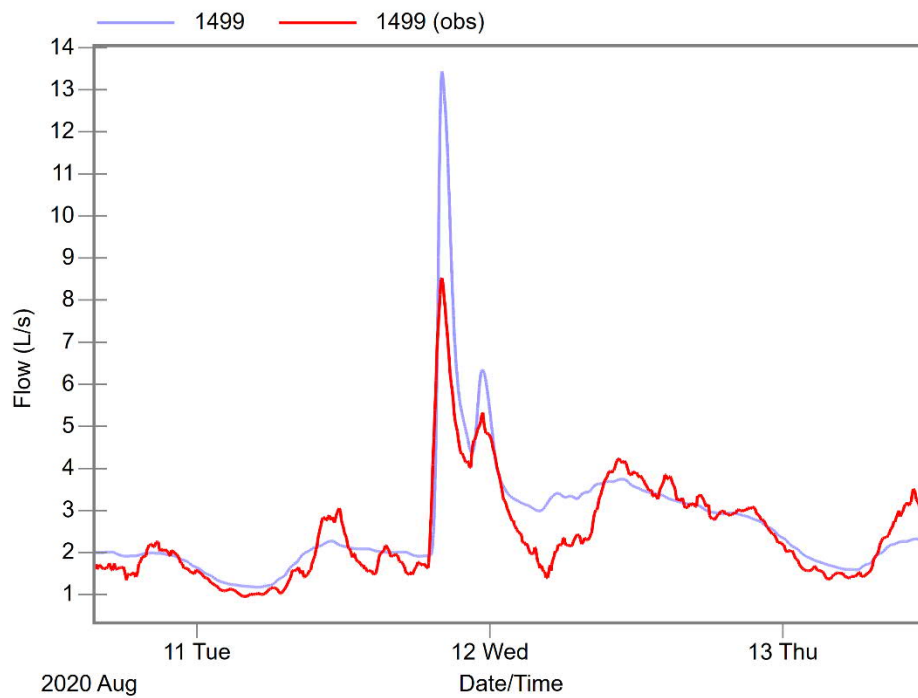
Flow Monitor 1



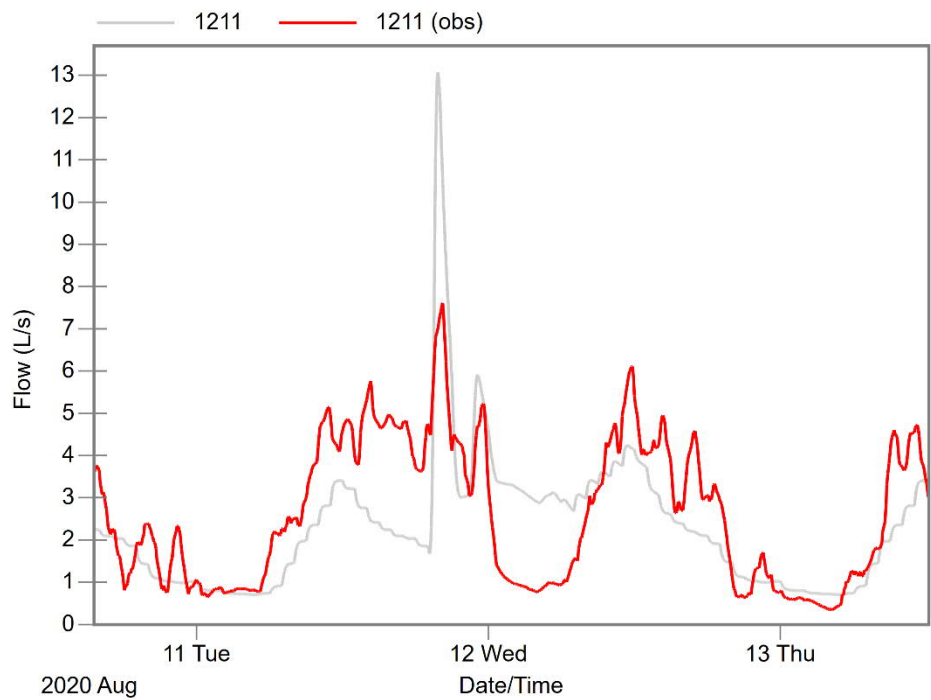
Flow Monitor 2



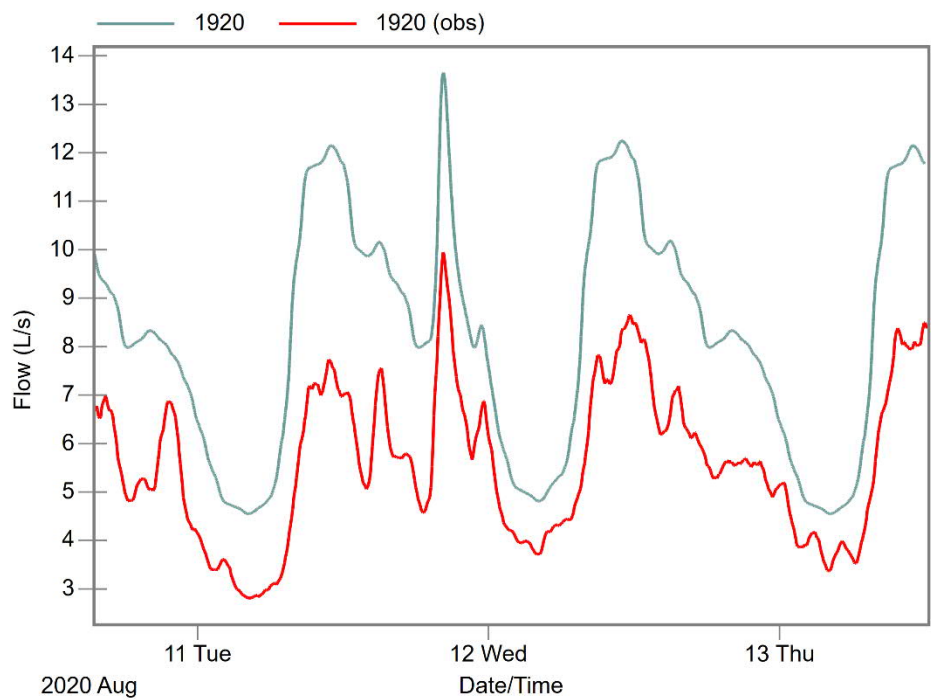
Flow Monitor 3



Flow Monitor 4

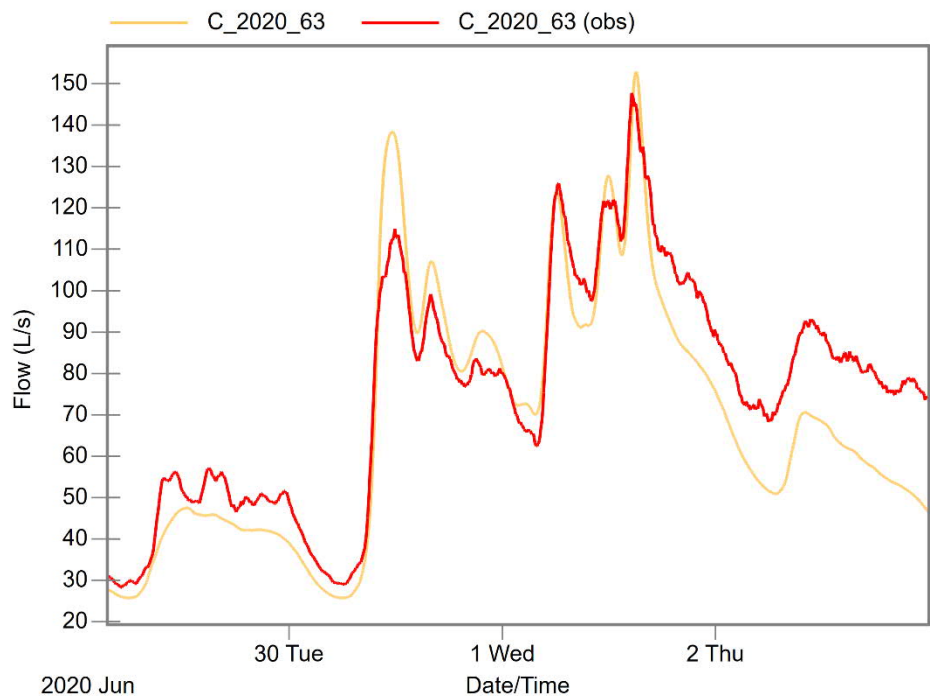


Flow Monitor 5

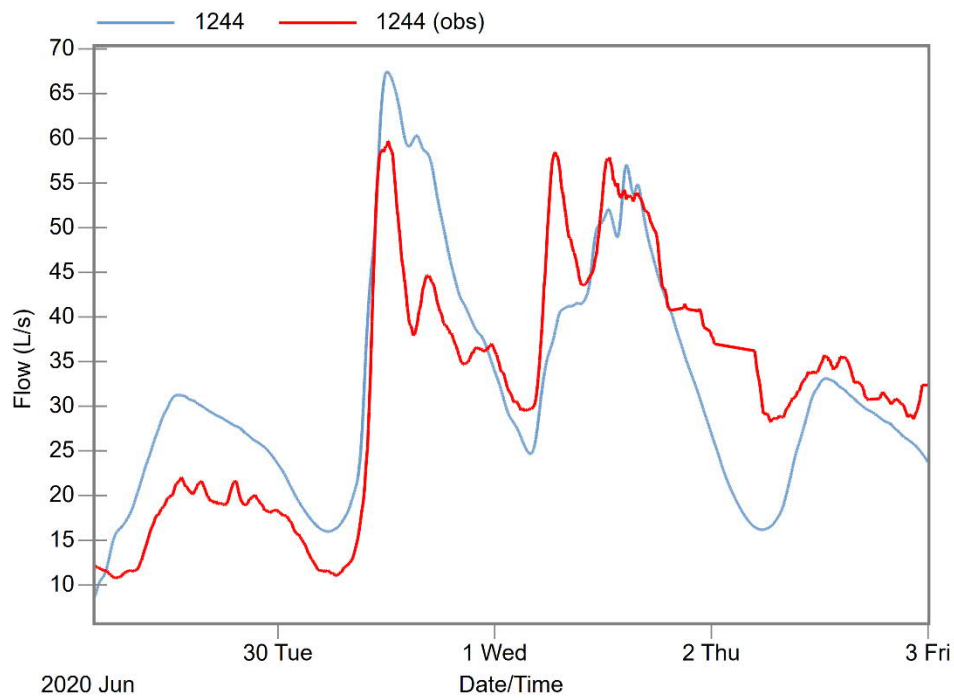


Flow Monitor 6

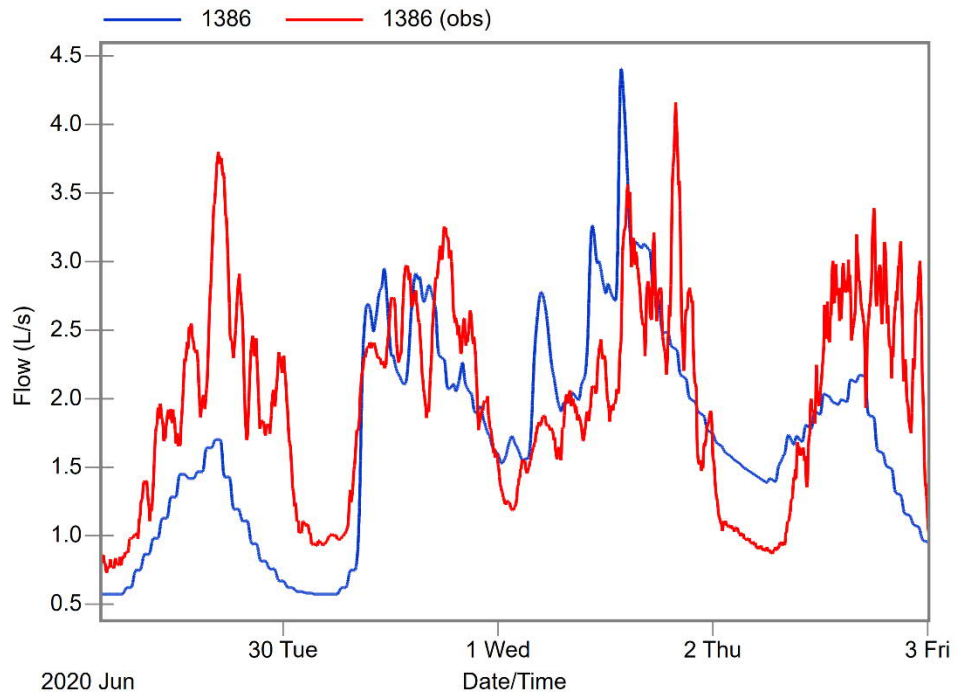
WET WEATHER FLOW VALIDATION
JUNE 29, 2020 - JULY 2, 2020



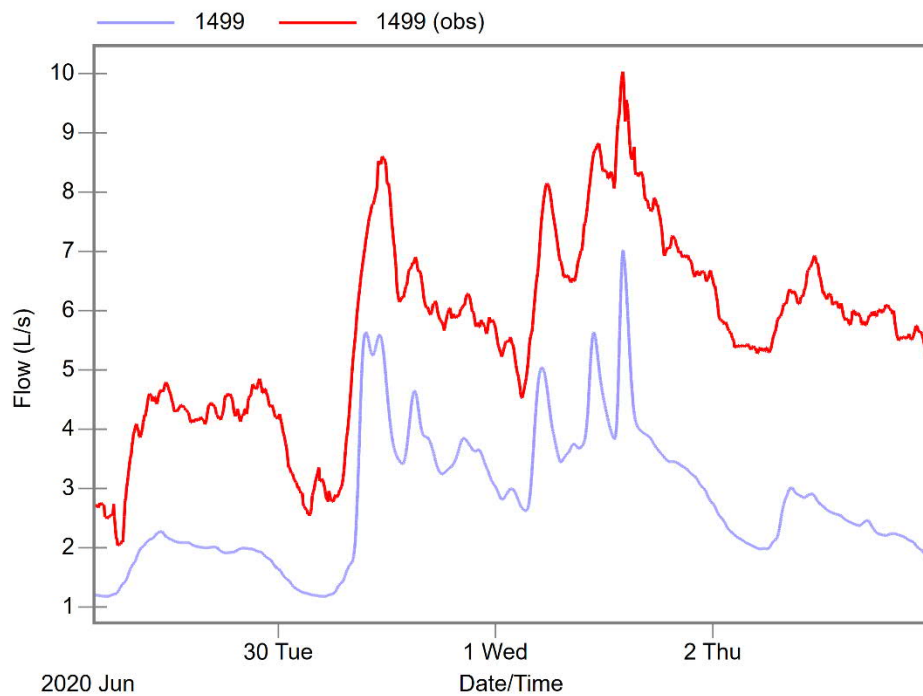
Flow Monitor 1



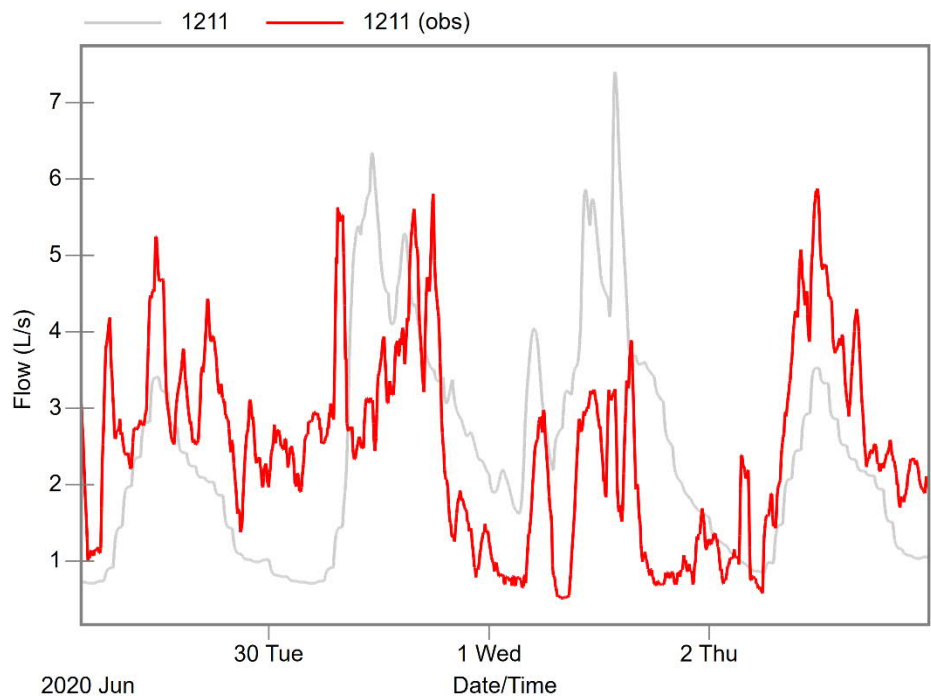
Flow Monitor 2



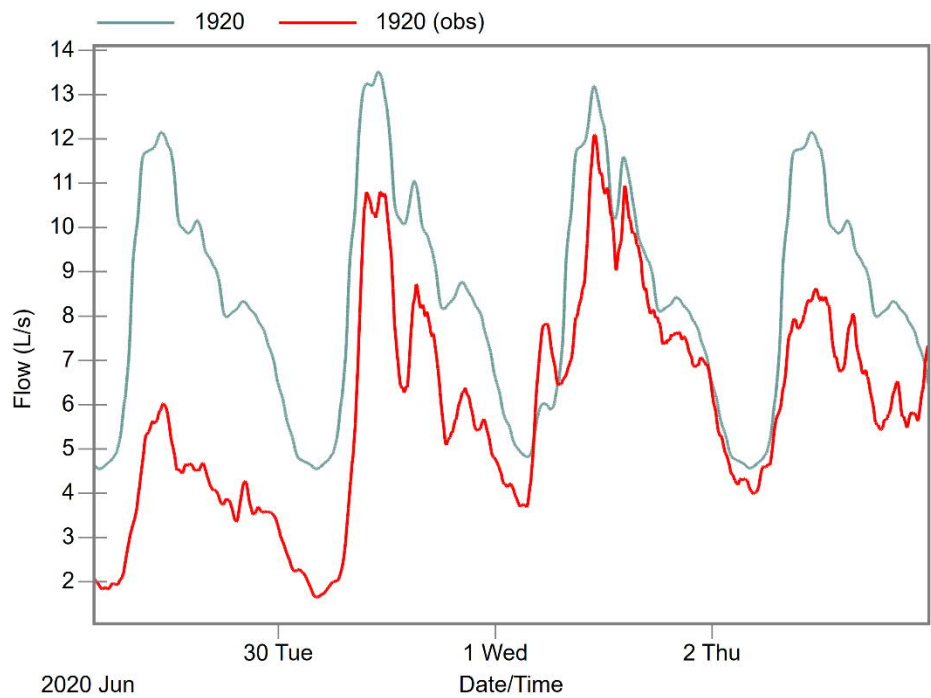
Flow Monitor 3



Flow Monitor 4



Flow Monitor 5



Flow Monitor 6

APPENDIX D - UPGRADES TO EXISTING SYSTEM

EXISTING AND PROPOSED PIPE UPGRADE CONFIGURATIONS

Table D-1: UP1 - existing and proposed pipe configurations

Location	PipeID	From_MH	To_MH	Length (m)	Existing				Proposed				Qp/Qf ^{1,2}
					Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	
48 th Street	1486	S4451B	S4428	149.05	755.81	755.80	0.375	0.007	755.67	755.45	0.525	0.148	0.25
48 th Street	1490	S4428	S4532	99.12	755.45	755.28	0.500	0.169	755.45	755.28	0.600	0.172	0.85
