City of Regina – Water and Wastewater Serviceability Study

Water and Wastewater Serviceability Strategies to Meet Regina's Intensification and Development Objectives

Prepared for:

City of Regina

Prepared by:

Stone & Arrow Consulting LP

November 13, 2024

Project No.: 111260018

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

Limitations and Sign-off

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Executive Summary

Stone & Arrow was engaged by the City to study water and wastewater infrastructure expansion to service growth in Regina, both within the current City Limits and in outlying areas identified for future development. The objective of this project is to provide a Serviceability Study to summarize the water and wastewater servicing strategies to support growth for future greenfield and intensification developments in advance of development. This report is the key project deliverable.

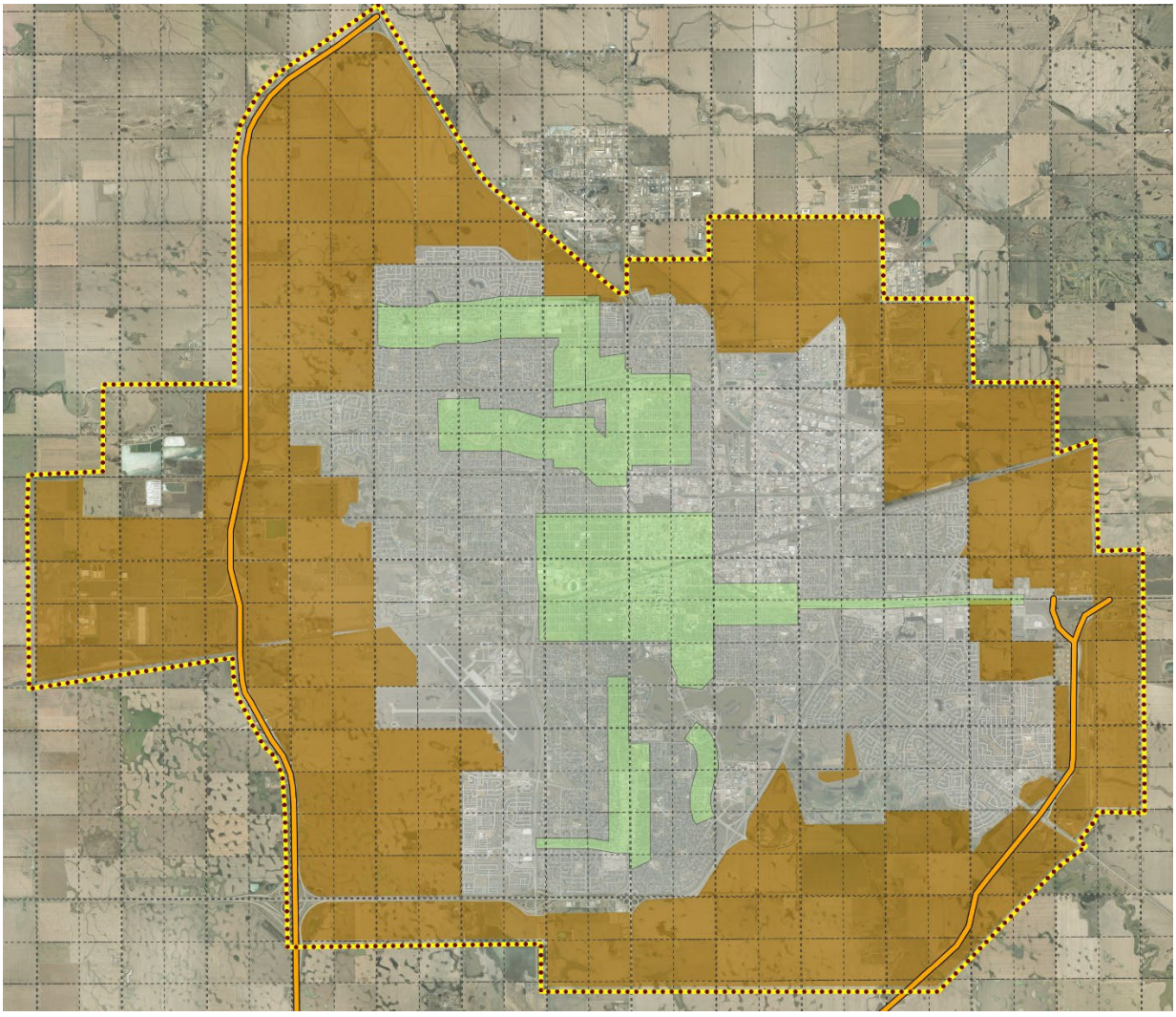


Figure i - Future Land Use Plan

The Serviceability Study focuses on growth areas for greenfield and intensification development as shown in Figure i. The grey area represents existing developed land. The green area shows future intensification areas. The brown area represents future greenfield developments for industrial, residential, and commercial purposes.

A Serviceability Study, similar to a master plan, should be considered a City-wide policy tool to inform the City, developers, and other partners of the infrastructure necessary to extend services to support growth in line with the goals of the Official Community Plan (OCP), 2013.

Analysis for the Serviceability Study was focused on an intentionally aggressive development scenario beyond the 500,000-population target identified in the OCP based on the project boundary. This focus helped with the creation of a long-term vision for City water and wastewater infrastructure. The long-term vision will help the City prevent the use of short-term and short-sighted interim solutions to smaller-scale development problems. These types of solutions lead to increased operations and maintenance costs and increased future development costs for developers and the City. An appropriate and practical long-term vision for water and wastewater infrastructure, coupled with proactive investment in infrastructure, will allow the City flexibility in its planning and financing of long-term infrastructure solutions to support growth. Maintaining consistent focus on the long-term vision will provide developers the cost certainty required to make new developments viable from a business perspective as Regina grows.

Three (3) scenarios were evaluated in the models: existing conditions, existing conditions plus intensification, and the ultimate scenario. The water and wastewater system responses were evaluated to determine the impact of the proposed development on the systems and the associated infrastructure required to service the proposed development.

Based on the analysis and conclusions noted herein, the following recommendations have been prepared with the acknowledgement that development of the identified scenarios is expected to take decades and that the intent of the Serviceability Study is to provide guidance to the City and developers with respect to the water and wastewater infrastructure required to meet the objectives of the OCP, Housing Accelerator Fund commitments, and other key guiding policy documents.

The analysis identified three general themes:

Existing Level of Service

- The City should continue to prioritize rehabilitation of existing infrastructure to maintain and improve existing levels of service. Opportunity exists to strategically upsize water and sewer mains in support of intensification as part of existing infrastructure replacement programs such as the Cast Iron Replacement and Rehabilitation Program.

Intensification

- The existing water and wastewater infrastructure can generally support the immediate development of intensification in certain areas without negatively impacting existing levels of service. Therefore, the City should prioritize intensification to maximize the use of existing infrastructure. Intensification development should be reviewed on a case-by-case basis with its impact on the City's existing infrastructure compared to its overall socio-economic benefit to the City. The City's development standards are conservative and appropriate to adhere to for large greenfield developments. Rigidly applying the City's current development standards to

intensification opportunities which are typically smaller and within the current city footprint will significantly limit the City's ability to achieve its intensification target. A case-by-case approach within the current city footprint is important to consider.

Greenfield

- Topography in Regina falls from higher in the northeast to lower in the southwest. Our water source, the Buffalo Pound Water Treatment Plant (BPWTP) is west of the City and requires pumping from west to east and uphill to reach the whole City. The further east the destination for the water, the more costly it is to get it there. Our Wastewater Treatment Plant (WWTP) is also west of the City which allows our collection system to function largely by gravity to reach the McCarthy Boulevard Pump Station (MBPS) which then pumps to the WWTP.
- Given the configuration of the water and wastewater systems the biggest opportunity for relatively large-scale and cost-efficient greenfield land development is on the west and southwest of the current City. Major water and wastewater improvements are required for any greenfield development given the configuration of the current systems, but these areas are serviceable with water and wastewater in the relatively short-term.

The total scale of the recommendations is a significant financial investment. Therefore, prior to proceeding with any of the recommendations in part or whole, it is recommended that as a next step, the City review all of the recommendations and prioritize them in alignment with the City's objectives.

Table of Contents

1 INTRODUCTION 1
1.1 Objective 2

2 DESIGN CONSIDERATIONS 4
2.1 Background Information Review and Gap Analysis 4
2.2 Land Use Plan 5
2.2.1 Project Boundary 5
2.2.2 Land Use Plan 6
2.3 Design Criteria 9
2.3.1 Design Population 9
2.3.2 Water 9
2.3.3 Wastewater 12
2.4 Opportunities and Constraints 12

3 WATER DISTRIBUTION SYSTEM 13
3.1 Existing System Operation 13
3.2 Growth Scenarios 16
3.3 Water System Assessment 16
3.3.1 Existing System Scenario Assessment 16
3.3.2 Existing System Plus Intensification Scenario Assessment 21
3.3.3 Ultimate Scenario Assessment 32
3.3.4 Assessment of Reservoir Capacity and Pumping Capacity 38

4 WASTEWATER COLLECTION SYSTEM 41
4.1 Existing System Operation 41
4.2 Wastewater System Assessment 41
4.2.1 Model Development 42
4.2.2 Existing System Scenario Assessment 42
4.2.3 Growth Scenario Development 49
4.2.4 Existing System Plus Intensification Scenario Assessment 51
4.2.5 Ultimate Scenario Assessment 54

5 OPINION OF PROBABLE COST 66
5.1 Water Distribution System 67
5.2 Wastewater Collection System 81

6 CONCLUSIONS 84
6.1 Water Distribution System 84
6.2 Wastewater Collection System 85

7 RECOMMENDATIONS 88

7.1 Water Distribution System 88
7.2 Wastewater Collection System 90

8 CLOSING 92

List of Tables

Table 2-1: Summary of Future Land Uses* 6
Table 3-1: Growth Scenario and Population 16
Table 3-2: Hydraulic Grades 17
Table 3-3: Peak Hour Analysis 18
Table 3-4: Fire Flow Results 21
Table 3-5: Intensification Population and Demands 21
Table 3-6: Peak Hour Analysis of the Existing System with Intensification 23
Table 3-7: Fire Flow Analysis of the Existing System with Intensification 26
Table 3-8: Peak Hour Analysis of Downtown Solution 27
Table 3-9: Fire flow Analysis of Downtown Solution 31
Table 3-10: Ultimate Scenario Population and Demand 32
Table 3-11: Peak Hour Analysis of the Ultimate Scenarios 35
Table 3-12: Fire Flow Analysis of Ultimate Scenario 38
Table 3-13: Existing Reservoir Storage Capacity 39
Table 3-14: Pumping Hydraulic Grades and Capacities 40
Table 4-1 Performance Assessment of Upgrades Scenarios 44
Table 4-2 Overflow Volumes from the Release Points 57
Table 5-1: Water Serviceability Summary 68
Table 5-2: Serviceability Summary of the Existing with Intensification 82

List of Figures

Figure i - Future Land Use Plan ii
Figure 1-1: Serviceability Plan 3
Figure 2-1: Land Use Plan 8
Figure 3-1: Existing Water Supply and Distribution Network 15
Figure 3-2: Scenario 1 – Existing System Without Redbear Pumping Station 19
Figure 3-3: Scenario 2 – Existing System Without Redbear Pumping Station 20
Figure 3-4: Scenario 3 – Existing System with Intensification 24
Figure 3-5: Scenario 4 – East Bypass Loop Added to Existing System 25
Figure 3-6: Scenario 5 – No Downtown Pump Station 28
Figure 3-7: Scenario 6 – New Downtown Pump Station at 4th Avenue 29
Figure 3-8: Scenario 7 – Convert Downtown Supply Lines to Trunk Mains 30
Figure 3-9: Scenario 8 – Ultimate Network with North Station Active 36
Figure 3-10: Scenario 9 – Ultimate Scenario with West Pump Station Active 37

Figure 4-1: Flow Hydrographs before MBPS 45
Figure 4-2: Existing System Overview 46
Figure 4-3: Existing Condition DWF Flooding and Surcharging Nodes 47
Figure 4-4: Existing Condition WWF Flooding and Surcharging Nodes 48
Figure 4-5: Diurnal Patterns applied in Greenfield Areas (a) Residential (b) Commercial/Industrial 50
Figure 4-6: 1:25-Year, 24-Hour Rainfall Event 51
Figure 4-7: DWF Assessment for Existing plus Intensification Scenario 52
Figure 4-8: WWF Assessment for Existing plus Intensification Scenario 53
Figure 4-9: Future Subcatchment DWF and WWF 58
Figure 4-10: Proposed Sewer Network and System Upgrades- Option 1 59
Figure 4-11: Proposed Sewer Network and System Upgrades- Option 2 60
Figure 4-12: DWF Assessment for Ultimate Scenario – Option 1 61
Figure 4-13: WWF Assessment for Ultimate Scenario – Option 1 62
Figure 4-14: DWF Assessment for Ultimate Scenario – Option 2 63
Figure 4-15: WWF Assessment for Ultimate Scenario – Option 2 64
Figure 5-1: Water – Downtown Intensification 73
Figure 5-2: Water – North Intensification 74
Figure 5-3: Water – South Intensification 75
Figure 5-4: Water – East Serviceability 76
Figure 5-5: Water – Southeast Serviceability 77
Figure 5-6: Water – Southwest Serviceability 78
Figure 5-7: Water – West Serviceability 79
Figure 5-8: Water – Northwest Serviceability 80

List of Appendices

Appendix A Background Information Review and Gaps Analysis
Appendix B Land Use Plan
Appendix C Design Criteria
Appendix D Opportunities and Constraints
Appendix E Second WWTP Assessment
Appendix F Detailed Cost Breakdown (OPC)

1 Introduction

The City of Regina (City) is experiencing demand for development in the East, City Centre, and West (Northwest, and Southwest) sections of the City. Capacity limitations within the City's existing water and wastewater infrastructure has limited the City's ability to support growth in multiple sections of the City as per the City's Official Community Plan (OCP).

The OCP includes policies to support orderly and sustainable long-term growth in Regina. Section 14.19 of the OCP provides direction on the phasing and financing of new growth and developments. The phasing and financing of new growth and development should align with several factors:

- Optimization of Existing Services/Amenities
- Meeting Intensification Targets
- Projected Population and Employment Growth
- Provision of New Services and Amenities in Complete Neighborhoods
- Contiguous Development
- Build-Out of New Growth Areas
- Meeting Level of Service Requirements
- Balanced Residential and Employment Growth
- Financial Capacity of the City
- Affordable Land Development
- Market Readiness

To support the policies within the OCP, the City has engaged Stone & Arrow Consulting LP (Stone & Arrow) in collaboration with Stantec Consulting Ltd. and Associated Engineering (Sask) Ltd. to provide direction on the City's water and wastewater infrastructure upgrades and expansion to support growth through completion of a Water and Wastewater Serviceability Study (Serviceability Study).

A Serviceability Study, similar to a master plan, should be considered a City-wide policy tool to inform the City, developers, and other partners of the infrastructure necessary to extend services to support growth in line with the goals of the OCP.

The Serviceability Study intentionally projects development beyond the 500,000-population target identified in the OCP based on the project boundary defined in Section 2.2.1. This is intended to create a long-term vision for the City to prevent the use of short-term interim solutions for servicing needs and allow the City ultimate flexibility in its planning and financing of long-term infrastructure solutions to support growth.

The Serviceability Study is not intended to replace the need for secondary plans and concept plans. Secondary plans and concept plans will still need to be completed to confirm land use, urban design, and local infrastructure required for specific geographical areas of the City. The Serviceability Study should be used to inform the City and developers of the infrastructure required within each secondary plan and or concept plan to meet the objectives of the OCP, Housing Accelerator Fund commitments, and other key guiding policy documents.