48 th Street	1537	S4532	S4530	99.36	755.28	755.18	0.500	0.101	755.28	755.18	0.600	0.101	1.13
48 th Street	1538	S4530	S4529B	61.26	755.18	755.13	0.500	0.082	755.18	755.12	0.600	0.098	1.15
48 th Street	1539	S4529B	S4529	7.34	755.12	755.11	0.500	0.136	755.12	755.11	0.600	0.136	0.97
48 th Street	1540	S4529	S4502	68.09	755.11	755.07	0.500	0.059	755.11	755.04	0.600	0.103	1.13
54 th Avenue	1576	S4502	S4504C	106.38	755.07	754.93	0.500	0.132	755.07	754.93	0.600	0.132	1.03
54 th Avenue	1577	S4504C	S4508	105.16	754.93	754.83	0.500	0.095	754.93	754.82	0.600	0.105	1.16
47 th Street	1578	S4508	S4507	46.63	754.83	754.82	0.500	0.021	754.83	754.78	0.600	0.107	1.25
47 th Street	1580	S4507	S5211	92.96	754.73	754.66	0.525	0.075	754.73	754.64	0.600	0.097	1.32
47 th Street	1698	S5211	S5213E	104.85	754.66	754.65	0.525	0.010	754.66	754.45	0.600	0.200	0.92
47 th St. & 56 th Ave.	5009	S5213E	S5213	3.96	754.65	754.64	0.525	0.253	754.45	754.44	0.600	0.253	0.82
56 th Avenue	1700	S5213	S5215B	32.61	754.55	754.55	0.525	0.000	754.44	754.41	0.600	0.092	1.36
56 th Avenue	1701	S5215B	S5215	8.84	754.52	751.94	0.525	30.514	754.41	751.94	0.600	29.100	0.08

¹ Qp/Qf = Peak flow fraction of conduit full flow computed during the 1:100-year, 4-hour simulation
² For Qp/Qf > 0.86, manhole surcharges were kept to greater than 2.5 m below the ground/rim elevation in residential areas

Table D-2: UP2 – existing and proposed pipe configurations

Location	PipeID	From_MH	To_MH	Length (m)	Existing				Proposed				Qp/Qf ^{3,4}
					Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	
50 th Street	1323	S3733	S3732	53.95	757.01	756.92	0.200	0.159	757.01	756.89	0.300	0.222	1.01
50 th Street	1325	S3732	S3723	43.95	756.92	756.85	0.200	0.159	756.92	756.82	0.300	0.228	1.03
50 th Street	1333	S3723	S3722	99.36	756.85	756.70	0.375	0.151	-	-	-	-	0.61
50 th Street	1327	S3722	S3710	99.36	756.70	756.51	0.375	0.191	-	-	-	-	0.62
50 th Street	1336	S3710	S3709	99.97	756.51	756.37	0.375	0.140	-	-	-	-	0.81
50 th Street	1340	S3709	S4453	99.67	756.37	756.00	0.375	0.371	756.37	756.12	0.450	0.251	0.40
50 th Street	1461	S4453	S4447	99.97	756.00	756.02	0.375	-0.020	756.12	756.02	0.450	0.100	0.71
50 th Street	1475	S4447	S4432	99.36	756.02	755.86	0.375	0.161	756.02	755.86	0.450	0.161	1.16
50th Avenue	1476	S4432	S4431	48.77	755.83	755.72	0.450	0.226	755.83	755.72	0.525	0.226	0.86
50 th Avenue	1477	S4431	S4430	62.79	755.72	755.63	0.450	0.143	755.72	755.63	0.525	0.143	1.08
50 th Avenue	1487	S4430	S4429	85.95	755.63	755.60	0.450	0.035	755.63	755.54	0.600	0.105	0.88
50 th Avenue	1488	S4429	S4428	85.56	755.60	755.39	0.450	0.245	755.60	755.39	0.600	0.245	0.57

³ Qp/Qf = Peak flow fraction of conduit full flow computed during the 1:100-year, 4-hour simulation
⁴ For Qp/Qf > 0.86, manhole surcharges were kept to greater than 2.5 m below the ground/rim elevation in residential areas

Table D-3: UP3 - existing and proposed pipe configurations

Location	PipeID	From_MH	To_MH	Length (m)	Existing				Proposed				Qp/Qf ^{5,6}
					Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	
53 rd Street	1451	S4467	S4466	99.36	757.53	757.19	0.250	0.342	757.53	757.19	0.375	0.342	0.55
49 th Avenue	1452	S4466	S4464	85.95	757.20	757.00	0.250	0.233	757.20	757.00	0.375	0.233	0.76
49 th Avenue	1453	S4464	S4461	86.56	756.94	756.80	0.250	0.162	756.94	756.80	0.375	0.162	0.92
49 th Avenue	1457	S4461	S4460	71.32	756.80	756.67	0.250	0.182	756.80	756.67	0.375	0.182	0.88
49 th Avenue	1458	S4460	S4457	71.32	756.67	756.42	0.250	0.351	756.67	756.42	0.375	0.351	0.64
49 th Avenue	1459	S4457	S4455	70.71	756.42	756.25	0.300	0.240	756.42	756.25	0.375	0.240	0.79
49 th Avenue	1460	S4455	S4447	71.02	756.25	756.19	0.300	0.084	756.25	756.08	0.375	0.239	0.80
50 th Street	1475	S4447	S4432	99.36	756.02	755.86	0.375	0.161	756.02	755.86	0.450	0.161	1.16
50 th Avenue	1476	S4432	S4431	48.77	755.83	755.72	0.450	0.226	755.83	755.72	0.525	0.226	0.86
50 th Avenue	1477	S4431	S4430	62.79	755.72	755.63	0.450	0.143	755.72	755.63	0.525	0.143	1.08

⁵ Qp/Qf = Peak flow fraction of conduit full flow computed during the 1:100-year, 4-hour simulation
⁶ For Qp/Qf > 0.86, manhole surcharges were kept to greater than 2.5 m below the ground/rim elevation in residential areas

Table D-4: UP4 – existing and proposed pipe configurations

Location	PipeID	From_MH	To_MH	Length (m)	Existing				Proposed				Qp/Qf ^{7,8}
					Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	Inlet_Elev (m)	Outlet_Elev (m)	Diameter (m)	Slope (%)	
55th Avenue	1774	S5327	S5329	94.79	753.38	753.14	0.250	0.253	753.38	753.14	0.375	0.253	0.80
55th Avenue	1773	S5329	S5330	87.48	753.14	752.86	0.250	0.320	753.14	752.86	0.375	0.320	0.72
55th Avenue	1772	S5330	S5331	87.48	752.86	752.65	0.250	0.240	752.86	752.65	0.375	0.240	0.85

⁷ Qp/Qf = Peak flow fraction of conduit full flow computed during 1:100-year, 4-hour simulation
⁸ For Qp/Qf > 0.86, manhole surcharges were kept to greater than 2.5 m below the ground/rim elevation in residential areas

EXISTING SYSTEM

SIMULATED HYDRAULIC GRADE LINE PROFILES (1:100-YEAR, 4-HOUR)