1.1 Objective

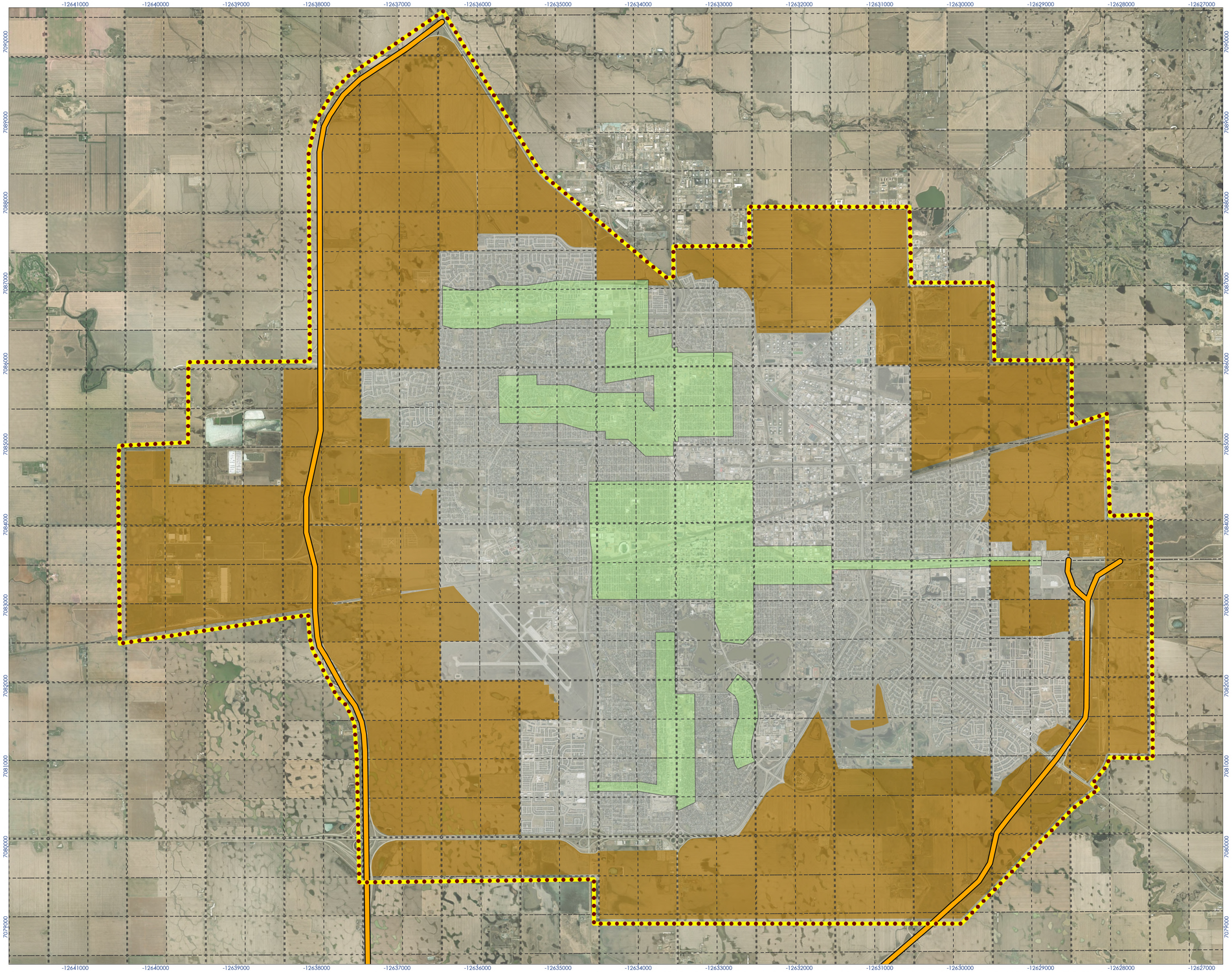
Stone & Arrow was engaged by the City to provide engineering services for the water and wastewater infrastructure expansion to service increased population growth in Regina's East, City Center, and West. The objective of this project is to provide a Serviceability Study to summarize the water and wastewater servicing strategies to support growth for future greenfield and intensification developments in Regina's East, City Centre, and West in advance of development. This document represents the Serviceability Study.

The Serviceability Study focuses on growth areas for greenfield and intensification development as shown in Figure 1-1. The grey area represents existing developed land, the green area represents future intensification areas, and the brown area represents future greenfield development.

Intensification development refers to construction of new buildings or addition to existing buildings on serviced land within existing built areas. Greenfield development refers to development of land that is not currently serviced either within or outside of the City. Refer to Section 2.2 for further detail on the greenfield and intensification areas.

The scope of work of the Serviceability Study included:

- Reviewing and assessing the existing water distribution system and wastewater system and identifying major constraints
- Identifying additional demands (water) and flows (wastewater) and the expected system's responses to the additional loading
- Hydraulic analyses of the systems using the City's existing WaterCAD and InfoWorks ICM models respectively along with model updates
- Recommending ultimate development infrastructure improvements
- Identifying the financial implications associated with the servicing improvements



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LEGEND

- PROJECT BOUNDARY
- BYPASS
- 1 QS = 64.7 ha = 160 ac
- EXISTING DEVELOPED LAND
- INTENSIFICATION AREAS
- GREENFIELD DEVELOPMENT

N

0 925 1,850 metres

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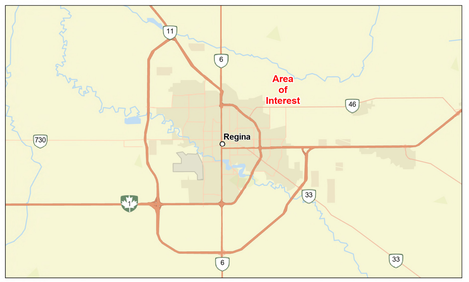
Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
World Imagery: Maxar



Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

1-1

Title

SERVICEABILITY PLAN

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2 Design Considerations

As part of this project, Stone & Arrow developed four preliminary technical memos to summarize the background information and design criteria to inform the analysis. The following section summarizes the preliminary technical memos. A copy of each technical memo has been included in Appendices A through D.

2.1 Background Information Review and Gap Analysis

To complete this assignment, Stone & Arrow compiled, reviewed, and assessed several documents and data sources. Further, a gap analysis was completed on the information to identify any gaps that would impact the Serviceability Study. The following list summarizes key information that was obtained by Stone & Arrow in the completion of this study. For a full list of documents refer to Appendix A for the Background Information Review and Gap Analysis Technical Memo.

- Water Master Plan, February 2019
- Wastewater Master Plan – Phase 1: System Response, prepared by Stantec in June 2019, (Stantec, 2019a)
- Wastewater Master Plan – Phase 2: System Renewal, prepared by Stantec in June 2019 (Stantec, 2019b)
- Serviceability Study Wastewater Catchment Area and Water Network Expansion for Regina North, prepared by Associated Engineering (AE) in March 2023 (AE, 2023)
- Northwest Sector Serviceability Study, November 2008
- Northeast Serviceability Study, May 2012
- Downtown Regional Relief Element Alignment and Configuration Review, prepared by AECOM in August 2022 (AECOM, 2022)
- Wastewater Capacity Upgrades – South Trunk, Relief Alignment A, Preliminary Drawings, prepared by AECOM May 2023 (AECOM, 2023a)
- Wastewater Capacity Upgrades – South Trunk, Lakeview Relief Alignment 3, Preliminary Drawings, prepared by AECOM in May 2023 (AECOM, 2023b)
- The McCarthy Boulevard Pumping Station Upgrade, Record Drawing, prepared by AE in January 2021 (AE, 2021)
- City of Regina High Flow Pump Test, December 2022
- The Creeks Wastewater Pumping Station Expansion, Record Drawing, prepared by AE in November 2020 (AE, 2020).
- City of Regina Creeks Wastewater Pumping Station Expansion – Force Main Twinning, May 2018
- City of Regina Creeks Wastewater Pumping Station Expansion Design Brief, May 2019
- The Services Agreement in between the City of Regina (CoR) and Global Transportation Hub (GTH) Authority, December 2018.

- Aurora Retail Corp. Victoria Avenue East Commercial Corridor Servicing Evaluation, prepared by AE in January 2016 (AE, 2016)
- Official Community Plan, Fleet Street Business Park, Secondary Plan, Part B.9, published by the City of Regina.
- Tower Crossing Secondary Plan, OCP – Part B.15, published by the City of Regina.
- Coopertown Neighbourhod Plan, OCP – Part B.17, published by the City of Regina.
- Westerra Sewage Pumping Station and Forcemain- Design Basis Report, prepared by WSP in September 2018 (WSP 2018)
- City of Regina Domestic Model Calibration, prepared by Stantec in June 2014 (Stantec, 2014).
- The Waterworks and Sewage Works Regulations
- Waterworks Design Standard – EPB 501
- Sewage Works Design Standard – EBP 503
- General Information Design Standard, May 2022
- Water Design Standard, May 2022
- Wastewater Design Standard, January 2021
- City of Regina Downtown Serviceability Study, January 2014
- Eastern Pressure Solution Water Supply Main – Design Brief draft, February 2023
- Eastern Pressure Solution Redbear Avenue Pumping Station and Reservoirs, August 2023
- Design Regina Official Community Plan, 2013

2.2 Land Use Plan

The intent of the land use plan was to establish the project boundary and identify future development of areas between existing and or approved developments and the project boundary including intensification areas within existing developments. Development of a composite land use plan that clearly defines the assumptions for this project allows for informed stakeholder engagement resulting in overall buy-in of the proposed plan and reduced pressure from external stakeholders and the development community.

2.2.1 Project Boundary

The original study area boundaries have been combined into a single study area as per the 6181 - Water and Wastewater Serviceability Study - East, City Center and West Technical Memo provided on July 20, 2023. The City provided confirmation of the existing developed land and identified lands currently approved for development that should be considered.

Stone & Arrow facilitated Workshop 1 on December 19 from 9:00 AM to 12:00 PM 2024 with the City to determine the project boundary and land uses for greenfield development for the Serviceability Study. The workshop concluded that the rationale for the Project Boundary, as identified on Figure 2-1, should incorporate the following boundaries and built infrastructure:

1. Regina Bypass
2. Joint Planning Area (from Regina's Official Community Plan, 2013)
3. City Limits (from OCP, 2013)
4. Future Long-Term Growth Area (~500K from OCP, 2013)
5. Original Project Boundary (from RFP)

2.2.2 Land Use Plan

Figure 2-1 identifies existing developed land and future land uses for greenfield development for land between the existing developed land and the project boundary, as determined in Workshop 1. Future land uses were broken down into general categories including residential, commercial, and industrial. The future land uses are based on a combination of existing City policy documents and an understanding of future development.

In addition to future land uses for greenfield development, intensification areas were identified to maintain consistency with the OCP and Housing Accelerator Fund application commitments.

A second workshop, Workshop 2, was facilitated by Stone & Arrow on January 22 from 9:00 AM to 12:00 PM 2024 with the same group. The focus of Workshop 2 was discussion of intensification strategies, identification of intensification areas, and assignment of intensification densities to those areas. The resulting intensification consensus is shown on Figure 2-1.

Refer to Table 2-1 below for a summary of the future land uses.

Table 2-1: Summary of Future Land Uses*

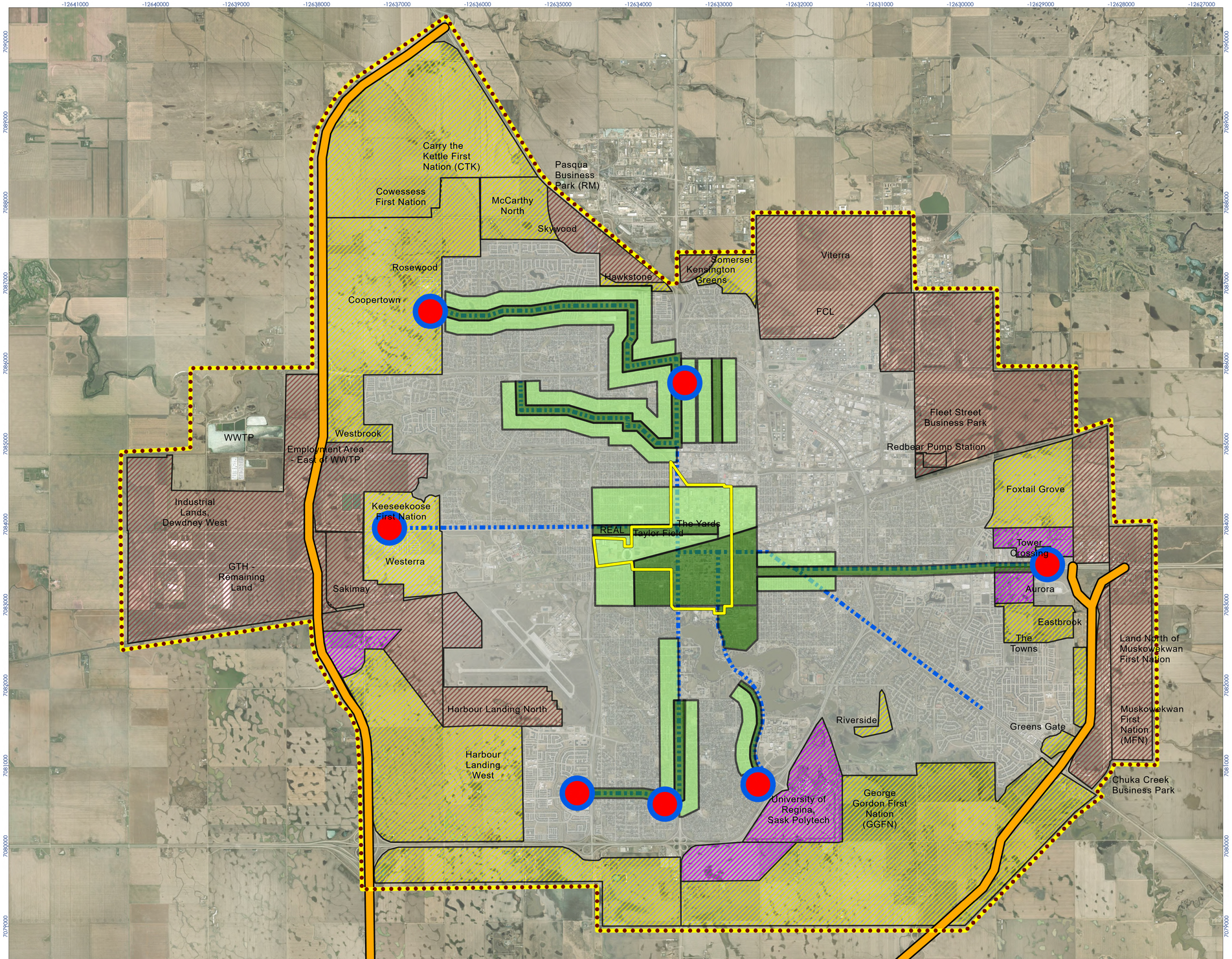
Land Use Type	Area (Ha)	Density	Equivalent Residential Population
Existing	-	-	226,000**
Residential	6,277	50 ppl/ha	314,000
Commercial	675	65 ppl/ha	39,500
Industrial	4,991	25 ppl/ha	125,000
Intensification – Medium	1,591	65 ppl/ha	103,000
Intensification – High	936	235 ppl/ha	220,000
Adjustment	-	-	(97,000)***

* Adapted from Water Design Standard, September 2023 and Wastewater Design Standard, May 2022
** 2021 Census data
*** Adjustment taking the existing population within the intensification into account

The Equivalent Residential Population column in Table 2-1 above shows the ultimate population at "full build out" for each of the land use types. These populations are required as flow generating inputs for the water and wastewater modeling and should not be thought of as population targets, but as maximum population thresholds for modeling purposes.

For the two intensification types, the Equivalent Residential Populations do not account for the actual current land uses, only a maximum threshold for modeling purposes for the ultimate population at “full build out”. They are not a likely population in the short or medium term and are not a projected population increase for the intensification areas.

The purpose of assigning land use types and population densities to the study area is to provide appropriate water and wastewater demand assumptions for the analysis. The proposed land uses are not to be considered as assigned land uses per official City of Regina standards or policies. It is understood that future land uses may change over time through reviews of the OCP Growth Plan as more detailed plans for neighborhoods/employment areas are developed.



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LEGEND

- PROJECT BOUNDARY
- BYPASS
- CITY CENTRE
- EXPRESS ROUTE
- URBAN CENTRE
- EXISTING DEVELOPED LAND (11943 ha)

INTENSIFICATION AREAS

- 65 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

FUTURE LAND USE

- COMMERCIAL (675 ha)
- INDUSTRIAL (4991 ha)
- RESIDENTIAL (6277 ha)

NOTE:
THE FUTURE LAND USE AREAS SHOWN INCLUDE SOME AREAS WHICH HAVE ALREADY BEEN DEVELOPED.

N

0 925 1,850 metres

(At original document size of 22x34)
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Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
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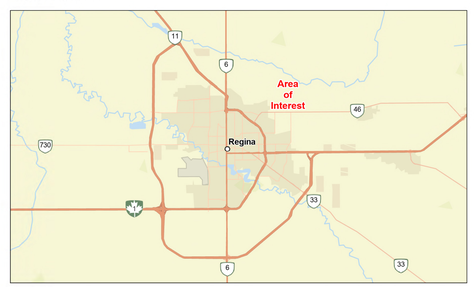
World Imagery: Maxar



Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-01-18

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

2-1

Title

FUTURE LAND USE PLAN

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2.3 Design Criteria

The design criteria memo summarizes the design standards used in the Serviceability Study. The analysis of the water and wastewater systems used the City's General Information, Water, and Wastewater Design Standards unless otherwise noted.