UP1 - Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

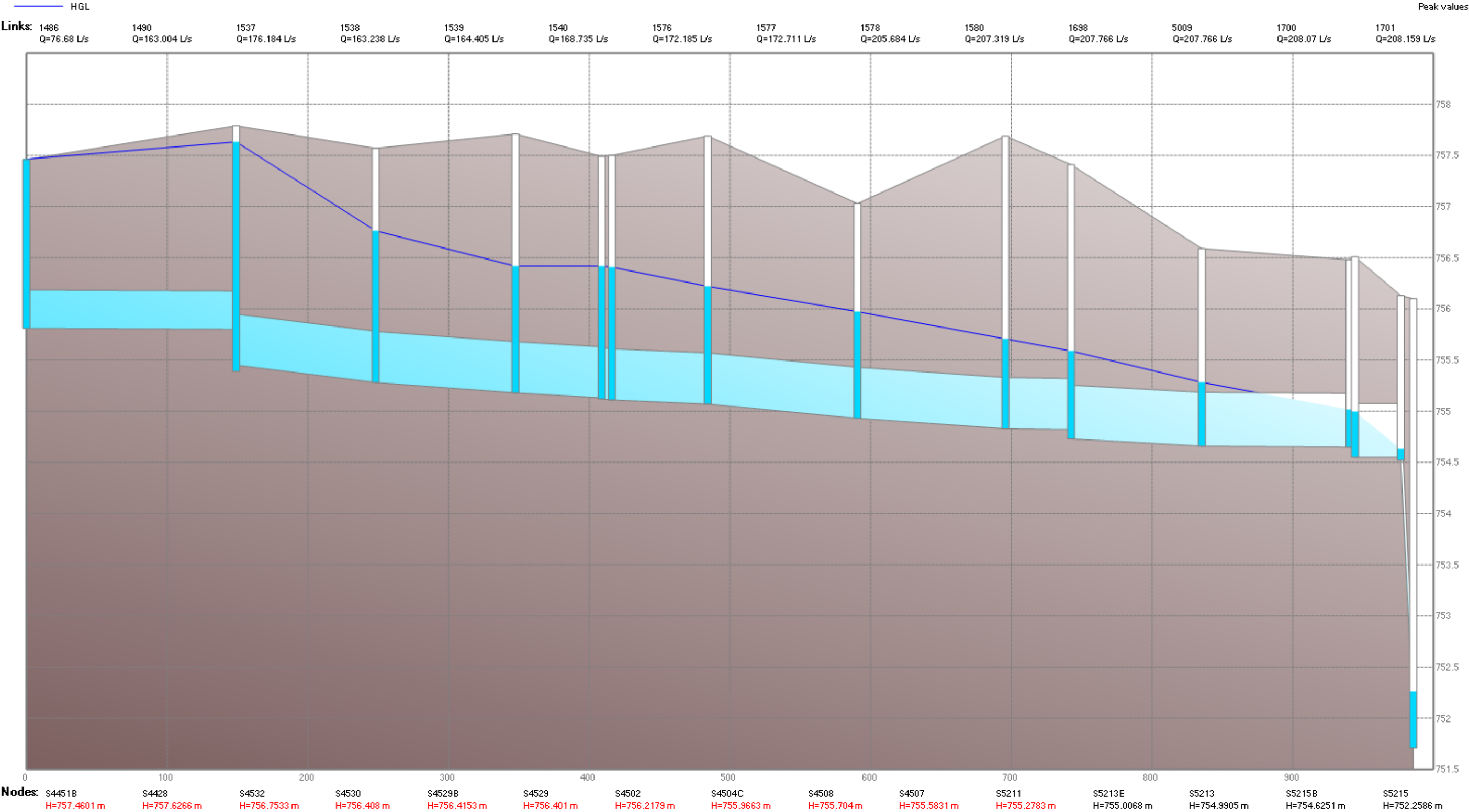


Figure D-1: Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

UP2 - Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

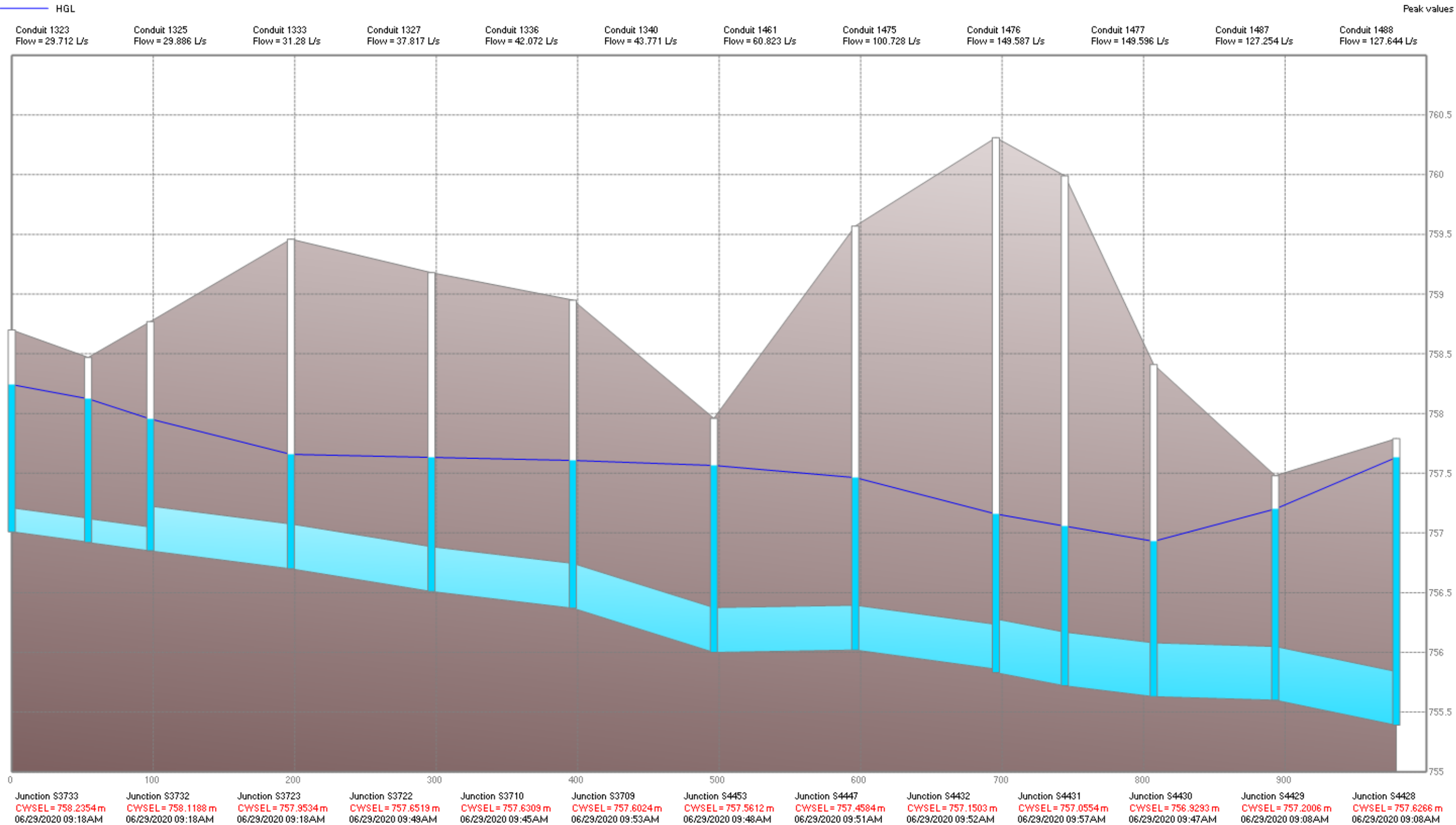


Figure D-2: Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

UP3 - Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

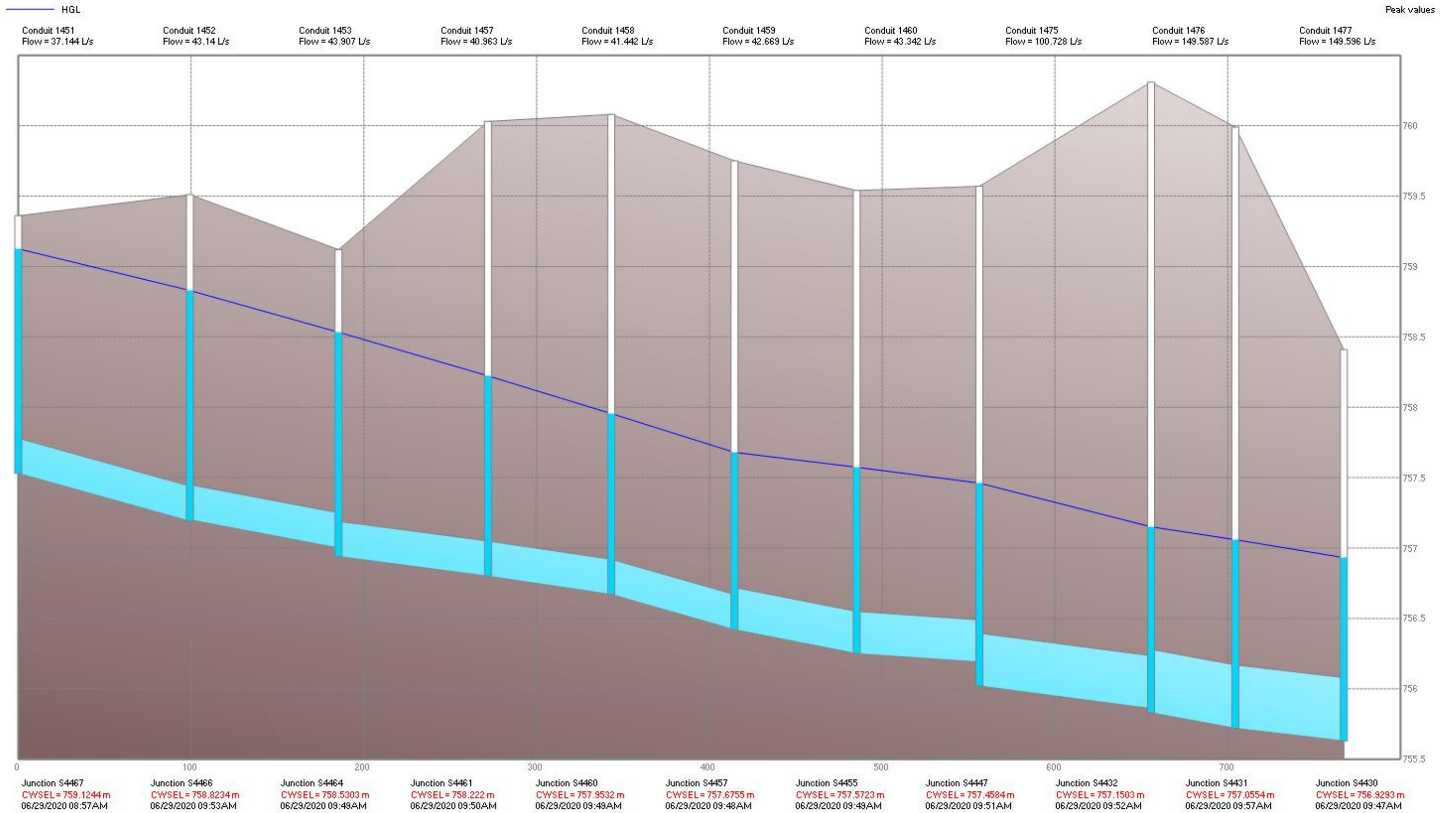


Figure D-3: Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

UP4 - Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

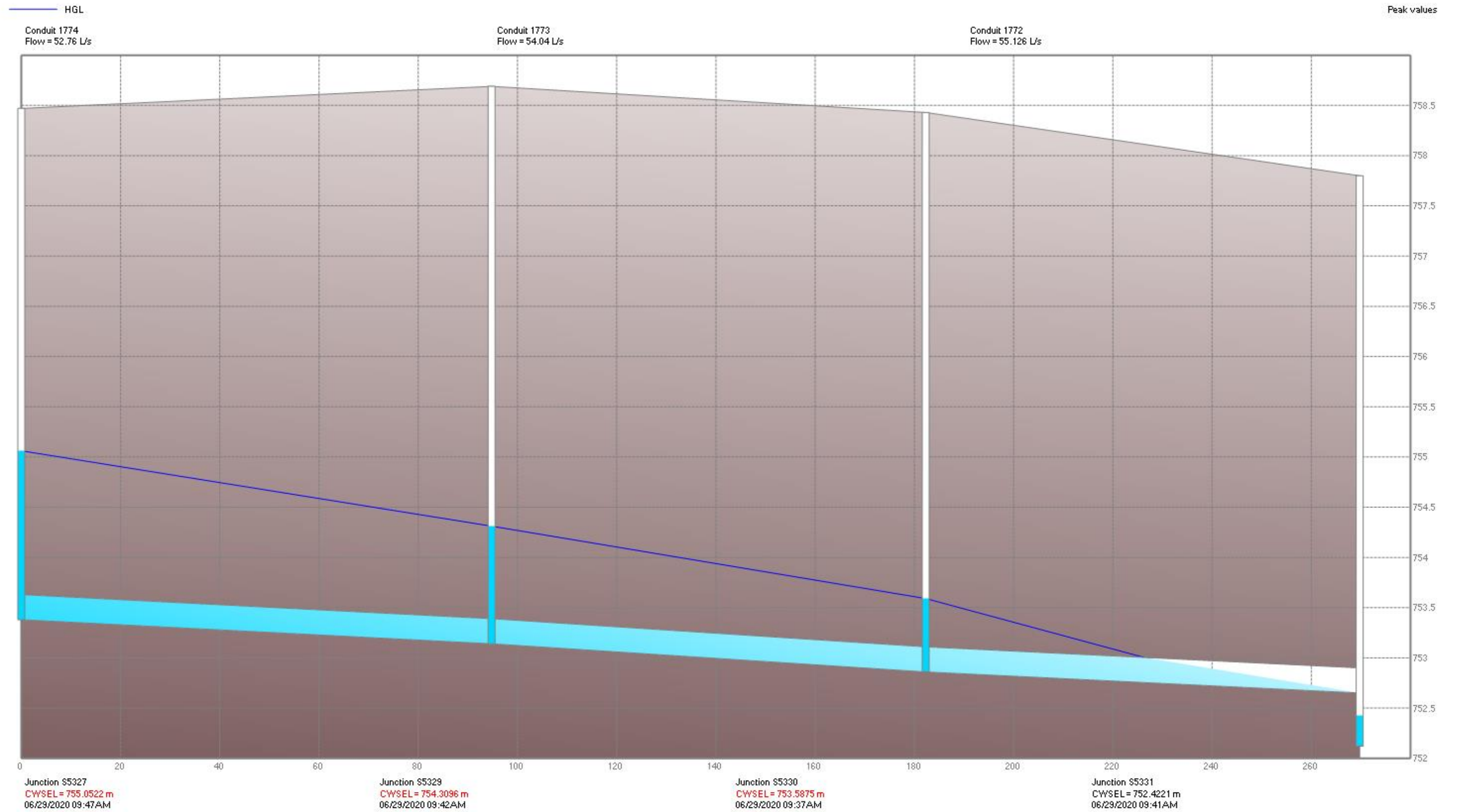


Figure D-4: Existing System Hydraulic Grade Line Profile (1:100-year, 4-hour)

PROPOSED UPGRADES
SIMULATED HYDRAULIC GRADE LINE PROFILES (1:100-YEAR, 4-HOUR)

UP1 - Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

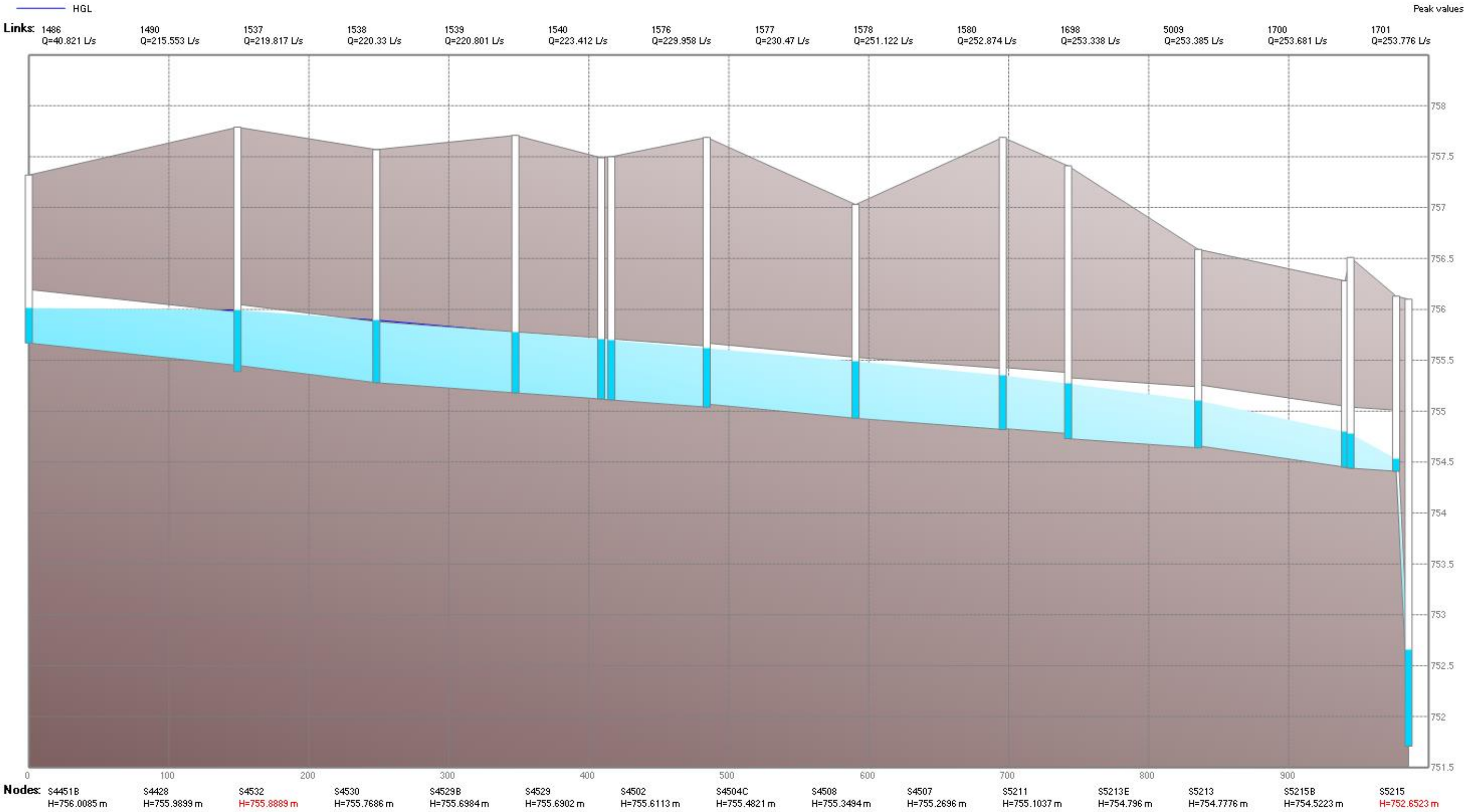


Figure D-5: Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

UP2 - Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

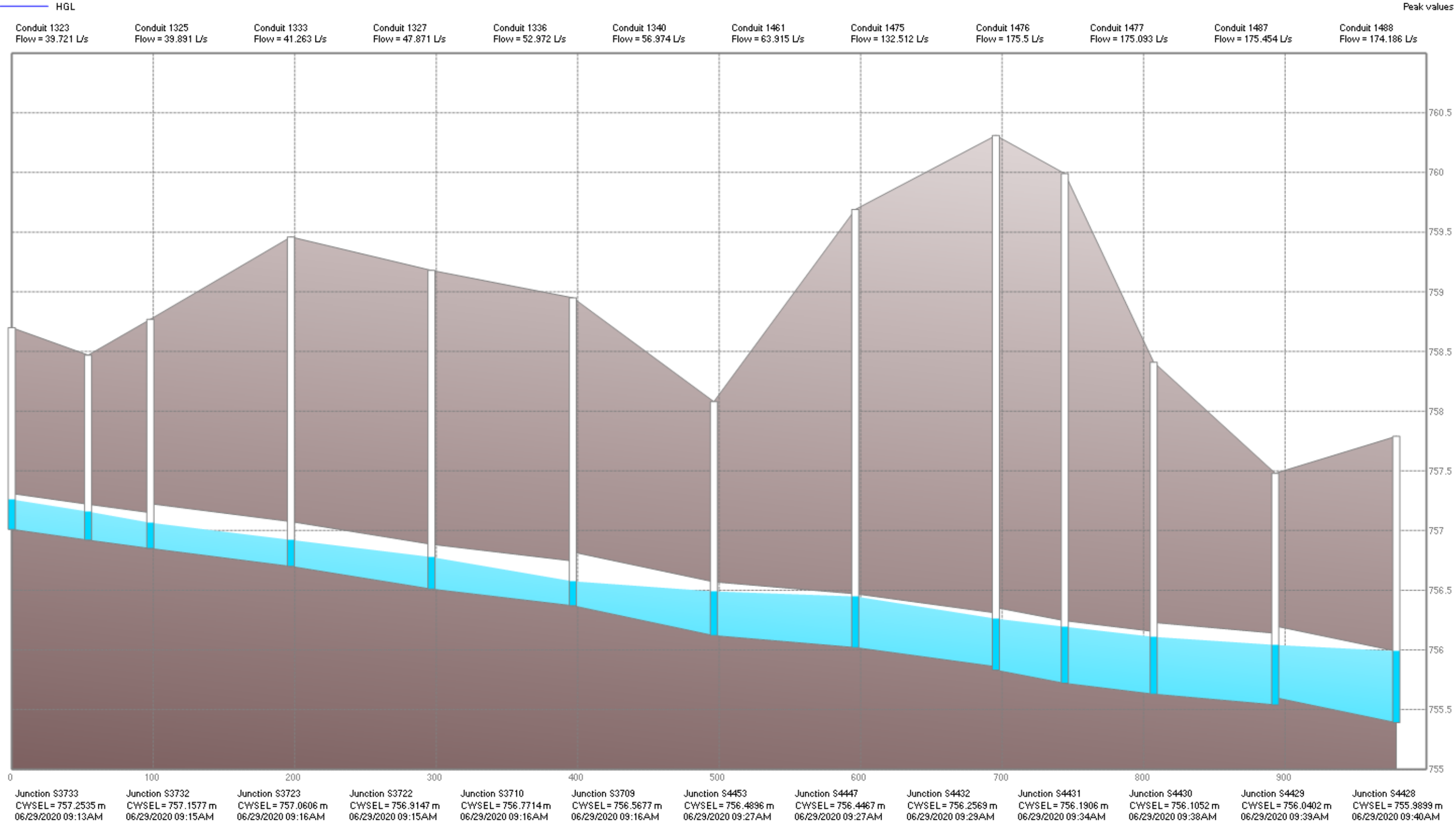


Figure D-6: Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

UP3 - Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

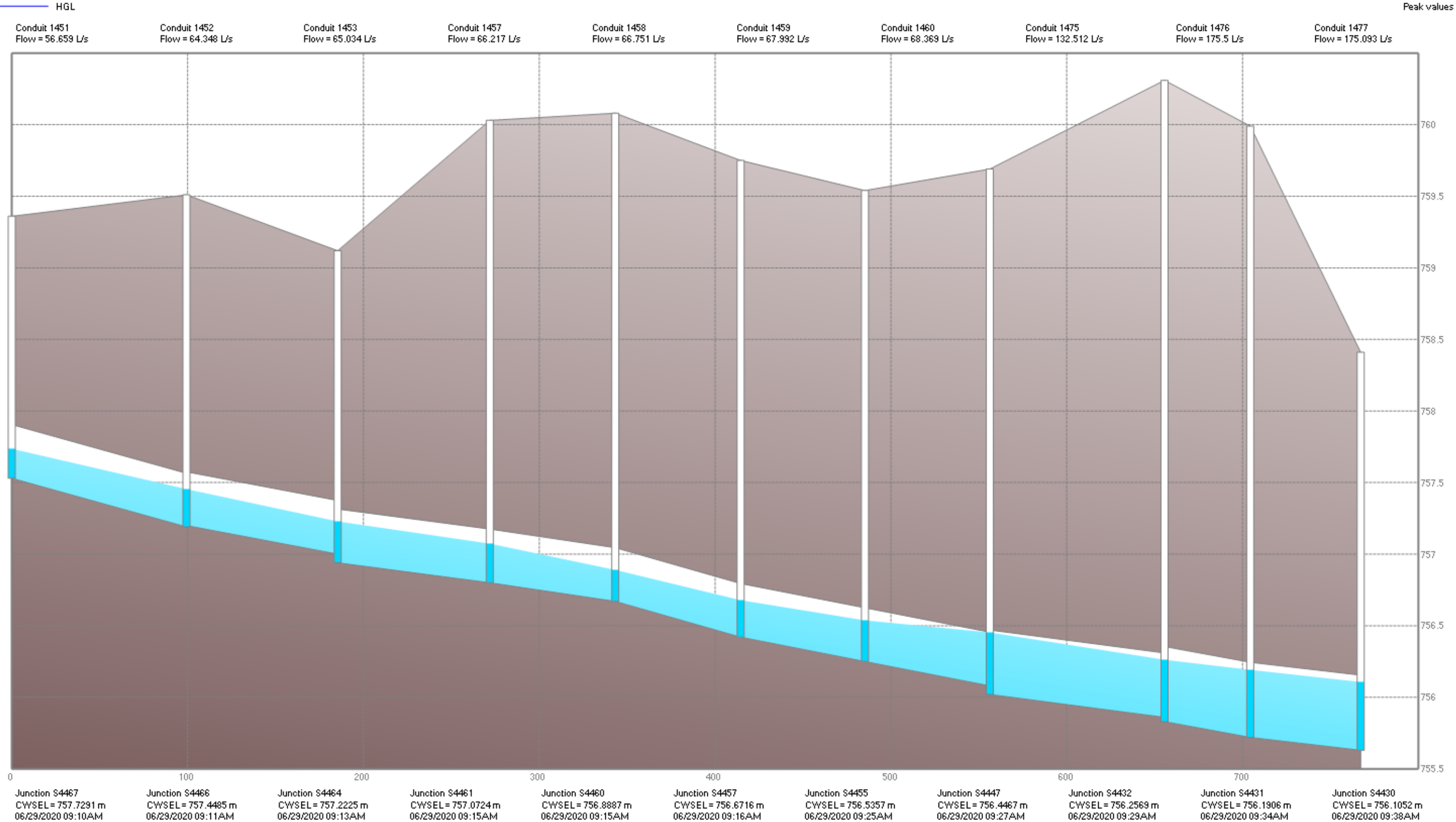


Figure D-7: Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

UP4 - Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

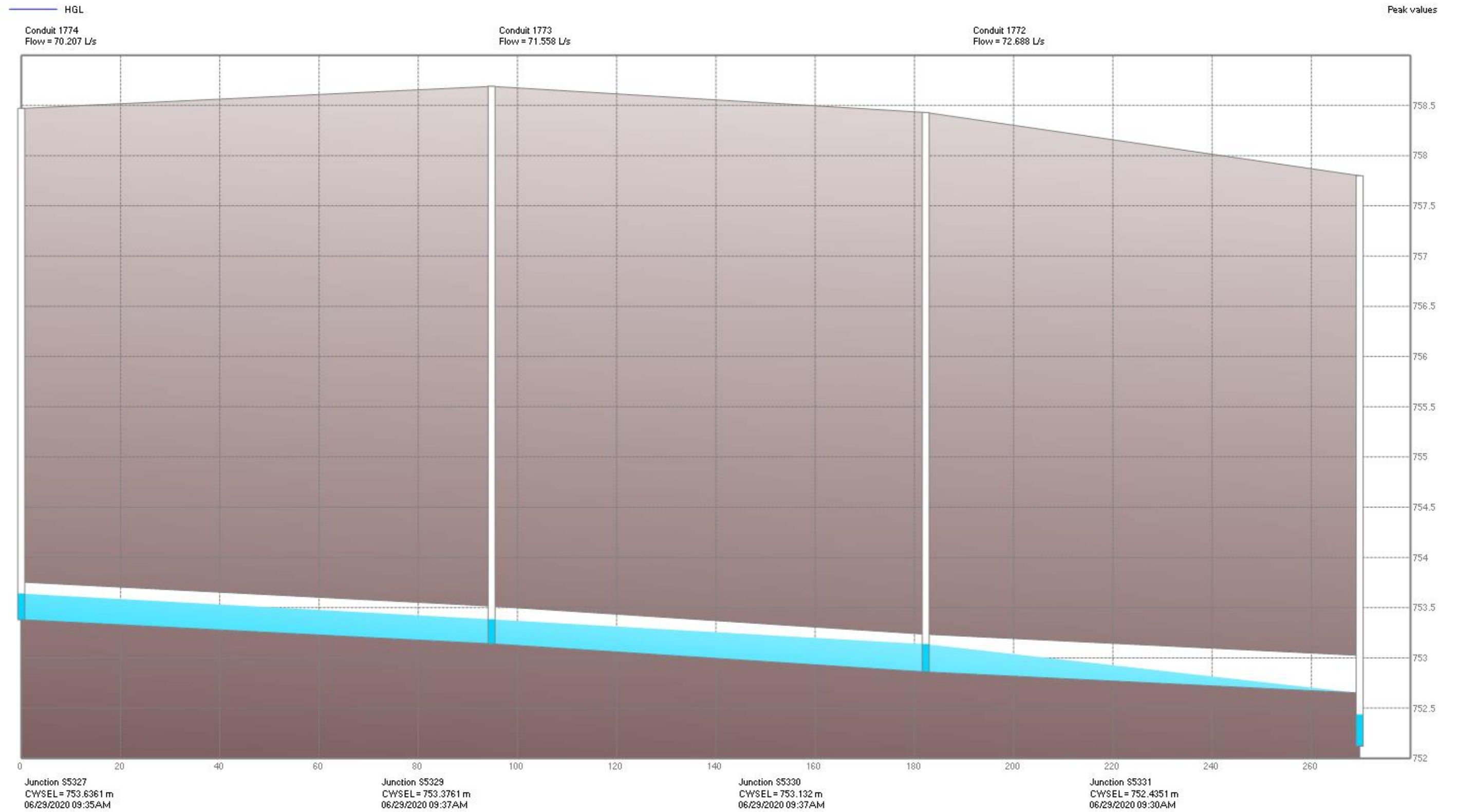


Figure D-8: Upgraded System Hydraulic Grade Line Profile (1:100-year, 4-hour)

**UPGRADES TO EXISTING SYSTEM FOR ULTIMATE DEVELOPMENT
(1:100-YEAR, 4-HOUR)**

Table D-5: Stage 1 Pipe Upgrade

Location	Pipe_ID	From_MH	To_MH	Length (m)	Slope (%)	Existing Diameter (m)	Proposed Diameter (m)	Qp/Qf ^{1,2}
Ashwood Street	1961	S6808	S6811	66.75	0.285	0.200	0.250	0.16
Aspen Ridge Subdivision	1914	S6819	S6113	84.73	0.224	0.300	0.525 ³	0.93
Aspen Ridge Subdivision	1915	S6113	S6115	103.02	0.155	0.300	0.525 ³	1.12
Aspen Ridge Subdivision	1916	S6115	S6112	91.44	0.295	0.300	0.525 ³	0.95
Aspen Ridge Subdivision	1917	S6112	S6116	82.92	0.193	0.300	0.525 ³	1.22
Aspen Ridge Subdivision	1918	S6116	S6120	84.43	0.237	0.300	0.525 ³	1.10
From 53rd Avenue - crossing the CPR	1919	S6120	S6121	65.84	0.106	0.300	0.525 ³	1.64
Garded Meadows Subdivision	1920	S6121	S6122	30.18	0.232	0.300	0.525 ³	1.11
Garded Meadows Subdivision	1921	S6122	S6123	46.02	0.196	0.300	0.525 ³	1.21
Garded Meadows Subdivision	1922	S6123	S6124	97.23	0.195	0.300	0.525 ³	1.31
Garded Meadows Subdivision	1723	S6124	S5224	71.63	0.405	0.300	0.525 ³	1.00
Garded Meadows Subdivision	1722	S5224	S5225	68.58	0.773	0.300	0.525 ³	0.73
Garnet Crescent	1724	S5225	S5226	57.70	0.121	0.675	0.900	1.72