2.3.1 Design Population

The design population for all future developments used the Design Population Table identified in the City of Regina (City) Water Design Standards, September 2023 and Wastewater Design Standards, May 2022. In addition to the population tables, two categories of intensification were identified, discussed, and confirmed with City of Regina stakeholders at Workshop 2. The intensification design populations are intended to represent future population densities within existing areas consistent with the City's intensification goals.

1. Intensification – Medium
    - Consistent with "Commercial, Mixed" zoning at a population density of 65 persons/hectare.
2. Intensification – High
    - Consistent with "High Rise Residential" zoning at a population density of 235 persons/hectare.

2.3.2 Water

2.3.2.1 Design Standards

The City of Regina Water Design Standards, September 2023, were used in conjunction with the Water Master Plan to develop the water model for the "Existing with Intensification System" as well as the "Ultimate Water System". It is assumed that the City of Regina's Water Design Standards, September 2023 will apply to all areas within the model, including areas outside of the City limits.

2.3.2.2 Water Demand

The City of Regina Design Standards - September 2023, lists the Average Daily Demand as 390 litres per capita per day irrespective of the applicable land use. The Standards do not provide water demands that will apply to non residential uses such as commercial and industrial but rather indicates the population densities that should be used to calculate the water use.

The City Water Master Plan Final Report (February 2019, AECOM) considered the water consumption records of the City to determine the Average Daily Demand (ADD). The total ADD of 390 Lpcd accounts for all water use in the system including the residential, commercial, and industrial uses as well as system leakages. The residential ADD was determined as 68% of the total water use through water consumption records. It is therefore appropriate to use an Average Daily Demand of 265 Lpcd for residential water use.

The Water Master Plan Final Report does not explicitly outline water consumption values for non-residential land uses. However, it was decided to use 175 Lpcd for non-residential land uses to remain consistent with the existing City WaterCAD model.

In summary, the following water use values were applied to the WaterCAD model for the analysis of the serviceability study:

- Residential - 265 Lpcd
- Commercial, industrial, institutional - 175 Lpcd

The residential densities for commercial, industrial, and institutional uses were applied to the planned areas to calculate the equivalent population. These equivalent populations for the non-residential areas were then summed up and a demand of 175 Lpcd was then applied calculate the average day demand.

The land use density for the institutional land use was increased from 50 ppl/ha to 65 ppl/ha for it to be consistent with commercial densities. The water demand for both commercial and industrial is the same at 175 Lpcd. The total water demand for commercial, including the University of Regina (institutional) is calculated at 88.8 L/s as opposed to 80.05 L/s which is calculated when the commercial and institutional densities are separated. This is an increase of 8 L/s of water demand. Therefore, the impact of combining the institutional and commercial demands is minimal considering that the total water demand for the serviceability plan is approximately 3,000 L/s.

The capacity required for the future storage reservoirs was determined by utilizing the 390 Lpcd demand as set out in the City of Regina Water Design Standards. The per capita water rate of 390 Lpcd was applied to the future population projections to calculate the total average day water demand and total storage required by multiplying by two as recommended by the Water Security Agency.

2.3.2.3 Performance Criteria

The modelling results generated from the different analysis for each scenario were verified to confirm that the system operates to the following criteria as set out in the City of Regina Design Standards:

Velocity:

- ≤ 1.5 m/s at Peak Hour Demand
- ≤ 3.2 m/s at Peak Day Demand plus Fire Flow

Supply pressure:

- Peak Hour Demand maximum allowable pressure drop ≤ 27.6 kPa
- Peak Hour Demand minimum allowable pressure corrected to proposed ground elevation ≥ 269.4 kPa.
- Peak Day Demand minimum allowable residual pressure at any point in the system within 500 m of the fire site under Fire Flow condition corrected to proposed ground elevation ≥ 140 kPa.

2.3.2.4 Design Fire Flow Criteria

WaterCAD simulation of the existing City distribution system does indicate some fire flow deficiency typically in isolated cases where there are dead end mains or slightly undersized mains from previous development. This study viewed fire flow deficiencies at a high level. Although, correcting all fire flow deficiencies is beyond the scope of work of this study, we have reviewed the fire flow recommendations from the Water Master Plan which states the following:

Single junctions are more likely to fail for higher levels of fire flow (level 2, 3 & 4) and a closer review is required for these areas to determine if the flow can be achieved from multiple hydrants. It is recommended the City develop a critical building list and conduct a detailed fire flow review for the single junctions not meeting fire flow. The results can then be cross referenced with the review and the findings from the WMPS to determine the true level of service condition. Once a detailed evaluation of the fire flow is complete and a true level of service obtained, it is recommended that the City incorporate these upgrades to the water system through the small and large diameter rehabilitation program.

We have reviewed the level of fire flow deficiencies whilst completing scenario analysis to ensure that recommended solutions improve the level of fire flow service to the City on a whole by reducing the number of fire flow deficiencies.

The analysis assumed that the fire flow would occur concurrently with the peak day demand in the system. The minimum fire flow required in the system were incorporated as per the following table. In future development areas where residential, institutional and commercial development may be mixed and exact location for higher fire flow needs is unknown, we have used a fire flow target of 250 L/s to ensure the trunk and feeder mains we have modelled can provide 250 L/s to the area.

Zoning Designation	Fire Flow Requirement Designation	Required Minimum Fire Flow
FW, PUD, RU, R1	Level 1	90 L/s
ML, RN, RL, MH, OA, RH, RMH, DCD-TAN	Level 2	150 L/s
MLM, DCD-D, I, IL, IP, LP, RW, DCD-WH	Level 3	250 L/s
IH	Level 4	300 L/s

2.3.2.5 Validation

The current WaterCAD model provided by the City was not validated as part of this project. The field verification scope was removed as part of the proposal submission as the WaterCAD model was previously validated through field verification during the Water Master Plan project in 2019. As recent model validation has been completed and the WaterCAD model provides simulated results that are not out of the ordinary, the model and its results are generally accepted and suitable for use in this Study.

2.3.3 Wastewater

2.3.3.1 Design Standards

The City of Regina Wastewater Design Standards, January 2021, were used in conjunction with the Wastewater Master Plan to develop the wastewater model for the "Existing with Intensification System" as well as the "Ultimate Water System". It is assumed that the City of Regina's Wastewater Design Standards, January 2021 will apply to all areas within the model, including areas outside of the City limits.

2.3.3.2 Estimated Wastewater Flows

- Average daily wastewater flow used for designing residential, high, and medium intensification areas and industrial areas will be 225 Lpcd. Commercial areas will be 454 Lpcd.
- A detailed review of the McCarthy Boulevard and Creeks Pump Station's operating capacities were completed as part of the assessment to identify discrepancies within the model. Any major discrepancies have been identified as part of the analysis.

2.3.3.3 Detailed Design

- Recommendations will be consistent with the City of Regina's Wastewater Design Standards, May 2024.

2.3.3.4 Validation

The current Wastewater model provided by the City was not validated as part of this project. The Wastewater model was previously validated through field verification during the Wastewater Master Plan project in 2019. As recent model validation has been completed and the Wastewater model provides simulated results that are not out of the ordinary, the model and its results are generally accepted and suitable for use in this Study.

2.4 Opportunities and Constraints

The opportunities and constraints memo identifies high-level and systemic opportunities and constraints for future development of the City's water distribution and wastewater collection infrastructure. These considerations guided the detailed modelling and analysis of both systems and are described in detail in the following sections.

3 Water Distribution System

The following sections assess the serviceability of the City's water distribution system to sustain the growth identified in this Serviceability Study. Specifically, the sections outline the existing system operations, provide a summary of the existing system assessment, outline the established growth scenarios and system response, and discuss various servicing sequencing and options, covering aspects such as sizing and routing.

The water distribution system is assessed for three growth scenarios including the existing system, the existing system with the addition of residential intensification, and the ultimate scenario which includes the existing, intensification, and greenfield development.

3.1 Existing System Operation

The City of Regina receives its water supply from the Buffalo Pound Water Treatment Plant (BPWTP) through two parallel pipelines. The first supply pipeline, with a diameter of 900 mm was installed in the 1950s. The second pipeline, installed in stages between 1990 and 2003, has a diameter of 1050 mm. The potable water is pumped over 60 km to the City of Regina, where the City's water storage and distribution system stores and distributes potable water to the City's consumers.

The City's water distribution system consists of two pressure zones (the Primary and the North Pressure Zone), five existing water storage reservoirs, and three pumping stations. Two additional reservoirs and one pumping station are under construction in the City's northeast and will be called the Redbear Reservoirs and Pumping Station. See Figure 3-1: Existing Water Supply and Distribution Network for reference.

The primary reservoirs for the distribution system are the Pasqua, Northwest, and the future Redbear Reservoirs. These reservoirs are and will be used to meet daily demand fluctuations. The Albert Street, Tor Hill, and 4th Avenue Reservoirs are secondary reservoirs used only during peak water demands. The Northwest and Pasqua Reservoirs are filled from the BPWTP supply pipelines. These reservoirs were built in the 1970s and are in good condition. The North Pumping Station transfers water from these two reservoirs to the Albert Street Reservoir and the Farrell Pumping Station through a dedicated transfer pipeline. A secondary supply system with a dedicated transfer pipeline exists between the Tor Hill Reservoir, 4th Avenue Reservoir, and the Farrell Pumping Station. The Tor Hill Reservoir is filled from the distribution system while the 4th Avenue Reservoir is filled via the Tor Hill Reservoir.

The Redbear Reservoirs will be filled from the Northwest and Pasqua Reservoirs via transfer by the North Pumping Station and a dedicated supply pipeline which is currently under construction.

The Albert Street Reservoir is located in the Sherwood Industrial Park north of Highway No. 11. It was constructed in the 1930s for the purpose of well water storage from a well system in the northern aquifer located north of the city. The northern aquifer wells and its associated raw water pipeline were abandoned many decades ago. The Albert Street Reservoir is currently part of the City's potable water storage system. It is filled from a single pipeline from the North Pumping Station and supplies the Farrell Pumping Station for downtown supply during peak demands.

The Tor Hill Reservoir is located northeast of the city near the Tor Hill Golf Course. In the past, the city supplemented the treated water supply from BPWTP with groundwater obtained from the Boggy Creek well field located northeast of the City. However, since twinning of the BPWTP supply line, the City no longer uses groundwater as a daily source of potable water. The wells are maintained for emergency purposes only. Since wells are no longer used, the Tor Hill Reservoir is not ideally located for existing operations. The Tor Hill Reservoir is currently used to supply the 4th Avenue Reservoir by gravity during periods of peak demand.

The 4th Avenue Reservoir is located near the intersection of Ross Avenue and Toronto Street near downtown. It is our understanding that the 4th Avenue Reservoir leaks and recent rehabilitation of the reservoir was not completely successful in eliminating reservoir leakage. The 4th Avenue Reservoir supplies the Farrell Pumping Station but due to the distance from the Farrell Pumping Station and lack of elevation difference, the lower volume of the 4th Avenue Reservoir is not useable.

The distribution of water throughout the city occurs through two pressure zones, the Primary Pressure Zone and the North Pressure Zone. The Primary Pressure Zone is currently serviced by the North Pumping Station and the Farrell Pumping Station. The North Pumping Station is the City's primary pumping station and operates 24 hours per day. A large diameter trunk main called the "City Loop" (500 mm to 1050 mm in diameter) originates at the North Pumping Station and encircles the City mostly along the Ring Road and Lewvan Drive. The inner portion of the City Loop or the downtown area is serviced by the Farrell Pumping Station which operates only during the daytime hours when demands are higher.

The east portion of the Primary Pressure Zone has seen significant development over the last decade. With the increased water demand in the southeast, this area has experienced deficient pressures compared to other areas of the City. To improve water service to the City's southeast, an Eastern Pressure Solution project is currently underway which includes construction of the Redbear Reservoirs and Pumping Station in the City's northeast and a dedicated supply pipeline from the North Pumping Station to the Redbear site. Once complete, the Redbear Pumping Station will service the Primary Pressure Zone and will improve pressures in the City's east.

The North Pressure Zone is currently serviced by the North Zone Pumping Station located on the northwest corner of Pasqua Street and 9th Avenue North. The North Zone Pumping Station is fed by gravity from the Northwest Reservoir.

The Redbear Pump Station is located near the boundary of the Primary and North Pressure Zones and as such, the Redbear Pump Station can also distribute to the North Pressure Zone as development in the City's northeast progresses.

The Farrell Pumping Station is located near the corner of Dewdney Avenue and Broad Street. The station is fed by the Albert Street Reservoir and the 4th Avenue Reservoir, and it can also be supplied by the North Pumping Station. The station is currently used to supplement the North Pumping Station, specifically providing service to the City's downtown during daytime hours when water demands are higher. The Farrell Pumping Station is aging and in need of replacement.

Figure 3-1: Existing Water Supply and Distribution Network illustrates the existing supply and distribution system for the City as described above.

ALBERT STREET RESERVOIR

TOR HILL RESERVOIR

NORTHWEST RESERVOIR
NORTH ZONE PUMP STATION

BPWTP SUPPLY PIPELINES

PASQUA RESERVOIR
NORTH PUMP STATION

REDBEAR RESERVOIRS
REDBEAR PUMP STATION

4th AVENUE RESERVOIR

FARRELL PUMP STATION

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LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE
- EXISTING RESERVOIRS
- REDBEAR PUMP STATION
- NORTH PUMP STATION
- NORTH ZONE PUMP STATION
- FARRELL PUMP STATION
- CITY LOOP
- REDBEAR SUPPLY LINE
- SUPPLY LINES
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

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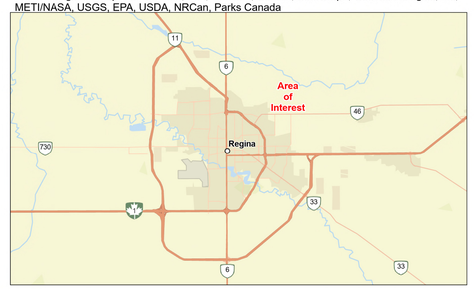
Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
World Navigation Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada



Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

3-1

Title

EXISTING WATER SUPPLY AND DISTRIBUTION NETWORK

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3.2 Growth Scenarios

This section summarizes the growth scenarios for the Serviceability Study as approved by the City during Workshop 1 and 2. The growth scenarios are not population based (i.e., 300,000; 400,000; 500,000). They are based on area of development. This allows the City to strategically plan for areas designated for development based on the land use figure. By aligning development with infrastructure needs, the City can identify when and what type of infrastructure will be necessary to support the proposed development for specific areas.

The growth scenarios include:

- Existing
- Existing with intensification
- Ultimate scenario

The equivalent population implication for the growth scenarios is summarized as follows:

Table 3-1: Growth Scenario and Population

Growth Scenario	Average Daily Demand (ML/d)	Equivalent population
Existing	88	226,000
Existing with Intensification	148	452,000
Ultimate Scenario	260	767,000

3.3 Water System Assessment

This section summarizes the steps taken to assess the water system including:

- Existing system model development, hydraulic analysis, and assessment of the existing distribution system; including Eastern Pressure Solution
- Future system model development, hydraulic analysis of various future scenarios including intensification and greenfield development.

3.3.1 Existing System Scenario Assessment

This scenario considers the City in its existing state, as well as current upgrades taking place such as the Eastern Pressure Solution which will improve the existing system.

3.3.1.1 Model Development

The COR-20170517-WMP-Ext_SystemReview.wtg WaterCAD model was used as the basis for the analysis for the serviceability study. The updates made to the model are listed below:

The WaterCAD model received from the City was updated to reflect the current status of the City. These updates included the following:

- The model was updated to ensure it reflects the existing City status by comparing it to GIS data and all missing watermains added.
- The Eastern Pressure Solution (i.e.. the Redbear Pumping Station) was added as it is considered existing because it is currently under construction with planned completion by 2026.
- Developments with approved concepts, such as the Towns and Eastbrook, were also added to the existing scenario model.

The model was run using reservoirs set at specific Hydraulic Grade Lines (HGL) versus modelling the installed pumps at pump stations. Considering that the horizon of the future planning is many decades into the future, it can be expected that existing pumps would be ready for replacement or will have already been replaced. Utilizing HGL versus pumps is appropriate for future planning assessments such that the existing pump capacity does not limit the distribution system results.