¹ Qp/Qf = Peak flow fraction of conduit full flow computed during the 1:100-year, 4-hour simulation
² For Qp/Qf > 0.86, manhole surcharges were kept to greater than 2.5 m below the ground/rim elevation in residential areas
³ Twinned pipes

Table D-6: Stage 2 Pipe Upgrade - 1

Location	Pipe_ID	From_MH	To_MH	Length (m)	Slope (%)	Existing Diameter (m)	Proposed Diameter (m)	Qp/Qf ^{4,5}
Between East Centennial and Glendale Subdivisions	1751	S5344	S5345	33.00	0.121	0.675	0.900	0.84
Glendale Subdivision	1750	S5345	S5346	107.00	0.121	0.675	0.900	0.84
Glendale Subdivision	1714	S5346	S5243	126.90	0.118	0.675	0.900	0.85
Glendale Subdivision	1715	S5243	S5242	115.80	0.121	0.675	0.900	0.84
Crosses 47th Street	1716	S5242	S5241	46.00	0.130	0.675	0.900	0.82
Garden Meadows Subdivision	1717	S5241	S5201B	73.20	0.055	0.675	0.900	1.27
Garden Meadows Subdivision	1718	S5201B	S5240	95.00	0.126	0.675	0.900	0.83
Garden Meadows Subdivision	1719	S5240	S5239	120.00	0.083	0.675	0.900	1.03
Garden Meadows Subdivision	1720	S5239	S5238	121.90	0.131	0.675	0.900	0.82
Garden Meadows Subdivision	1721	S5238	S5225	137.80	0.116	0.675	0.900	0.88
Garden Meadows Drive	1653	S5226	S5101B	57.70	0.121	0.675	0.900	1.72
Garden Meadows Drive	1655	S5101B	S5103B	136.86	0.132	0.750	1.200	0.97
Garden Meadows Drive	1659	S5103B	S5102	124.97	0.104	0.750	1.200	1.09
Garden Meadows Drive	1633	S5102	S5105	23.77	0.122	0.750	1.200	1.01
Garden Meadows Drive	1660	S5105	S6203	134.42	0.097	0.750	1.200	1.20
Garden Meadows Drive	1931	S6203	S6205	153.31	0.117	0.750	1.200	1.09
Garden Meadows Drive	1932	S6205	S6212	67.20	0.074	0.750	1.200	1.37
Garden Meadows Drive	C_2020_56	S6212	S_2020_50	27.13	0.221	0.750	1.200	0.82

Table D-7: Stage 2 Pipe Upgrade - 2

Location	Pipe_ID	From_MH	To_MH	Length (m)	Slope (%)	Existing Diameter (m)	Proposed Diameter (m)	Qp/Qf ^{4,5}
47th Street	1727	S5202	S5203	107.29	0.298	0.200	0.300	0.35
47th Street	1729	S5203	S5204	84.43	0.296	0.200	0.300	0.51
47th Street	1730	S5204	S5214B	106.07	0.292	0.200	0.300	0.66

⁴ Qp/Qf = Peak flow fraction of conduit full flow computed during the 1:100-year, 4-hour simulation
⁵ For Qp/Qf > 0.86, manhole surcharges were kept to greater than 2.5 m below the ground/rim elevation in residential areas

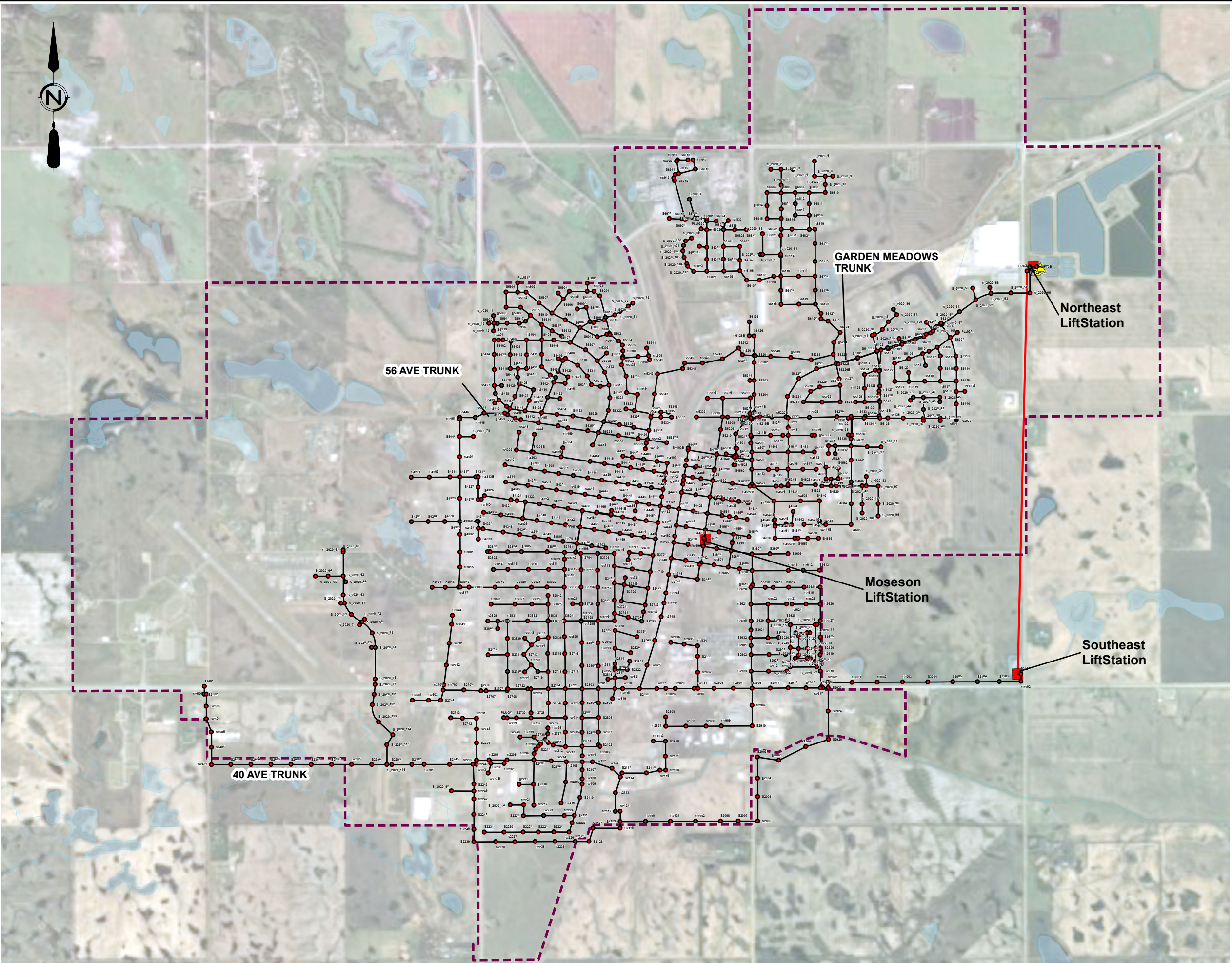
Table D-8: Ultimate Stage Pipe Upgrade – 1

Location	Pipe_ID	From_MH	To_MH	Length (m)	Slope (%)	Existing Diameter (m)	Proposed Diameter (m)	Qp/Qf ^{6,7}
Crossing 40th Avenue	1110	S2501	S2502	45.20	0.420	0.300	0.375	0.97
64th Street	1109	S2502	S2506	14.20	0.141	0.300	0.375	1.67
64th Street	1108	S2506	S2503	73.00	0.274	0.300	0.375	1.20
64th Street	1107	S2503	S2504	73.50	0.218	0.300	0.375	1.38
Range Road 243	1106	S2504	S2505	86.00	0.221	0.300	0.375	1.40
Range Road 243	1105	S2505	S2401	90.50	0.221	0.300	0.375	1.40
Range Road 243	1104	S2401	S2402	103.20	0.223	0.300	0.375	1.39

Table D-9: Ultimate Stage Pipe Upgrade – 2

Location	Pipe_ID	From_MH	To_MH	Length (m)	Slope (%)	Existing Diameter (m)	Proposed Diameter (m)	Qp/Qf ^{6,7}
50th Avenue	1393	S4201	S4202	108.51	0.092	0.300	0.450	0.64
50th Avenue	1394	S4202	S4311	123.14	0.171	0.300	0.450	0.47
50th Avenue	1399	S4311	S4312	58.22	0.429	0.300	0.450	0.29
57th Street	1410	S4312	S4301	120.09	0.142	0.250	0.450	0.75
57th Street	1411	S4301	S5447	119.79	0.367	0.250	0.450	0.48
57th Street	1791	S5447	S5451	105.31	0.290	0.250	0.450	0.58

⁶ Qp/Qf = Peak flow fraction of conduit full flow computed during the 1:100-year, 4-hour simulation
⁷ For Qp/Qf > 0.86, manhole surcharges were kept to greater than 2.5 m below the ground/rim elevation in residential areas



- Legend
-  Sanitary Lagoon
 -  Sanitary Lift Station
 -  Sanitary Manhole
 -  Sanitary Pipe
 -  Sanitary Forcemain
 -  City of Wetaskiwin

FIGURE D-1
CITY OF WETASKIWIN
SANITARY MASTER PLAN UPDATE

EXISTING SANITARY SYSTEM MANHOLE
NUMBERING PLAN

AE PROJECT No.	2020-3787
SCALE	1:22,000
APPROVED	
DATE	2021JUN11
REV	
DESCRIPTION	ISSUED FOR FINAL

APPENDIX E - UNIT COST BREAKDOWN

Table E-1
City of Wetaskiwin
Sanitary Collection System Unit Costs (\$/m)

Undeveloped Lands

Item	200mm	250mm	300mm	375mm	450mm	525mm	600mm	750mm	900mm	1200mm	1500mm
Topsoil Stripping and Stockpile (assume depth of 0.4m)	\$ 22	\$ 22	\$ 22	\$ 22	\$ 30	\$ 30	\$ 30	\$ 30	\$ 30	\$ 46	\$ 46
Trenching and backfilling	\$ 757	\$ 797	\$ 803	\$ 812	\$ 1,065	\$ 1,074	\$ 1,082	\$ 1,098	\$ 1,115	\$ 1,611	\$ 1,644
Pipe Zone Material	\$ 35	\$ 35	\$ 35	\$ 35	\$ 60	\$ 60	\$ 60	\$ 90	\$ 90	\$ 110	\$ 110
Supply and Install DR 35 Pipe	\$ 60	\$ 65	\$ 70	\$ 89	\$ 123	\$ 155	\$ 209	\$ 365	\$ 527	\$ 1,125	\$ 1,631
Place Topsoil, compact and seed	\$ 26	\$ 26	\$ 26	\$ 26	\$ 34	\$ 34	\$ 34	\$ 34	\$ 34	\$ 50	\$ 50
Manholes (1 every 100 m)	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120	\$ 220	\$ 220	\$ 310	\$ 440	\$ 750	\$ 750
Miscellaneous (Mob/De-Mob, Survey, Signage) (10%)	\$ 102	\$ 107	\$ 108	\$ 110	\$ 143	\$ 157	\$ 164	\$ 193	\$ 224	\$ 369	\$ 423
Total Construction	\$ 1,122	\$ 1,172	\$ 1,184	\$ 1,214	\$ 1,575	\$ 1,730	\$ 1,799	\$ 2,120	\$ 2,460	\$ 4,061	\$ 4,654
Contingency (15%)	\$ 168	\$ 176	\$ 178	\$ 182	\$ 236	\$ 260	\$ 270	\$ 318	\$ 369	\$ 609	\$ 698
Engineering (15%)	\$ 168	\$ 176	\$ 178	\$ 182	\$ 236	\$ 260	\$ 270	\$ 318	\$ 369	\$ 609	\$ 698
Total (rounded)	\$ 1,460	\$ 1,520	\$ 1,540	\$ 1,580	\$ 2,050	\$ 2,250	\$ 2,340	\$ 2,760	\$ 3,200	\$ 5,280	\$ 6,050