The hydraulic grade line used for each pumping station during the existing system analysis are listed in Table 3-2.

Table 3-2: Hydraulic Grades

Pump Station	Existing	HGL from WMP
North Zone	629.1 m	629.13
North	618.4 m	618.4
Farrell	617.6 m	617.61
Redbear	618.4 m	618.4 & 635 North Zone

3.3.1.2 Existing System Scenarios

The existing system was updated to reflect current conditions within the City and two scenarios were modeled during peak hour and peak day plus fire flow demand. These scenarios include:

- Scenario 1: Existing Distribution System without Redbear Pumping Station
- Scenario 2: Existing Distribution System with Redbear Pump Station Operational

Peak hour demand and peak plus fire flow analysis of these scenarios are summarized in the next sections. The analysis of these areas is summarized below and illustrated in Figure 3-2 and Figure 3-3.

3.3.1.3 Hydraulic Analysis

Scenario 1: Existing System without Redbear Pumping Station

Hydraulic analysis for this scenario considers the existing distribution system of the City with Farrell, North, and North Zone Pumping Station operational and the Redbear Pumping station not operational. This is the current operating condition until Redbear Pump Station construction is complete.

The results from this analysis, as shown in Figure 3-2, illustrate that the eastern region of the City is experiencing deficiencies in distribution pressures during the peak hour analysis. Some areas in the

South and Downtown are experiencing lower distribution pressures which meet pressure criteria but at a lower level of service regarding water pressure.

Scenario 2: Existing System with Redbear Pump Station

Hydraulic analysis for this scenario considered the existing distribution system with the addition of the Redbear Pump Station as part of the Eastern Pressure Solution Project. With the Redbear Pump Station in operation, the peak hour water distribution pressure in the east improves substantially as shown in Figure 3-3.

Peak Hour Analysis Results

The Peak Hour Analysis completed illustrates the pressure results for the model nodes within four different pressure ranges. These ranges are as follows:

1. <269.4 kPa: All nodes with a pressure rating below 269.4 kPa are illustrated as red nodes. These nodes do not meet the minimum pressure requirements and is noted as a deficiency. Water users in these areas will notice lower water pressures.

2. 269.4-280 kPa: All nodes with a pressure rating between 269.4-280 kPa are illustrated as orange nodes. These nodes are nearing the minimum pressure requirements but are still acceptable. Water users in these areas are likely to notice a lower water pressure more frequently.

3. 280.0-344.7 kPa: Nodes with a pressure rating in this range are illustrated in blue. These nodes are at acceptable pressures within the system but considered a lower level of service. Water users in these areas may notice a slightly lower water pressure occasionally.

4. >344.7 kPa: Nodes with a pressure rating exceeding 344.7 Kpa are noted as acceptable. These nodes are not illustrated on the figures.

Table 3-3 summarizes the range of pressures under each of the two scenarios described above. As illustrated in the table, Figure 3-2, and Figure 3-3, the addition of the Redbear Pumping Station dramatically improves the City's distribution pressure in the east and southeast.

Table 3-3: Peak Hour Analysis

Node Pressure kPa (PSI)	<269.4 kPa (<39.1 PSI)	269.4 – 280 kPa (39.1 – 40.6 PSI)	280.0 – 344.7 kPa (40.6 – 50 PSI)	>344.7 kPa (>50 PSI)
Scenario 1: Existing System Without Redbear Pump Station	429	208	1464	2862
Scenario 2: Existing System with Redbear Pump Station	1	1	926	4035

Figure 3-2 and Figure 3-3 illustrate the simulated peak hour pressure results of each of the two scenarios above.

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LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- OFF
- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)
- 596 CONTOUR CONSTRAINT

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Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
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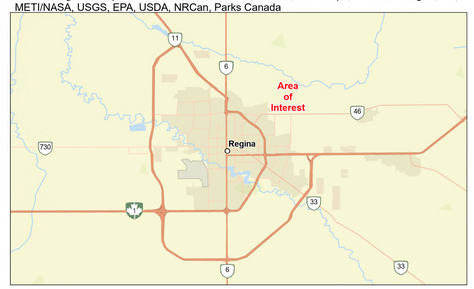

Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

3-2

Title

SCENARIO 1: EXISTING SYSTEM WITHOUT REDBEAR PUMPING STATION

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LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)
- 596 CONTOUR CONSTRAINT

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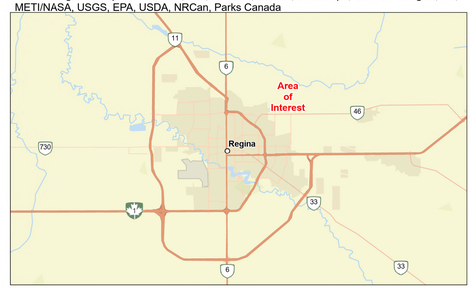

Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

3-3

Title

SCENARIO 2: EXISTING SYSTEM WITH REDBEAR PUMP STATION

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Fire Flow Analysis Results

In the existing system, we've identified several nodes that experience fire flow deficiencies. Although not part of the scope of work to rectify all fire flow deficiencies, suggested water system improvements should reduce the number of overall fire flow deficient nodes. Table 3-4 is a summary of the number of fire flow deficient nodes in two existing system scenarios. As illustrated, the number of deficient nodes is reduced with the addition of the Redbear Pump Station.

Table 3-4: Fire Flow Results

Scenario	Total Nodes	Fire Flow Deficient Nodes
Scenario 1: Existing Water System Without Redbear Pump Station	4963	586
Scenario 2: Existing Water System with Redbear Pump Station	4963	535

3.3.1.4 Summary of Existing Water System Assessment

The existing system analysis illustrates how the City has improved the level of service for the east and southeast with the East Pressure Solution Project. Once the Redbear Pump Station is operational, the level of service to the east will improve dramatically. However, as development in the east continues and water demand in this location increases, pressures will again begin to drop, and the City will require additional improvements to maintain the level of service of the water distribution system.

3.3.2 Existing System Plus Intensification Scenario Assessment

This growth scenario considers the existing City extents with the Redbear Pump Station active with the addition of residential intensification which would require the system to service an increase in population of approximately 226,000 persons. The intensification areas are located as shown in **Figure 2-1**.

It is important to note that intensification may not occur to the extent shown but that servicing should not prohibit growth within proposed intensification areas. The demands used and applied to the model illustrate what upgrades are required for the intensification to take place as per the land use.

It was assumed that the residential intensification within the existing areas will not replace the existing population already residing in those areas but rather adjustments to the equivalent population were applied in the intensification areas to avoid duplication of water demands added to the model.

The expected increase in the ADD (ML/d) and the Equivalent Population increase for each of the planned intensification areas are summarized in Table 3-5.

Table 3-5: Intensification Population and Demands

Area of Intensification	Equivalent Population	ADD (ML/d)
North of Downtown	117,100	10.3
Downtown	167,500	44.4
South of Downtown	38,900	31.1
Adjustment	(97,000)	(26)

Estimated Increase due to Intensification	226,500	59.8

The ADD for the City would increase from 88 ML/d to 148 ML/d with the addition of the residential intensification. As such, the following sections assess if the water distribution infrastructure will require upgrades to manage the increase in demands due to intensification.

3.3.2.1 Model Updates for Intensification

The WaterCAD model developed for the existing system scenario including the Redbear Pumping Station and the East Bypass Loop, was updated to include residential intensification in areas as identified in Figure 2-1. The model updates included the following:

- The intensification areas were added into the model as per Figure 2-1.
- The demands for the medium and high level of intensification were calculated for various areas.
- Existing water demand within intensification areas was retained and the additional demand for the area was added to simulate an increased population and water use within the areas.

3.3.2.2 Intensification Scenarios

As mentioned above, intensification will result in increased water demands downtown, as well as north, south and east of downtown. Below is an assessment of the impact of intensification on the existing system and improvements needed to the existing system to support intensification. A total of five scenarios were run to assess intensification including:

- Hydraulic Analysis of the Existing System with Intensification
  - Scenario 3: Existing System with Intensification
  - Scenario 4: East Bypass Loop Added to Existing System
- Hydraulic Analysis of the Downtown Distribution System with Intensification
  - Scenario 5: No Downtown Pump Station
  - Scenario 6: 4th Avenue Pump Station
  - Scenario 7: Convert Downtown Supply Mains to Trunk Mains

Peak hour demand and fire flow analysis of these scenarios are summarized in the next sections. The analysis of these areas is summarized below and illustrated in Figure 3-4 to Figure 3-8.

3.3.2.3 Hydraulic Analysis of the Existing System with Intensification

Scenario 3: Existing System with Intensification

To identify the impact of intensification on the existing distribution system, a simulation was run using the existing system with Redbear Pump Station in operation under peak hour demands. As illustrated in Figure 3-4, intensification causes a reduction in distribution pressures in the southeast even with the Redbear Pump Station operational.

Scenario 4: East Bypass Loop Solution

Figure 3-5 illustrates peak hour pressure results of adding an east trunk main along the Regina Bypass from the Redbear Pumping Station to Arcola Avenue. The reduction in nodes approaching the pressure criteria identifies that an East Bypass Loop is beneficial in providing improved water distribution to the southeast.

Peak Hour Analysis Results

Table 3-6 summarizes the range of pressures under each of the two scenarios described above. As summarized in the table and illustrated in Figure 3-4 and Figure 3-5, the addition of the East Bypass Loop in addition to the Redbear Pumping Station dramatically improves the City's distribution pressure in the east and southeast.

Table 3-6: Peak Hour Analysis of the Existing System with Intensification

Node Pressure kPa (PSI)	<269.4 kPa (<39.1 PSI)	269.4 – 280 kPa (39.1 – 40.6 PSI)	280.0 – 344.7 kPa (40.6 – 50 PSI)	>344.7 kPa (>50 PSI)
Scenario 3: Existing System with Intensification	74	65	1226	3603
Scenario 4: East Bypass Loop added to Existing System	1	0	205	4767

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LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- INTENSIFICATION AREAS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)
- 596 CONTOUR CONSTRAINT

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Notes

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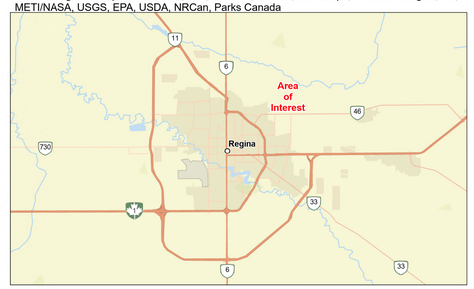

Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

3-4

Title

SCENARIO 3: EXISTING SYSTEM WITH INTENSIFICATION

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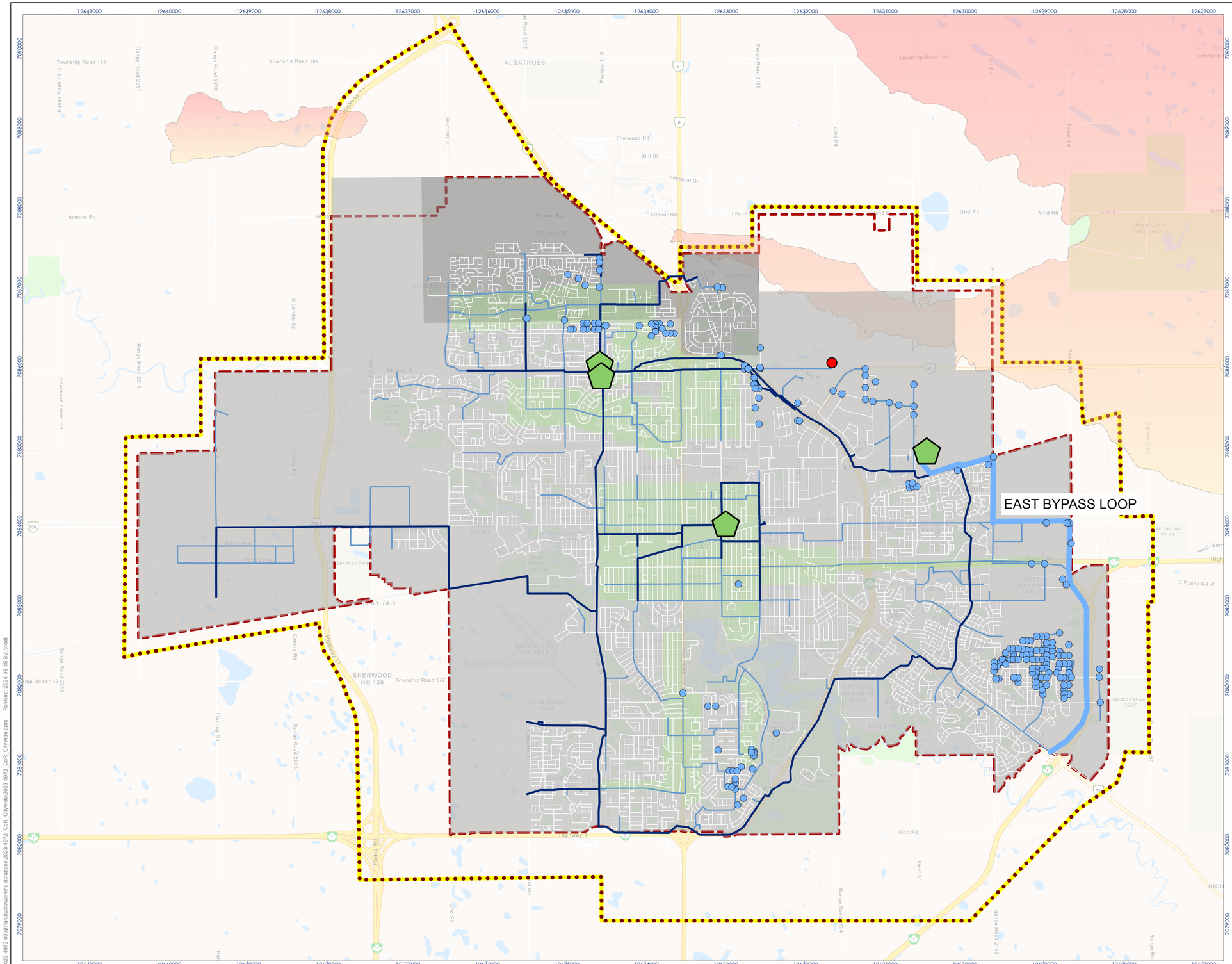

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- INTENSIFICATION AREAS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)
- 596 CONTOUR CONSTRAINT

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Notes

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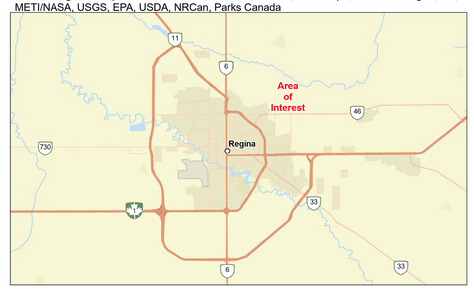

Project Location
Regina.
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

3-5

Title

SCENARIO 4: EAST BYPASS LOOP ADDED TO EXISTING SYSTEM

Q:\2023-4972-00\gis\analysis\working database\2023-4972_CoR_Citywide\2023-4972_CoR_Citywide.aprx Revised: 2024-08-15 By: bnotti

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Fire Flow Analysis Results

Table 3-7 is a summary of the fire flow deficient nodes in each of Scenarios 3 and 4.

Table 3-7: Fire Flow Analysis of the Existing System with Intensification

Scenario	Total Nodes	Fire Flow Deficient Nodes
Scenario 3: Existing System with Intensification	4968	431
Scenario 4: East Bypass Loop added to Existing System	4973	408

Summary of Existing System with Intensification

Based on results in Table 3-6 and Table 3-7, adding the East Bypass Loop improves peak hour pressures and reduces the number of deficient nodes during fire flow analysis. As such, the East Bypass Loop is recommended to proceed in medium term planning to support intensification and continued development in the East.

3.3.2.4 Hydraulic Analysis of the Downtown System with Intensification

The Farrell Pump Station is approaching the end of its operational life and the City has commenced planning for a new pump station near the 4th Avenue Reservoir as a replacement. However, during the Opportunities and Constraints workshop, the City raised concerns that the 4th Avenue Reservoir leaks and requires periodic repairs. Given the status of the reservoir and the current construction of Redbear Pump Station, the City raised the question if there is a need for a downtown pump station. The following sections analyzes the need for a downtown pump station.