Developed Lands

Item	200mm	250mm	300mm	375mm	450mm	525mm	600mm	750mm	900mm	1200mm	1500mm
Asphalt Pavement Removal	\$ 18	\$ 18	\$ 18	\$ 18	\$ 18	\$ 24	\$ 24	\$ 24	\$ 24	\$ 36	\$ 36
Granular Base Removal and Disposal	\$ 12	\$ 12	\$ 12	\$ 12	\$ 12	\$ 16	\$ 16	\$ 16	\$ 16	\$ 24	\$ 24
Curb,Gutter, Sidewalk Removal	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50
Trenching and Backfilling	\$ 757	\$ 797	\$ 803	\$ 812	\$ 1,065	\$ 1,074	\$ 1,082	\$ 1,098	\$ 1,115	\$ 1,611	\$ 1,644
Pipe Zone Material	\$ 35	\$ 35	\$ 35	\$ 35	\$ 60	\$ 60	\$ 60	\$ 90	\$ 90	\$ 110	\$ 110
Supply and Install DR 35 Pipe	\$ 60	\$ 65	\$ 70	\$ 89	\$ 123	\$ 155	\$ 209	\$ 365	\$ 527	\$ 1,125	\$ 1,631
Monolithic Sidewalk Curb and Gutter	\$ 200	\$ 200	\$ 200	\$ 200	\$ 200	\$ 200	\$ 200	\$ 200	\$ 200	\$ 200	\$ 200
Existing Pavement Repair	\$ 156	\$ 156	\$ 156	\$ 156	\$ 156	\$ 208	\$ 208	\$ 208	\$ 208	\$ 312	\$ 312
Reconnect Services	\$ 239	\$ 239	\$ 239	\$ 239	\$ -	\$ -	\$ -	\$ -	\$ -	-	\$ -
Manholes (1 every 100 m)	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120	\$ 220	\$ 220	\$ 310	\$ 440	\$ 750	\$ 750
Miscellaneous (Mob/De-Mob, Survey, Signage) (10%)	\$ 165	\$ 169	\$ 170	\$ 173	\$ 180	\$ 201	\$ 207	\$ 236	\$ 267	\$ 422	\$ 476
Total Construction	\$ 1,812	\$ 1,861	\$ 1,873	\$ 1,904	\$ 1,984	\$ 2,208	\$ 2,276	\$ 2,597	\$ 2,937	\$ 4,640	\$ 5,233
Contingency (15%)	\$ 286	\$ 294	\$ 296	\$ 301	\$ 314	\$ 349	\$ 360	\$ 410	\$ 464	\$ 733	\$ 827
Engineering (15%)	\$ 272	\$ 279	\$ 281	\$ 286	\$ 298	\$ 331	\$ 341	\$ 390	\$ 441	\$ 696	\$ 785
Total (rounded)	\$ 2,370	\$ 2,430	\$ 2,450	\$ 2,490	\$ 2,600	\$ 2,890	\$ 2,980	\$ 3,400	\$ 3,840	\$ 6,070	\$ 6,840

- Assumptions:
- All open cut excavation/ not trenchless (assumed to be open cut with a trench block)
 - Manholes every 100 m
 - Manhole depth assumed to be 5m
 - Does not account for wordly events (e.g., Snowstorm in Texas increased PVC pipe costs)
 - Excavation depth assumed to be 4-5m

Table E-2
City of Wetaskiwin
Pipe Upgrades Cost Breakdown

Upgrades to Existing System

UP1

Location	PipeID	From_MH	To_MH	Length (m)	Diameter (m)	Unit Cost (\$/m)	Pipe Cost	Type
48th Street	1486	S4451B	S4428	149.05	0.525	2890	\$ 431,000	Developed
48th Street	1490	S4428	S4532	99.12	0.600	2980	\$ 295,000	Developed
48th Street	1537	S4532	S4530	99.36	0.600	2980	\$ 296,000	Developed
48th Street	1538	S4530	S4529B	61.26	0.600	2980	\$ 183,000	Developed
48th Street	1539	S4529B	S4529	7.34	0.600	2980	\$ 22,000	Developed
48th Street	1540	S4529	S4502	68.09	0.600	2980	\$ 203,000	Developed
54th Avenue	1576	S4502	S4504C	106.38	0.600	2980	\$ 317,000	Developed
54th Avenue	1577	S4504C	S4508	105.16	0.600	2980	\$ 313,000	Developed
47th Street	1578	S4508	S4507	46.63	0.600	2980	\$ 139,000	Developed
47th Street	1580	S4507	S5211	92.96	0.600	2980	\$ 277,000	Developed
47th Street	1698	S5211	S5213E	104.85	0.600	2980	\$ 312,000	Developed
47th St. & 56th Ave.	5009	S5213E	S5213	3.96	0.600	2980	\$ 12,000	Developed
56th Avenue	1700	S5213	S5215B	32.61	0.600	2980	\$ 97,000	Developed
56th Avenue	1701	S5215B	S5215	8.84	0.600	2980	\$ 26,000	Developed
Total							\$ 2,923,000	

UP2

Location	PipeID	From_MH	To_MH	Length (m)	Diameter (m)	Unit Cost (\$/m)	Pipe Cost	Type
50th Street	1323	S3733	S3732	53.95	0.300	2450	\$ 132,000	Developed
50th Street	1325	S3732	S3723	43.95	0.300	2450	\$ 108,000	Developed
50th Street	1340	S3709	S4453	99.67	0.450	2600	\$ 259,000	Developed
50th Street	1461	S4453	S4447	99.97	0.450	2600	\$ 260,000	Developed
50th Street	1475	S4447	S4432	99.36	0.450	2600	\$ 258,000	Developed
50th Avenue	1476	S4432	S4431	48.77	0.525	2890	\$ 141,000	Developed
50th Avenue	1477	S4431	S4430	62.79	0.525	2890	\$ 181,000	Developed
50th Avenue	1487	S4430	S4429	85.95	0.600	2980	\$ 256,000	Developed
50th Avenue	1488	S4429	S4428	85.56	0.600	2980	\$ 255,000	Developed
Total							\$ 1,850,000	

UP3

Location	PipeID	From_MH	To_MH	Length (m)	Diameter (m)	Unit Cost (\$/m)	Pipe Cost	Type
53rd Street	1451	S4467	S4466	99.36	0.375	2490	\$ 247,000	Developed
49 Avenue	1452	S4466	S4464	85.95	0.375	2490	\$ 214,000	Developed
49 Avenue	1453	S4464	S4461	86.56	0.375	2490	\$ 216,000	Developed
49 Avenue	1457	S4461	S4460	71.32	0.375	2490	\$ 178,000	Developed
49 Avenue	1458	S4460	S4457	71.32	0.375	2490	\$ 178,000	Developed
49 Avenue	1459	S4457	S4455	70.71	0.375	2490	\$ 176,000	Developed
49 Avenue	1460	S4455	S4447	71.02	0.375	2490	\$ 177,000	Developed
50th Street	1475	S4447	S4432	99.36	0.450	2600	\$ 258,000	Developed
50th Avenue	1476	S4432	S4431	48.77	0.525	2890	\$ 141,000	Developed
50th Avenue	1477	S4431	S4430	62.79	0.525	2890	\$ 181,000	Developed
Total							\$ 1,966,000	

Table E-2
City of Wetaskiwin
Pipe Upgrades Cost Breakdown
Continued

UP4

Location	PipeID	From_MH	To_MH	Length (m)	Diameter (m)	Unit Cost (\$/m)	Pipe Cost	Type
55th Avenue	1774	S5327	S5329	94.79	0.375	2490	\$ 236,000	Developed
55th Avenue	1773	S5329	S5330	87.48	0.375	2490	\$ 218,000	Developed
55th Avenue	1772	S5330	S5331	87.48	0.375	2490	\$ 218,000	Developed
Total							\$ 672,000	

Stage 1 Development

Location	Pipe_ID	From_MH	To_MH	Length (m)	Diameter (m)	Unit Cost (\$/m)	Pipe Cost	Type
Ashwood Street	1961	S6808	S6811	66.75	0.250	2430	\$ 162,000	Developed
Aspen Ridge Subdivision	1914	S6819	S6113	84.73	0.525	2890	\$ 245,000	Developed
Aspen Ridge Subdivision	1915	S6113	S6115	103.02	0.525	2890	\$ 298,000	Developed
Aspen Ridge Subdivision	1916	S6115	S6112	91.44	0.525	2890	\$ 264,000	Developed
Aspen Ridge Subdivision	1917	S6112	S6116	82.92	0.525	2890	\$ 240,000	Developed
Aspen Ridge Subdivision	1918	S6116	S6120	84.43	0.525	2890	\$ 244,000	Developed
From 53rd Avenue - crossing the CPR	1919	S6120	S6121	65.84	0.525	2890	\$ 190,000	Developed
Garded Meadows Subdivision	1920	S6121	S6122	30.18	0.525	2890	\$ 87,000	Developed
Garded Meadows Subdivision	1921	S6122	S6123	46.02	0.525	2890	\$ 133,000	Developed
Garded Meadows Subdivision	1922	S6123	S6124	97.23	0.525	2890	\$ 281,000	Developed
Garded Meadows Subdivision	1723	S6124	S5224	71.63	0.525	2890	\$ 207,000	Developed
Garded Meadows Subdivision	1722	S5224	S5225	68.58	0.525	2890	\$ 198,000	Developed
Garnet Crescent	1724	S5225	S5226	57.70	0.900	3840	\$ 222,000	Developed
Total							\$ 2,771,000	

Stage 2 Development

Location	Pipe_ID	From_MH	To_MH	Length (m)	Diameter (m)	Unit Cost (\$/m)	Pipe Cost	Type
Between East Centennial and Glendale Subdivisions	1751	S5344	S5345	33.00	0.900	3840	\$ 127,000	Developed
Glendale Subdivision	1750	S5345	S5346	107.00	0.900	3840	\$ 411,000	Developed
Glendale Subdivision	1714	S5346	S5243	126.90	0.900	3840	\$ 487,000	Developed
Glendale Subdivision	1715	S5243	S5242	115.80	0.900	3840	\$ 445,000	Developed
Crosses 47th Street	1716	S5242	S5241	46.00	0.900	3840	\$ 177,000	Developed
Garden Meadows Subdivision	1717	S5241	S5201B	73.20	0.900	3840	\$ 281,000	Developed
Garden Meadows Subdivision	1718	S5201B	S5240	95.00	0.900	3840	\$ 365,000	Developed
Garden Meadows Subdivision	1719	S5240	S5239	120.00	0.900	3840	\$ 461,000	Developed
Garden Meadows Subdivision	1720	S5239	S5238	121.90	0.900	3840	\$ 468,000	Developed
Garden Meadows Subdivision	1721	S5238	S5225	137.80	0.900	3840	\$ 529,000	Developed
Garden Meadows Drive	1653	S5226	S5101B	136.86	1.200	6070	\$ 831,000	Developed
Garden Meadows Drive	1655	S5101B	S5103B	124.97	1.200	6070	\$ 759,000	Developed
Garden Meadows Drive	1659	S5103B	S5102	23.77	1.200	6070	\$ 144,000	Developed
Garden Meadows Drive	1633	S5102	S5105	134.42	1.200	6070	\$ 816,000	Developed
Garden Meadows Drive	1660	S5105	S6203	153.31	1.200	6070	\$ 931,000	Developed
Garden Meadows Drive	1931	S6203	S6205	67.20	1.200	6070	\$ 408,000	Developed
Garden Meadows Drive	1932	S6205	S6212	27.13	1.200	6070	\$ 165,000	Developed
Garden Meadows Drive	C_2020_56	S6212	S_2020_50	10.35	1.200	6070	\$ 63,000	Developed
Total							\$ 7,868,000	