Scenario 5: No Downtown Pump Station

To assess the need for a downtown pump station, a peak hour simulation was run using the existing system with the Redbear Pump Station operational and the East Bypass Loop in place with Farrell abandoned. The analysis illustrated in Figure 3-6 indicates a significant reduction in pressures downtown, south of downtown, and east of downtown, even with the Redbear Pump Station operational and the East Bypass Loop in place. As such, it appears a downtown pressure solution is needed to accommodate intensification.

Scenario 6: 4th Avenue Pump Station

The first downtown solution considered the system with Redbear Pump Station and the East Bypass Loop in place and with a 4th Avenue Pump Station added along with new trunk mains down Winnipeg Street, 4th Avenue, and Broad Street connecting to existing trunk mains near the abandoned Farrell Pump Station. Under this scenario, the 4th Avenue Reservoir, Tor Hill Reservoir, and the Albert Street Reservoir would be maintained and would provide supply to the new 4th Avenue Pump Station.

The analysis illustrated in Figure 3-7 indicates a significant improvement in pressures downtown, south of downtown, and east of downtown. As such, it appears a downtown pump station is a potential solution to accommodate intensification.

Scenario 7: Convert Downtown Supply Mains to Trunk Mains

An alternate downtown solution considered improvements needed without a downtown pump station. If there is no downtown pump station, the 4th Avenue Reservoir and the supply pipelines from Albert Street Reservoir and Tor Hill Reservoir are no longer required to transfer water from the two reservoirs to a downtown pump station. This scenario considered repurposing the existing Tor Hill supply pipeline for water distribution by connecting it to the RedBear Pumping Station to provide additional pressure downtown. In similar fashion, the Albert Street supply pipeline could be repurposed for distribution and connected to the City Loop to provide additional water distribution pressure downtown.

The downside of this scenario would be that the 4th Avenue Reservoir would become abandoned, and that storage volume would need to be replaced at Redbear Reservoirs or elsewhere. The Albert Street and Tor Hill Reservoirs would no longer supply a downtown pump station and to maintain their use, minor supply pipeline modifications are needed to redirect stored water from these reservoirs to the North Pump Station and Redbear Pump Station respectively.

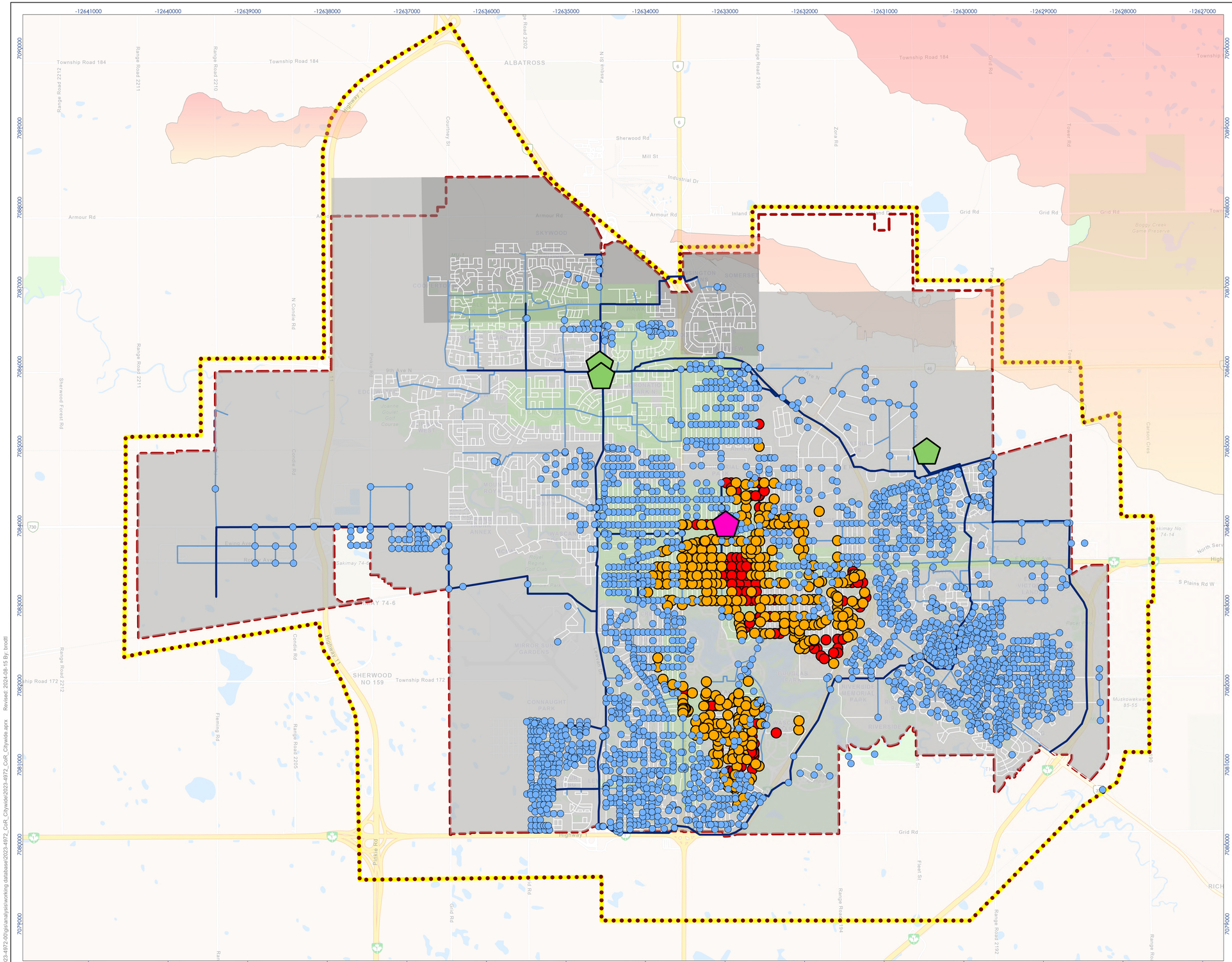
The analysis illustrated in Figure 3-8 indicates that this scenario provides improvement to the downtown pressure similar to a downtown pump station and may be an option to accommodate intensification if the City prefers to eliminate a downtown pumping station.

Peak Hour Analysis Results

Table 3-8 summarizes the range of pressures under each of the three scenarios described above. As illustrated in the table, Figure 3-6, Figure 3-7, and Figure 3-8, a downtown pressure solution is required and that solution could be a 4th Avenue Pump Station or the repurposing of the Tor Hill supply and Albert Street supply pipelines to provide distribution pressure from RedBear Pump Station and the City loop.

Table 3-8: Peak Hour Analysis of Downtown Solution

Node Pressure kPa (PSI)	<269.4 kPa (<39.1 PSI)	269.4 – 280 kPa (39.1 – 40.6 PSI)	280.0 – 344.7 kPa (40.6 – 50 PSI)	>344.7 kPa (>50 PSI)
Scenario 5: No Downtown Pump Station	96	372	2302	2202
Scenario 6: New Downtown Pump Station at 4th Avenue	1	0	158	4813
Scenario 7: Convert Downtown Supply Mains to Trunk Mains	1	0	664	4308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Township Road 184
Range Road 2212
Range Road 2211
Range Road 2210
Range Road 2202
ALBATROSS
Highway 11
Courtney St
N Simpson
Range Road 2195
Zora Rd
Tower Rd
Grid Rd
Sherwood Rd
Mill St
Industrial Dr
Armour Rd
Inland Dr
SKYWOOD
N Corville Rd
Parker Rd
9th Ave N
Joanne Cowell Golf Course
Sherwood Forest Rd
Range Road 2211
Township Road 184
Boggy Creek Game Preserve
Clarson Cres
Ewing Ave
Range Road 2211
Saskimay 74-6
Saskimay No. 74-14
North Service Rd
Highway 11
S Plains Rd W
MIRROR SUN GARDENS
SHERWOOD NO 159
Township Road 172
Range Road 2212
Fleming Rd
Range Road 2205
CONNAUGHT PARK
RIVERSIDE MEMORIAL PARK
Muskowekwan 85-55
Fleet St
Range Road 2192
Range Road 184
Pinkie Rd
Grid Rd
RICH
Range Road 2190
Range Road 2184
Range Road 2183
Range Road 2182
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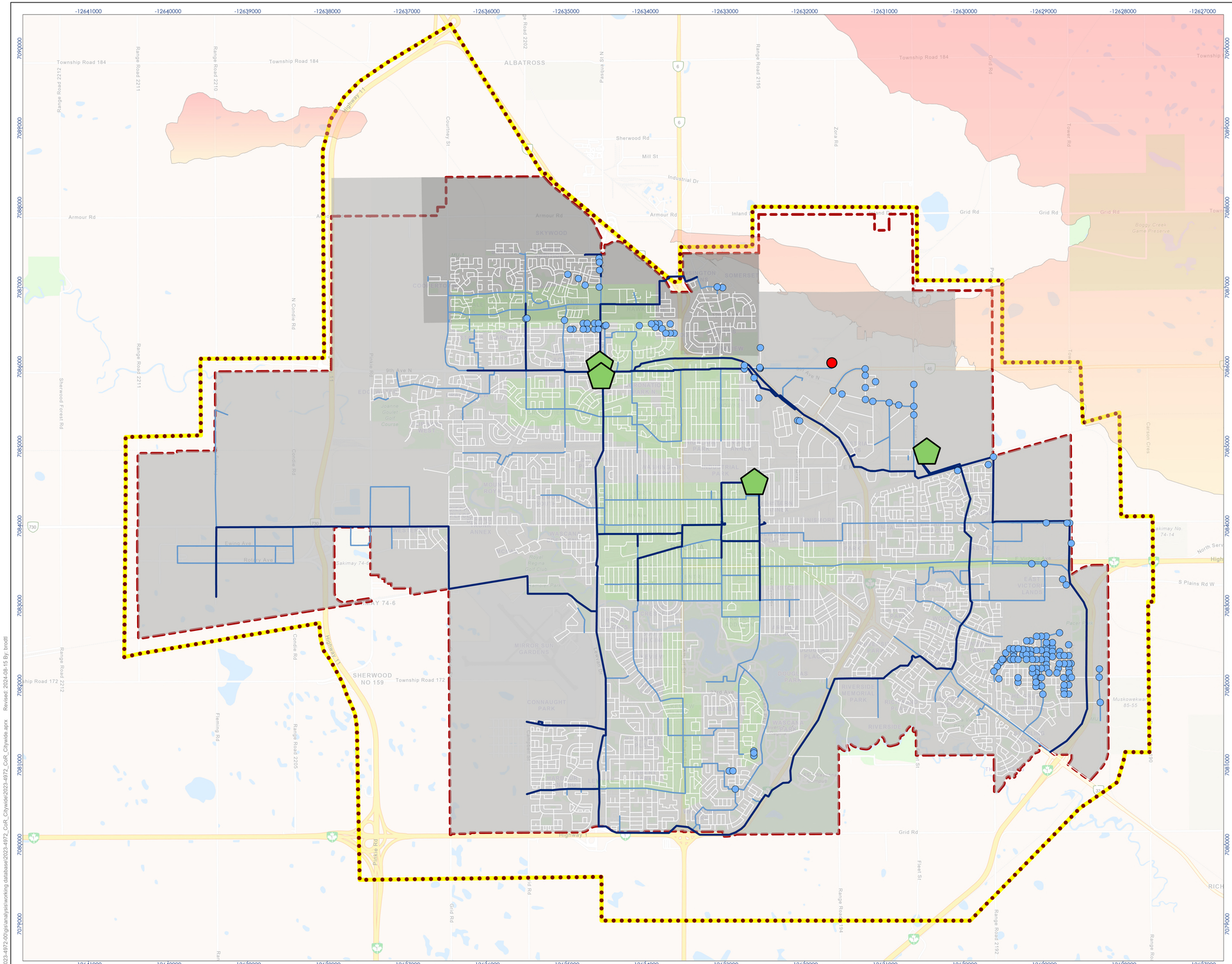

LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- INTENSIFICATION AREAS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)
- 596 CONTOUR CONSTRAINT

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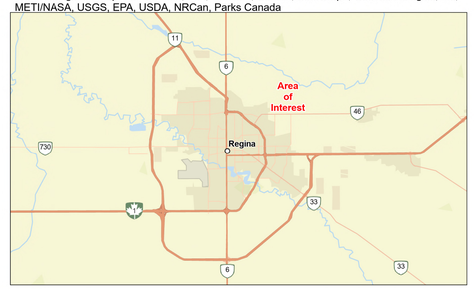

Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

3-7

Title

SCENARIO 6: NEW DOWNTOWN PUMP STATION AT 4TH AVENUE

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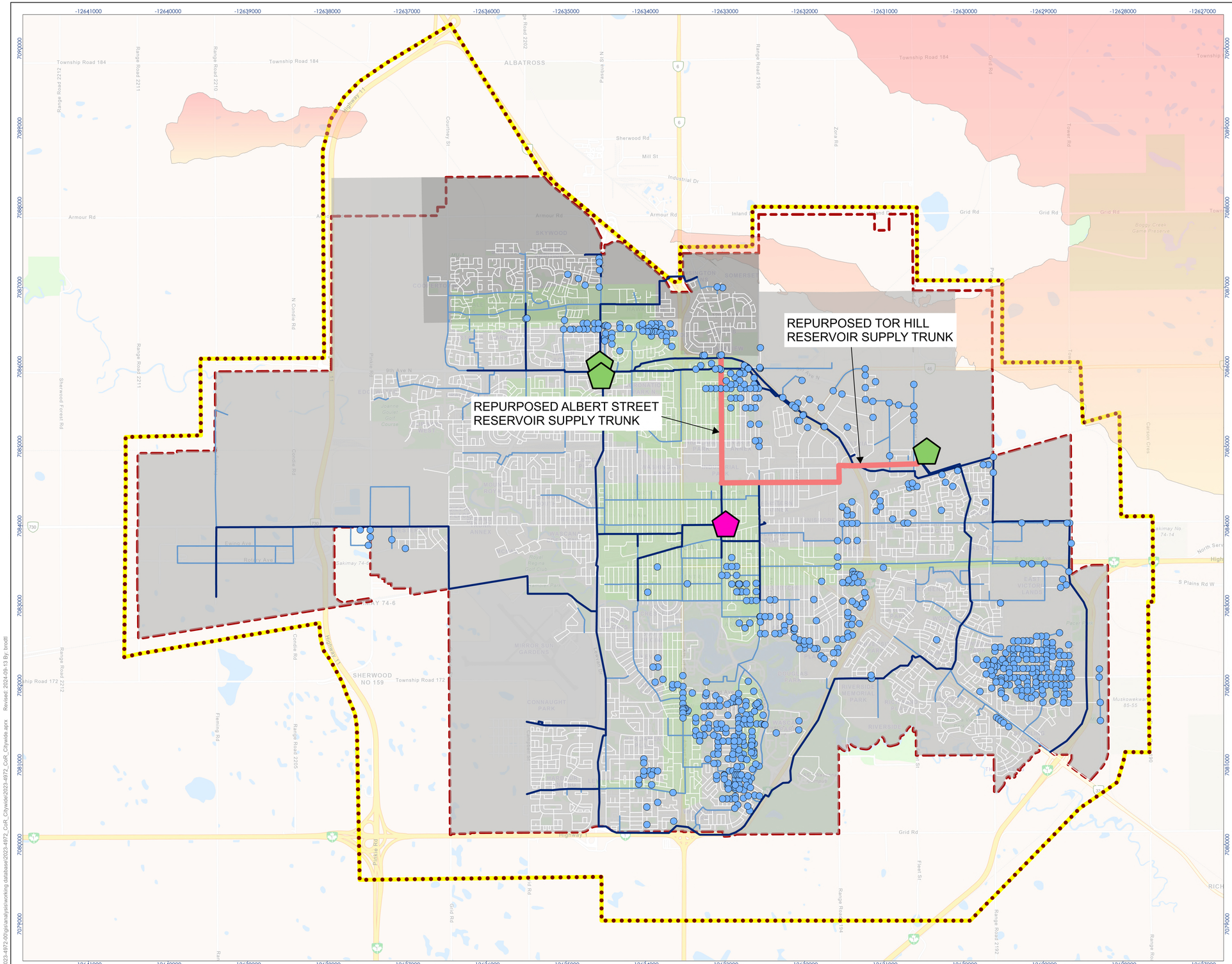

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- INTENSIFICATION AREAS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- OFF
- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)
- 596 CONTOUR CONSTRAINT

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Notes

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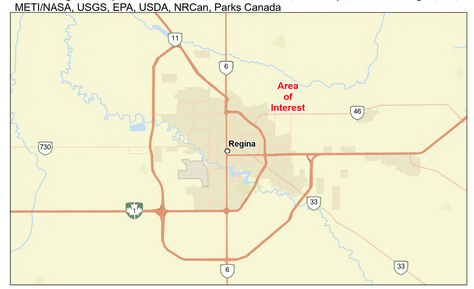

Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

3-8

Title

SCENARIO 7: CONVERT DOWNTOWN SUPPLY LINES TO TRUNK MAINS

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Fire Flow Analysis Results

Table 3-9 is a summary of the fire flow deficient nodes in each of the three downtown scenarios considered. As illustrated, the number of deficient nodes is reduced when the downtown is serviced by the 4th Avenue Pump Station or the conversion of supply mains to trunk mains.

Table 3-9: Fire flow Analysis of Downtown Solution

Scenario	Total Nodes	Fire Flow Deficient Nodes
Scenario 5: No Downtown Pump Station	4972	454
Scenario 6: New Downtown Pump Station at 4th Avenue	4972	396
Scenario 7: Convert Downtown Supply Mains to Trunk Mains	4973	408

Summary of Downtown System with Intensification

Based on peak hour and fire flow results in Table 3-8 and Table 3-9, it is evident that a Downtown Solution is required to accommodate intensification. Both Scenarios 6: Downtown Pump Station at 4th Avenue and Scenario 7: Convert Downtown Supply Mains to Trunk Mains, improve system pressure and fire flow results. The scenario recommended may require further technical and financial analysis to identify the most suitable solution for the City.

A 4th Avenue Pump Station as simulated in Scenario 6 would include relatively minimal changes to the supply and distribution system as the majority of the supply trunks are already near the 4th Avenue Reservoir. The Albert Street and Tor Hill Reservoirs could still supply the new 4th Avenue Pump Station. If the 4th Avenue Reservoir is deemed unrepairable, the reservoir could be replaced with a smaller underground reservoir with the pump station directly on top of the reservoir reducing the need for additional trunks between the 4th Avenue Reservoir and Pump Station. Scenario 6 appears to be the best suited solution based on the high-level analysis that has been completed.

If Scenario 7 is selected as the preferred solution, and a downtown pump station is eliminated from the distribution system, the City should be aware the 4th Avenue Reservoir volume is then unusable and the volume of storage would need to be replaced elsewhere. To maintain the use of the Albert Street and Tor Hill Reservoirs, their supply lines and stored water volume would need to be redirected to the North Pump Station and Redbear Pump Station respectively. Once the supply lines have been redirected to the North Pump Station and Redbear Pump Station, the supply to downtown could be repurposed, replaced, or rehabilitated to serve as a distribution trunk to downtown.

Internal Pipe Network Upgrades

The hydraulic analysis conducted to determine if the residential intensification can take place with strategic upsizing or upgrades to existing pipeline identified that the upsizing of the cast iron mains on Winnipeg Street and Saskatchewan Drive is crucial for the downtown supply. The analysis indicated that the water demand for the residential intensification can take place with strategically planned upgrades dependent on the size and location of the intensification.

3.3.3 Ultimate Scenario Assessment

The ultimate scenario includes the intensification areas within the City as well as the proposed greenfield development (residential, commercial, and industrial development) around the City as shown in Figure 2-1. The future land use will see the addition of approximately 12,000 hectares of mixed development to the City and translates to an equivalent population of approximately 479,000 persons.

The ultimate scenario considers including upgrades required to maintain a level of service for approximately 766,000 persons for the total project area.

The populations and water demand for the ultimate scenario are tabulated in Table 3-10 below:

Table 3-10: Ultimate Scenario Population and Demand

Land Use Type	Area (Ha)	Equivalent Residential Population	Average Day Demand (ML/d)
Existing		226,000*	88
Residential	6,277	314,000	83
Commercial	675	40,000	7
Industrial	4,991	125,000	21
Intensification – Medium	1,591	103,000	27
Intensification – High	936	220,000	58
Adjustment		(97,000)**	26
Total	**14,470**	**767,000**	**260**

* 2021 Census data

** The intensification within the existing areas will not replace the existing population already residing in those areas. The existing demands require adjustment to reduce duplication of the demands.

The future ADD of 260 ML/d is estimated to be approximately three times the existing ADD of 88 ML/d. This significant increase in water demand will require that the distribution system be upgraded to manage the future needs.

3.3.3.1 Model Updates for the Ultimate Scenario

The WaterCAD model, which was updated to reflect the existing conditions as well as the intensification as described in the previous section, was further updated to accommodate the proposed ultimate scenario. For the ultimate scenario we maintained the use of the 4th Avenue Pump Station for downtown service. If a downtown pump station is not pursued and existing supply mains are converted to trunk mains for downtown service, results will remain similar.

The updates to the WaterCAD model included the following:

- Greenfield development was added to the model in quarter sections to simplify the analysis of the proposed development. The future demand nodes were connected to the existing model by extending pipe from the existing model to connect to the future demands.

- The model was skeletonized by adding only 300 mm diameter pipes and larger into the model.
- A new west pumping station was included into the model, with two hydraulic grade lines or two pumping systems, a lower pressure for the Primary Pressure Zone as well as a higher pressure for distribution to the North Pressure Zone, simulating dedicated pumps for each zone.
- Similarly, the Redbear Pump Station has been designed with the ability to provide two distribution pressures, a lower pressure to the Primary Pressure Zone and a slightly higher pressure to the North Pressure Zone. We have equipped the Redbear Pump Station with the same ability to provide a lower pumping pressure to the primary pressure and a higher pressure to the North Pressure Zone.

  The North Pressure Zone was extended east and south, stopping north of Victoria Avenue and Highway No. 1.

3.3.3.2 Ultimate Scenarios

The ultimate scenario assessment considers the greenfield development areas around the City and will be development driven. Development of this magnitude will take many decades. Until development in the greenfield area begins to increase, the City's distribution system could likely provide adequate service utilizing the North Pump Station, Redbear Pump Station, and 4th Avenue Pump Station for the Primary Pressure Zone and the North Zone Pumping Station for the North Pressure Zone.

At some point in the future when greenfield development continues, an increase in water demands will result in the need for additional water storage. At that time, it is recommended that the City consider placing water storage reservoirs in the City's west near 9th Avenue N and the Regina Bypass in close proximity to the existing Buffalo Pound Supply System and the boundary of the North Pressure Zone and Primary Pressure Zone. With construction of reservoirs in the West, a pump station should also be constructed adjacent to the reservoirs with two pumping systems, one for the Primary Pressure Zone and one for the North Pressure Zone.

Placing the future Pump Station and Reservoirs west of the City, adjacent open space will provide the City with flexibility in sizing and staging. Comparatively, there is limited space at the North Pump Station as well as the North Zone Pump Station to add future reservoir storage.

With the development of the Redbear Pumping Station in the East and the proposed pumping facility in the West, the ultimate scenario proposes a Bypass Loop from the East Bypass Loop that was proposed near the onset of intensification and continuing to circle the City along the south portion and west portion of the Bypass connecting to the West Pump Station. The Bypass Loop would be interconnected to the existing distribution system and City Loop where appropriate to provide a strong interconnected distribution network sized suitably to accommodate the growth identified in this study.

Until such time that the West Reservoirs and Pump Station are constructed, the North Pump Station would continue to serve as the primary pump station. As development proceeds in the west, it will be necessary to begin construction of the Bypass Loop as well as a trunk main from the North Pump Station, west along 9th Avenue N to the Bypass Loop. Then once the West Reservoir and Pump Station is

constructed, the North Pump Station could be repurposed as a transfer facility for the sole purpose of pumping to the Albert, Redbear, and 4th Avenue Reservoirs.

Based on the above ultimate system, two ultimate scenarios were simulated to confirm the peak hour pressure and fire flow results are acceptable. The two ultimate scenarios considered are:

- Scenario 8: Ultimate Scenario with the North Pump Station
- Scenario 9: Ultimate Scenario with West Pump Station in lieu of the North Pump Station

3.3.3.3 Hydraulic Analysis for the Ultimate Scenario

The hydraulic analysis conducted for the ultimate scenario considered the upgrades required to efficiently distribute water to all proposed development areas shown on the land use figure. The two scenarios are summarized below:

Scenario 8: Ultimate Scenario with the North Pump Station

Although the ultimate distribution system will include West Reservoirs and a West Pump Station to service greenfield development in the west; until such time, the North Pump Station has sufficient capacity to service growth in the west portion of the Primary Pressure Zone. The North Zone Pump Station would need to accommodate west growth in the North Pressure Zone. Scenario 8 should be considered an interim solution to the ultimate system until the West Reservoir and Pump Station is developed.

This scenario assumes that the Bypass Loop is complete, Redbear Pump Station has been upgraded to include a pumping system for the North Pressure Zone, and the North Pressure Zone has been extended southeast past Victoria Avenue.

Scenario 9: Ultimate Scenario with West Pump Station in lieu of the North Pump Station

Scenario 9 is very similar to Scenario 8 except for the inclusion of a West Pump Station in place of the North Pump Station. It is assumed the West Pump Station would have the ability to pump to the Primary Pressure Zone and the North Pressure Zone. As such, this scenario has the West, Redbear, and 4th Avenue Pump Station servicing the Primary Pressure Zone and the West, North Zone, and Redbear Pump Stations servicing the North Pressure Zones.

Similar to Scenario 8, this scenario assumes the Bypass Loop is complete and the North Pressure Zone has been extended southeast past Victoria Avenue.

The North Pump Station will continue to operate for several decades until such time the City requires additional reservoir storage at which point the West Reservoir(s) and Pump Station should be considered.

Peak Hour Analysis Results

Peak hour analysis for Scenario 8 was completed and is included as Figure 3-9. The figure indicates the pressure criteria is satisfied in the Primary Pressure Zone but pressures are approaching a lower level of

service in the east and south as indicated by the blue nodes. The North Pressure Zone, however, appears to have some deficient pressure in the higher elevation of the northwest.

Peak hour analysis for Scenario 9 was completed and is included as Figure 3-10. The figure indicates the pressure criteria is satisfied in the Primary Pressure Zone but pressures are approaching a lower level of service in the east and south but also somewhat in the north portion of the Primary Pressure Zone. The deficient pressure nodes in the northwest portion of the North Pressure Zone in Scenario 8 are no longer deficient with the addition of the West Pumping Station assisting the North Zone and Redbear Pump Station for servicing of the North Pressure Zone.

Table 3-11 summarizes the range of pressures under Scenario 8 and 9 as described above. As illustrated in Table 3-11, Figure 3-9, and Figure 3-10: Scenario 9 – Ultimate Scenario with West Pump Station Active

, both scenarios are capable of providing adequate water service. Scenario 9 with the incorporation of the West Pump Station provides better pressure results than Scenario 8 with the North Pump Station, but Scenario 8 would be capable of providing adequate water service until such time the West Reservoir and Pump Station are required and constructed.

Table 3-11: Peak Hour Analysis of the Ultimate Scenarios

Node Pressure kPa (PSI)	Pressure Zone	<269.4 kPa (<39.1 PSI)	269.4 – 280 kPa (39.1 – 40.6 PSI)	280.0 – 344.7 kPa (40.6 – 50 PSI)	>344.7 kPa (>50 PSI)
Scenario 8: Ultimate Scenario with North Pump Station	Primary	1	0	1111	3325
	North	18	5	397	315
Scenario 9: Ultimate Scenario with West Pump Station in lieu of North Pump Station	Primary	1	0	868	3568
	North	2	0	19	715

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LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- OFF
- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

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Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
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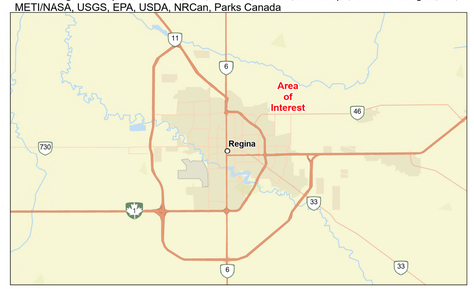
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
World Navigation Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada



Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.
3-9

Title

SCENARIO 8: ULTIMATE NETWORK WITH NORTH STATION ACTIVE

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STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

- PROJECT BOUNDARY
- CITY LIMITS
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE

PEAK HOUR PRESSURE kPa (PSI)

- LESS THAN 269.4 (39.1)
- 269.4 - 280.0 (39.1 - 40.6)
- 280.0 - 344.7 (40.6 - 50)
- GREATER THAN 344.7 (50)

PUMP STATION STATUS

- OFF
- ON

- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

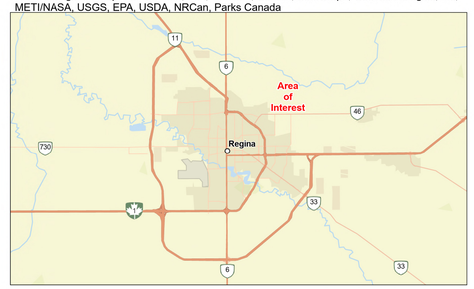
N

0 925 1,850 metres

(At original document size of 22x34)
1:34,960,006

Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
   World Navigation Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada



Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.
3-10

Title

SCENARIO 9: ULTIMATE SCENARIO WITH WEST PUMP STATION ACTIVE

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3.3.3.4 Fire Flow Analysis Results for the Ultimate Scenario

Table 3-12 is a summary of the fire flow deficient nodes in Scenarios 8 and 9. Similar to the peak hour analysis, fire flow analysis results illustrate that Scenario 9 provides marginally improved fire flow over Scenario 8.

Table 3-12: Fire Flow Analysis of Ultimate Scenario

Scenario	Pressure Zone	Total Nodes	Fire Flow Deficient Nodes
Scenario 8: Ultimate Scenario with North Pump Station	Primary	4437	354
	North	735	49
Scenario 9: Ultimate with West Pump Station in lieu of North Pump Station	Primary	4437	358
	North	736	37

3.3.3.5 Summary of the Ultimate Scenario Assessment

Summary of the ultimate scenario assessment indicates that Scenario 8 is adequate to serve as an interim solution while greenfield development occurs and until such time when additional reservoir storage is needed, and the West Reservoir and Pump Station are constructed as defined in Scenario 9.

The infrastructure required for the ultimate scenario to function is significant and will require fiscal planning and will take several decades to complete.

3.3.4 Assessment of Reservoir Capacity and Pumping Capacity

3.3.4.1 Additional Reservoir Storage Requirements

The Water Supply Authority standard for reservoir storage recommends maintaining a minimum storage capacity equivalent to twice the ADD. This ensures sufficient water availability even during peak consumption periods.

The city has several water supply reservoirs strategically placed to provide water to users. These reservoir capacities are listed in Table 3-12:

Table 3-13: Existing Reservoir Storage Capacity

Reservoir Name	Storage Size (ML)	Usable Storage (ML)
Northwest Storage	45.4	38.2
Pasqua	22.7	20.1
Albert street	45.4	43.9
4th Avenue	45.4	36.5
Torr Hill	22.7	21.6
Red Bear 1*	42.5	42.5
Red Bear 2*	42.5	42.5
Total	**266.6**	**245.3**

*Reservoirs currently under construction

The storage capacity in Table 3-13 is sufficient to serve approximately 311,500 individuals with a minimum of two days' worth of storage.

As part of the Eastern Pressure Solution, three additional reservoirs with a capacity of 50 ML each will be constructed at a later stage at the Red Bear pump station. This additional reservoir capacity increases the serviceability of the city from 311,000 persons to approximately 506,000 people.

In the Ultimate Scenario, the City will account for approximately 766,000 persons and would require a combined reservoir storage capacity of 527 ML to cater for the water demands of the City.

Planning for additional reservoir storage will be required prior to the City reaching the 500,000-population mark. The additional reservoir storage capacity can be constructed at the West Pump Station.

3.3.4.2 Pump Station Hydraulic Grades and Capacities

The City currently operates four pump stations and at the Ultimate Scenario there will be four pump stations with the addition of the West Pump Station. The West pump station is suggested for the Ultimate Scenario which will supply the Primary Pressure Zone as well as improve deficiencies in the North Pressure Zone. These stations operate at different hydraulic grades and capacities. These are summarized in Table 3-14.

Table 3-14: Pumping Hydraulic Grades and Capacities

Pump Station	Existing System			Existing Plus Intensification		Ultimate Scenario	
	HGL (M)	HGL from WMP	Pumping Capacity (ML/d)	HGL (M)	Pumping Capacity (ML/d)	HGL (M)	Pumping Capacity (ML/d)
North Zone Pump Station	629.1	629.13	35	629.13	35	630	35
North Pump Station	618.4	618.4	333	621	333	Decommissioned to transfer station	
Redbear Pump Station – Primary Zone	618.4	618.4	169	621	169	621	220
Redbear Pump Station – North Zone	N/A	635	N/A	632	44	632	50
Farrell Pump Station	617.6	617.6	118	Decommissioned and replaced by 4th Avenue Pump Station			
4th Avenue Pump Station	N/A		N/A	619	150	619	150
West Pump Station	N/A		N/A	N/A	N/A	621	310

The above table illustrates the progression in upgrades required to the City's pumping system for it to maintain the acceptable level of service of supply.

The Redbear Pump Station will require additional pumping upgrades to increase its capacity from 169 ML/d to 220 ML/d of supply to the Primary Pressure Zone whilst its capacity to the North Pressure Zone will be increased from 44 ML/d to 50 ML/d.

The Farrell Pump Station will be taken out of operation in the short-term considering it is at its end of operational life whilst the proposed new 4th Avenue Pump Station will be in operation from the existing with intensification scenario.

4 Wastewater Collection System

The following sections assess the serviceability of the City's wastewater collection system to sustain the growth identified in the Serviceability Study. Specifically, the sections outline the existing system operations, provide a summary of the system assessment, outline the established growth scenarios and system response, and discuss various servicing options, covering aspects such as sizing and routing.

Three growth scenarios are evaluated:

1. The existing system,
2. The existing system with the addition of residential intensification, and
3. The Ultimate Scenario which includes the existing system, adds intensification, and adds planned greenfield development.

4.1 Existing System Operation

Regina's topography is generally sloped from northeast to southwest with elevations varying from 595.0 m to 570.0 m. Wascana Creek roughly bisects the City and flows from southeast to northwest. The existing wastewater treatment plant (WWTP) is located to the west of the City. The wastewater collection system of the entire City drains to several major trunks, named Rochdale, Northwest, McCarthy, 7th Avenue, 15th Avenue, Wascana, and South Trunk, as shown in Figure 4-2. These major trunks convey sewage to McCarthy Boulevard Pump Station (MBPS) which pumps sewage to the WWTP through three 4.0 km long force mains. The MBPS handles sewage from the majority of the City, except for flows from the GTH and Westerra, areas located west of the City, which directly discharge to the forcemains of the MBPS via two local lift stations.

Given its relatively flat topography, the City commonly relies on lift stations to convey sewage from neighborhood sewer networks to nearby trunks. Several notable pump stations (PS) are the Creeks, Harbour Landing, Westerra, GTH, Glencairn, and Maple Ridge pump stations amongst others shown in Figure 4-2.

4.2 Wastewater System Assessment

This section summarizes the steps taken to assess the wastewater system including:

- Existing system model development, hydraulic analysis, and assessment of the existing collection system; including South Trunk and Creeks PS upgrades.
- Future system model development, hydraulic analysis of various future scenarios including intensification and greenfield development.

4.2.1 Model Development

Stone & Arrow updated the InfoWorks ICM model (North_Study_Wastewater_Final 20230330.icmt Version 10) with the following recently issued drawings:

- The south trunk twinning was added to the model using preliminary drawings issued in May 2023 (AECOM, 2023). This proposed trunk system will run parallel to the existing South Trunk system and will be connected to the existing south trunk system at two locations. The proposed system will be extended to the Lakeview neighborhood where it will be connected to the exiting sewer system at about ten locations. These upgrades included south trunk from MBPS to Regina Avenue and Lakeview neighborhood upgrades. This did not include Harbour Landing Pump Station Forcemain extension. The extension of upgrades added to the model are shown in Figure 4-2.
- The Creeks Pump Station was upgraded using record drawings (AE, 2020). Three additional pumps were added to the system having capacity identical to the existing pump. No change to the real time control (RTC) system as set in the ICM model was done to this pump station.

After reviewing the existing wastewater model obtained from the City, it was observed that the model incorporates the following recent upgrades:

- Recently constructed 10,606 m^3 of storage at Creeks PS (AE, 2020) was captured in the model. In addition, the forcemain of these PS was found twinned.
- Recent upgrades to the MBPS (AE, 2021) captured in the model with having 5 pumps in the primary pump station and two pumps in the secondary station. It was observed in the ICM model that MBPS including secondary station can convey about is about 650 ML/day (or 7.50 m^3/sec).
- The GTH pump station was incorporated into the model at the location shown in Services Agreement between the City and GTH Authority.

4.2.2 Existing System Scenario Assessment

Existing system deficiencies are tabulated in

Table 4-1 and shown in Figure 4-3 and Figure 4-4 for DWF and WWF, respectively. The deficiencies were assessed based on the computed depths of the hydraulic grade line (HGL) at every manhole throughout the City. Nodes are grouped into three categories based on the computed depths of the HGL at that node:

1. Flooding Nodes
    - HGL above ground
    - When the HGL at a manhole is above the rim elevation, it represents street flooding
    - Shown in red on figures

2. Surcharging Nodes

    - HGL < 1.83 m below surface
    - When the HGL at a manhole is less than 1.83 m (6 ft) deep below the rim elevation, it poses a risk of basement flooding near that location given the typical depth of basements
    - Shown in yellow on figures

3. Acceptable Nodes

    - HGL > 1.83 m below surface
    - Manholes with HGLs deeper than 1.83 m are considered acceptable
    - Not shown on the figures

The system deficiencies were also quantified by assessing the total flood volumes that escaped the model during the design events, either from manholes or from system outfalls representing direct releases to the environment. The final deficiency assessment criterion was the peak flow rate in the conduit immediately upstream of the MBPS, the most crucial conveyance bottleneck in the City's wastewater collection system.

The node counts for each category, flooding volumes and peak flows at MBPS are shown in Table 4-1 for quantitative comparison of system performance in different scenarios. The computational nodes on force mains are excluded from these counts because the HGL on an active force main is necessarily high but does not represent surcharging or flooding at those locations. Note that

Table 4-1 also includes other scenarios and alternatives which are discussed in the following sections of the report.

No flooded nodes were observed during the DWF scenario. Although HGLs were found less than 1.83 m deep in 140 nodes, 113 of these nodes were found to be associated with pipes with inverts less than 1.83 m deep. Therefore, the sanitary sewer system has sufficient capacity for DWF under existing conditions in most areas within the City.

For WWF, a substantial number of surcharging and flooding nodes were observed. These deficiencies were caused by a combination of several factors such as inadequate capacity of local pump stations, undersized local sewers, or undersized trunks. Capacity deficiencies were observed at downstream reaches of the 7th Avenue and South Trunk systems and at upstream reaches of the McCarthy Trunk system. The other trunks were found having sufficient capacity.

The peak flow rates at a conduit (GIS ID 19995) immediately upstream of the MBPS are presented in Table 4-1 and the full hydrographs are shown in Figure 4-1 for all scenarios. The computed flow rates are 1.12 m^3/s and 6.90 m^3/s, respectively, for DWF and WWF scenarios, for existing conditions. This indicates that the MBPS has capacity for the peak WWF under existing conditions when all seven pumps are running.

It is important to note that the flooded nodes attenuate peak flow rates as sewage comes out from the system and comes back when the node is no longer flooded. In reality, the sewage from flooded nodes

may be intercepted by the nearby catch basins, reducing the peak flow rate to the sanitary system. However, this transfer of flows from the wastewater collection system to the storm system is not captured in the model. All wastewater is assumed to flow back in through the flooded nodes unless the node is specifically identified as an outfall.

Table 4-1 Performance Assessment of Upgrades Scenarios

Scenarios	Flooding Nodes	Surcharging Nodes	Acceptable Nodes	Total Flood Volumes (m^3)	Peak Flow at MBPS (m^3/s)
Existing Condition – DWF	0	140	13,266	0	1.12
Existing Condition – WWF	229	869	12,308	5,107	6.90
Existing plus Intensification without Upgrades – DWF	0	146	13,260	0	2.39
Existing plus Intensification without Upgrades – WWF	281	1,205	11,920	6,360	7.17
Ultimate without Upgrades – DWF	8	172	13,226	1,185	2.76
Ultimate without Upgrades – WWF	367	1,601	11,438	22,448	7.0
Ultimate with Upgrades Option 1 – DWF	0	144	13,262	0	3.07
Ultimate with Upgrades Option 1 – WWF	224	816	12,366	5,288	7.0
Ultimate with Upgrades Option 2 – DWF	0	144	13,262	0	3.02
Ultimate with Upgrades Option 2 – WWF	185	750	12,471	4,049	7.0
Ultimate with Storage Tunnel along Railway Corridor – DWF	8	172	13,226	1,185	2.8
Ultimate with Storage Tunnel along Railway Corridor – WWF	313	1,156	11,937	20,343	6.84

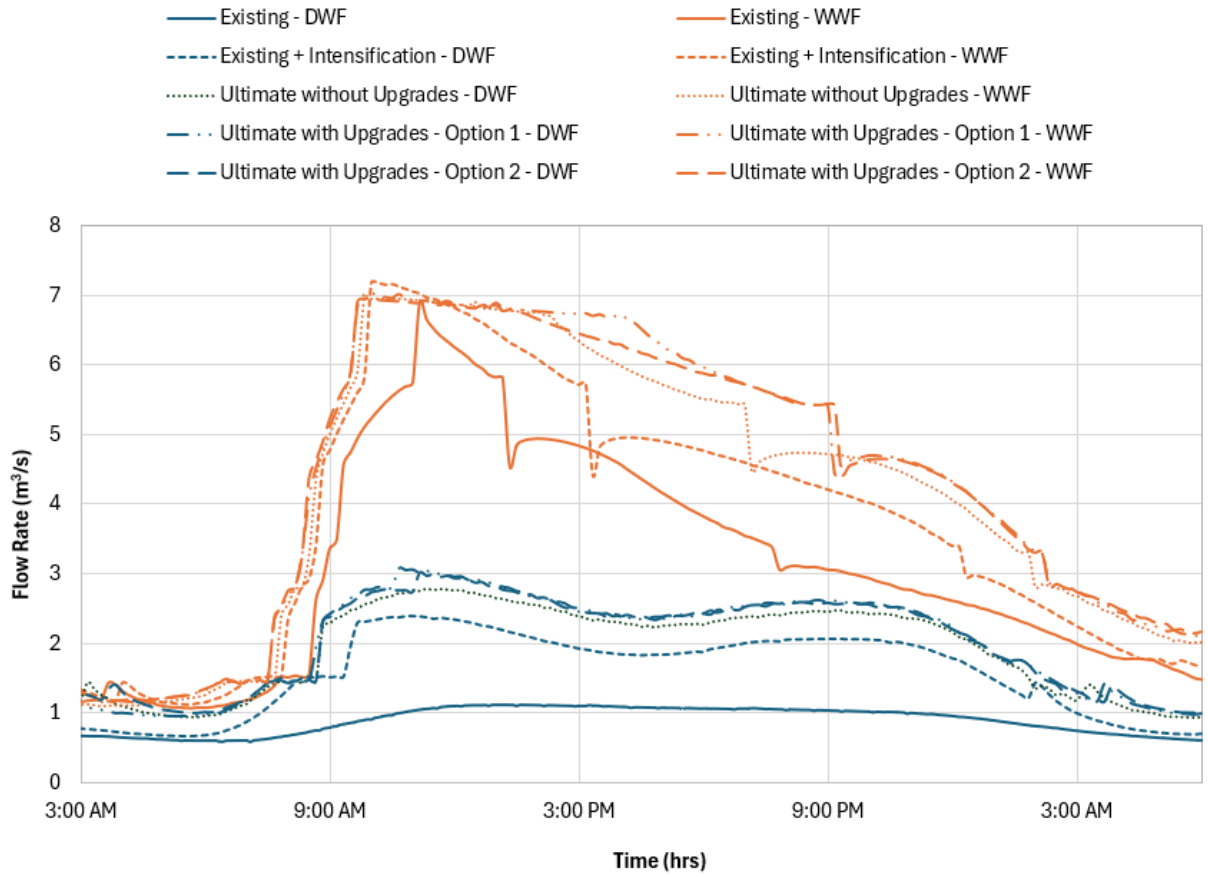
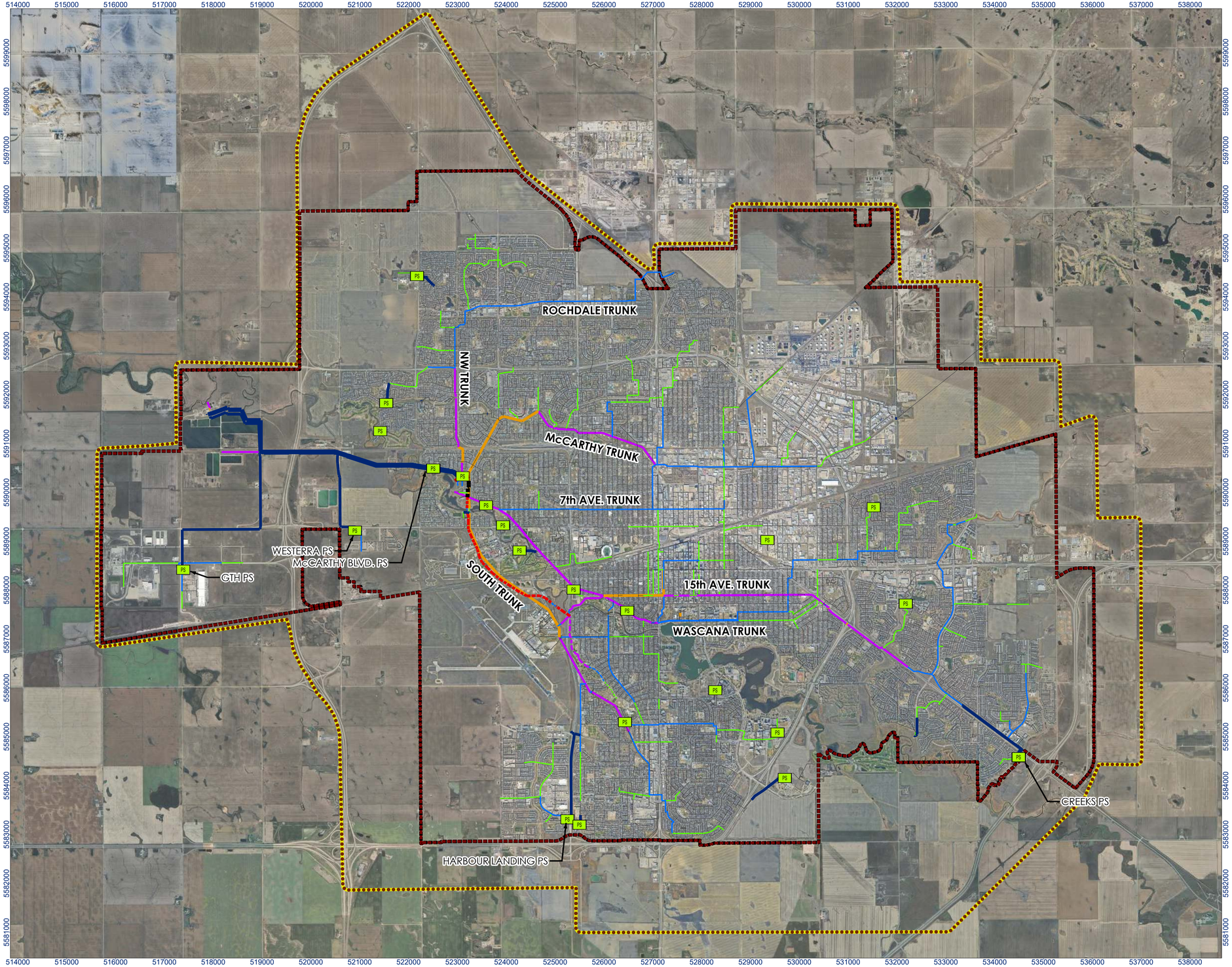


Figure 4-1: Flow Hydrographs before MBPS



STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

Existing Sewer Line
Diameter
- <=300mm
- 350mm - 525mm
- 600mm - 900mm
- 1050mm - 1200mm
- 1350mm - 1500mm
- 1800mm
- PS Pump Station
- Force Main

New Trunk (Under Design Stage)
Diameter
- 450mm
- 750mm - 900mm
- 1050mm - 1200mm
- 1950mm
- 2100mm
- City of Regina
- Project Boundary

N

0 1 2 Kilometers
(At original document size of 22x34)
1:40,000

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Data Sources:
3. Background: Tiled service layer: © OpenStreetMap (and) contributors, CC-BY-SA
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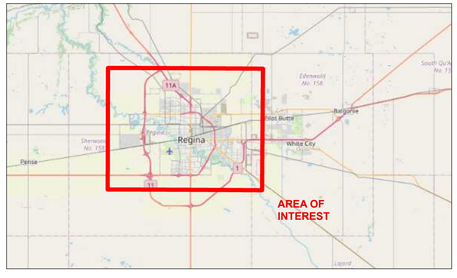

Project Location
City of Regina, SK

Prepared by DP on 2024-08-16
TR by FL on 2024-08-16

Client/Project
111260018 REV0

City of Regina
Water and Wastewater Serviceability Study

Figure No.
4-2

Title
Existing System Overview

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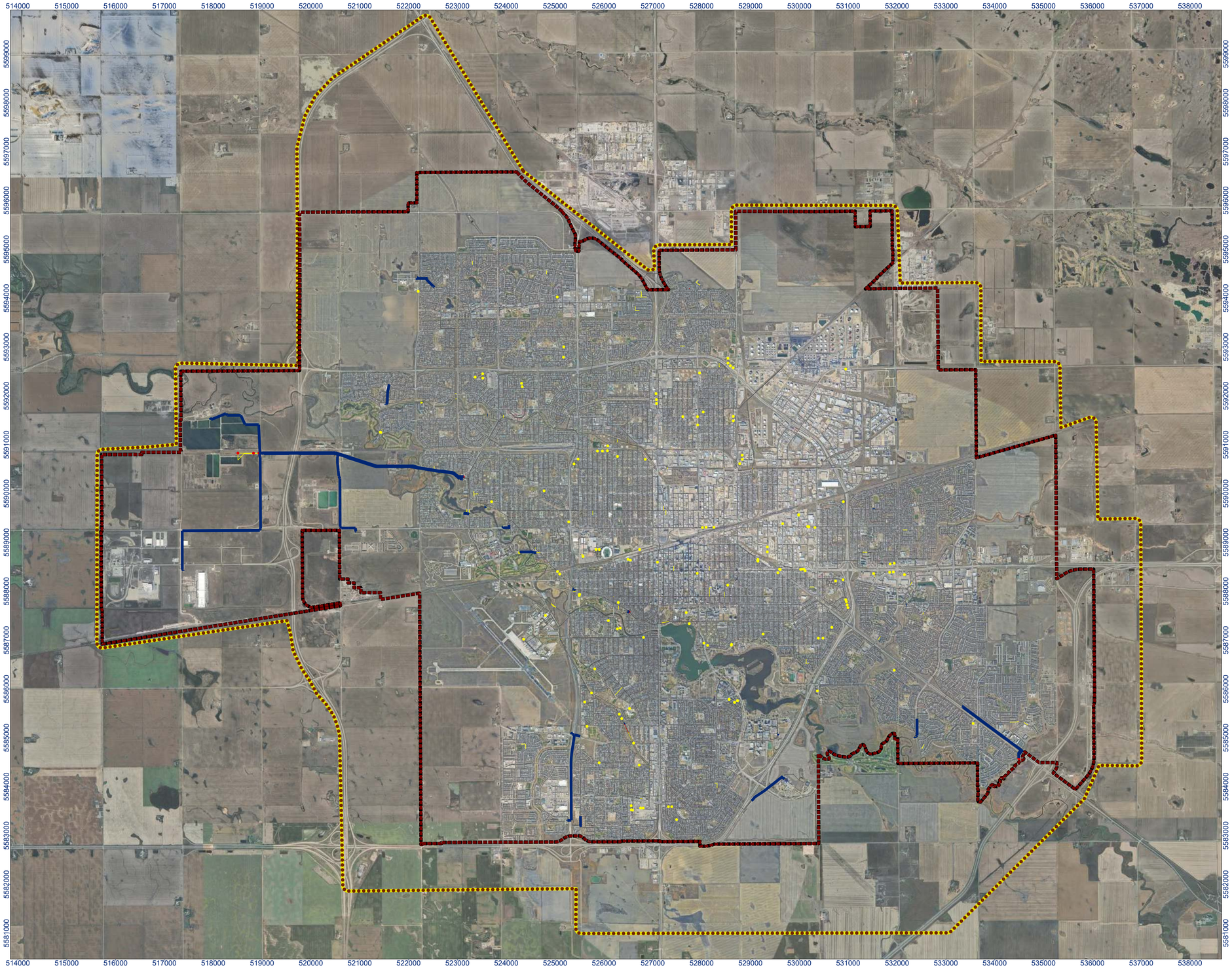

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL

- HGL above ground
- HGL within 1.83m below surface
- Force Main

Max. Surcharge State

- Free Flow
- Backwater Condition
- Bottleneck
- City of Regina
- Project Boundary

N

0 1 2 Kilometers
(At original document size of 22x34)
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Notes

1. Coordinate System: NAD 1983 UTM Zone 13N
2. Data Sources:
3. Background: Tiled service layer: © OpenStreetMap (and) contributors, CC-BY-SA
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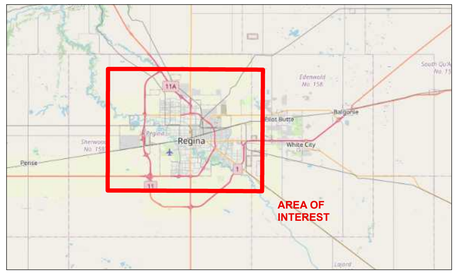

Project Location

City of Regina, SK

Prepared by DP on 2024-08-16
TR by FL on 2024-08-16

Client/Project

111260018 REV0

City of Regina
Water and Wastewater Serviceability Study

Figure No.

4-3

Title

Existing Condition DWF Flooding and Surcharging Nodes

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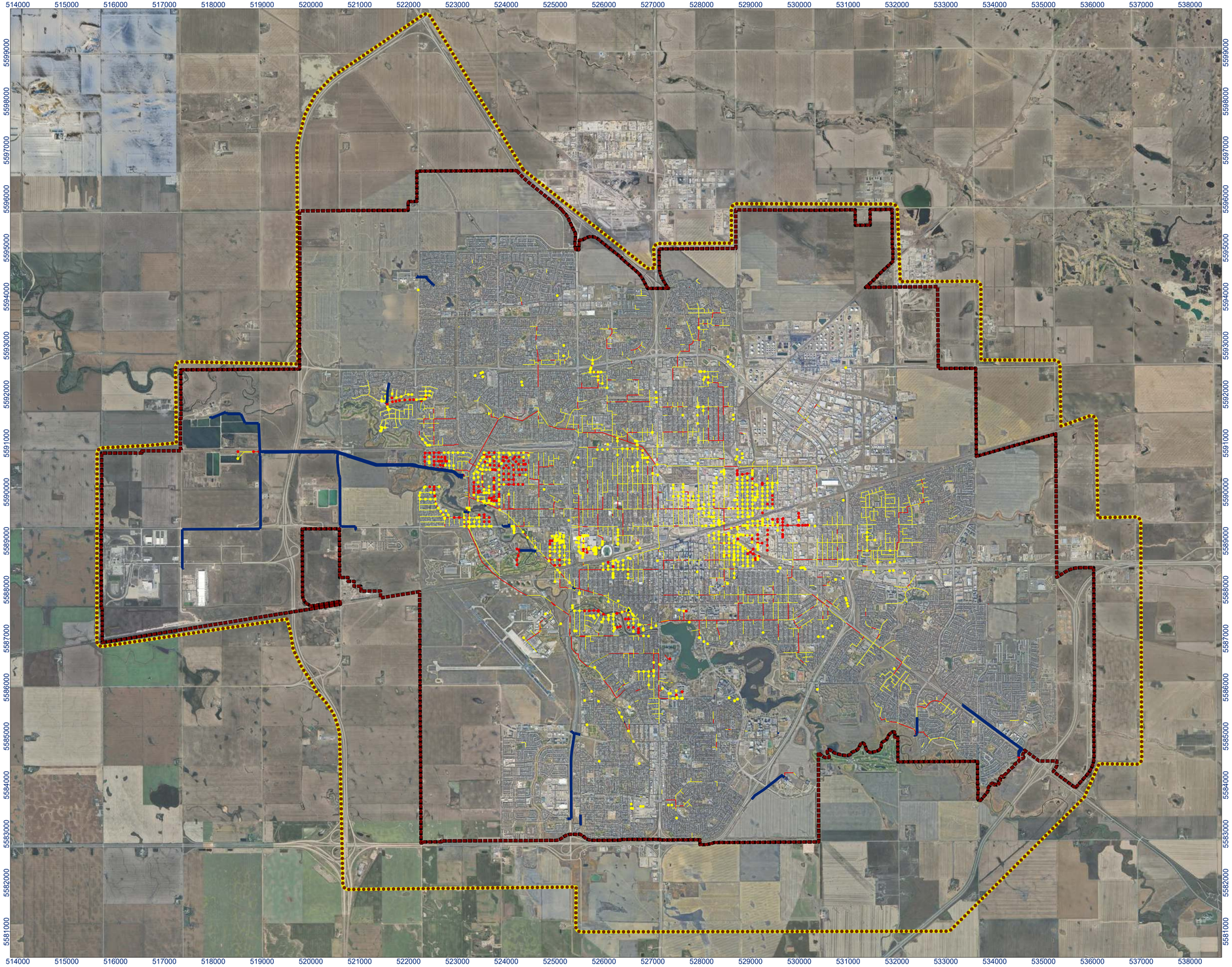

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL

- HGL above ground
- HGL within 1.83m below surface
- Force Main

Max. Surcharge State

- Free Flow
- Backwater Condition
- Bottleneck
- City of Regina
- Project Boundary

N

0 1 2 Kilometers
(At original document size of 22x34)
1:40,000

Notes

1. Coordinate System: NAD 1983 UTM Zone 13N
2. Data Sources:
3. Background: Tiled service layer: © OpenStreetMap (and) contributors, CC-BY-SA
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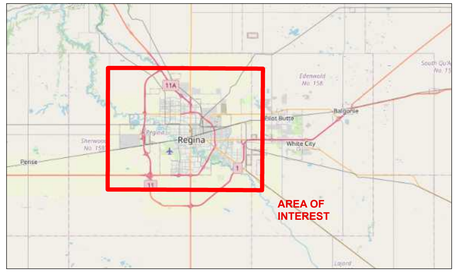

Project Location
City of Regina, SK

Prepared by AL on 2024-08-16
TR by FL on 2024-08-16

Client/Project
111260018 REV0

City of Regina
Water and Wastewater Serviceability Study

Figure No.
4-4

Title
Existing Condition WWF Flooding and Surcharge Nodes

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4.2.3 Growth Scenario Development

4.2.3.1 Sewage Generation Rates

This study considers two growth scenarios beyond the existing built footprint: intensification within the existing City footprint and greenfield developments located on currently undeveloped areas.

The intensification areas are located within the City's existing development footprint as shown in Figure 2-1. The population numbers in the intensification areas were increased at each lot to match the densities mentioned in Table 2-1. However, when existing population at a specific lot was found greater than the computed intensification population, the existing population number was conservatively retained. This adjustment increased the total population in the intensification areas to about 323,000. A residential sewage generation rate of 225 L/cap/day was applied to both high and medium intensification areas. No changes to the groundwater infiltration (GWI) or base flow and rainfall derived inflow and infiltration (RDII) parameters were made in intensification areas since GWI and RDII parameters in these areas were calibrated previously (Stantec 2014).

The greenfield areas are the proposed developments that will be located at the outskirts of the existing City development footprint, as shown in Figure 2-1. These areas include residential, commercial, and industrial land uses. The total residential population in greenfield areas is about 314,000 as mentioned in Table 2-1. Existing developments observed in the base ICM model inside the greenfield area boundaries were conservatively retained in the DWF calculation. The future DWF from the greenfield developments were added to the existing DWF from these developments.

The GWI contribution for the greenfield areas was computed using 6,200 L/ha/day rate per calibration report (Stantec 2014). For RDII estimation, the RTK hydrograph "New Development Separated" (R1 = 0.022, T1 = 1.0, K1 = 23) was applied. The diurnal patterns used in the residential and commercial/industrial areas are shown in Figure 4-5. In the InfoWorks ICM model, the diurnal patterns account for the peaking factor and vary in between residential and commercial/industrial land uses.

The WWF model applied a 1:25-year, 24-hour rainfall event with Chicago Distribution. The rainfall distribution peaks at 7:30 am, which coincides with the peak of the diurnal pattern as shown in Figure 4-6.

The contributing area for the RDII calculation was assumed conservatively as total area for all land uses including industrial areas since the actual density of pipe network is not known at this stage. Although industrial areas may have a sparse sewer network and RDII may be overestimated based on this assumption, industrial areas may also have trade flows or wastewater generated from internal process systems which was not accounted for in this assessment.

4.2.3.2 Collection System in Greenfield Areas

The LiDAR for the greenfield areas was provided by the City and was applied in developing sewer network in these areas. For areas not covered by the LiDAR, open-source elevation data obtained from NASA's Shuttle Radar Topography Mission (SRTM) was used. The conceptual collection system was created using only pipe sizes greater than or equal to 300 mm diameter. The collection system was restricted to a minimum slope of 0.1% and minimum cover of 2.64 m. A lift station was proposed when the depth of the sewer main exceeded 8.0 m as it is typically cost prohibitive to construct sewer mains below

this depth. The land use polygons of greenfield areas were split and connected to the collection system at suitable locations.

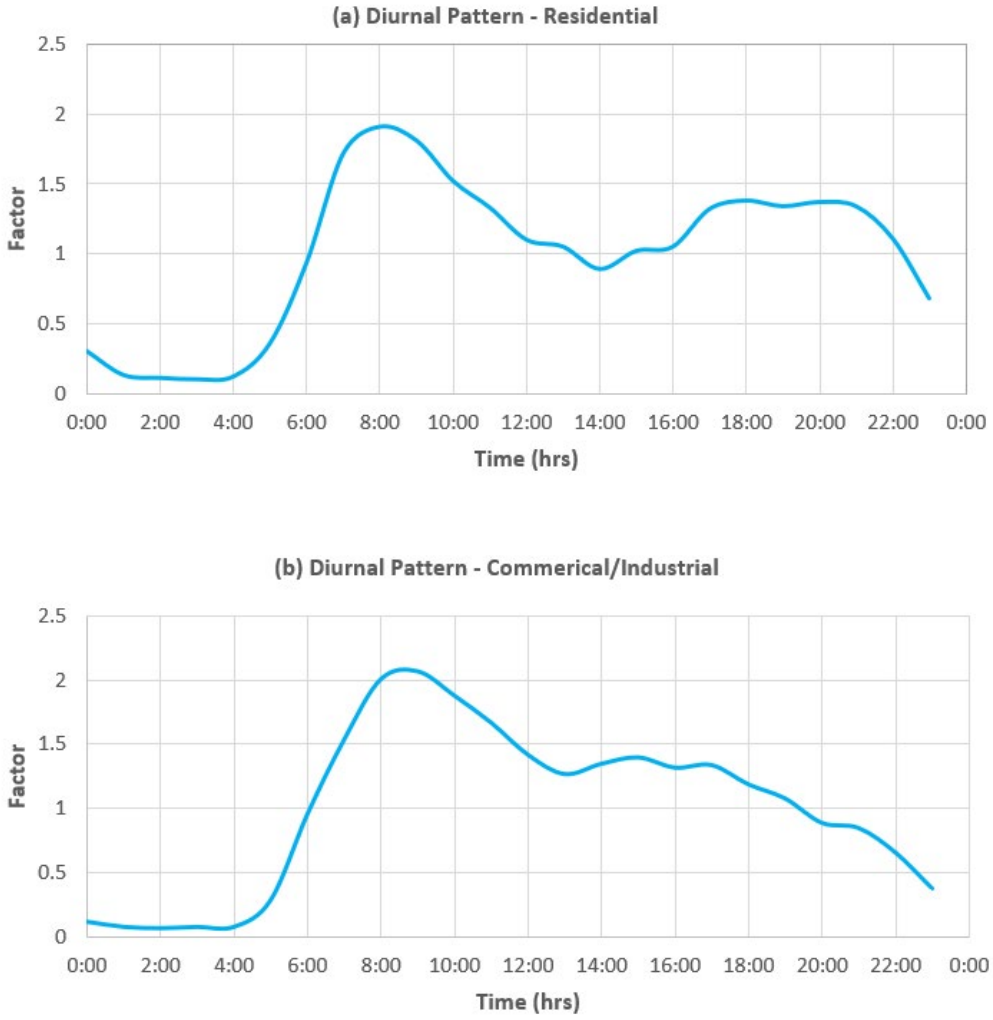


Figure 4-5: Diurnal Patterns applied in Greenfield Areas (a) Residential (b) Commercial/Industrial

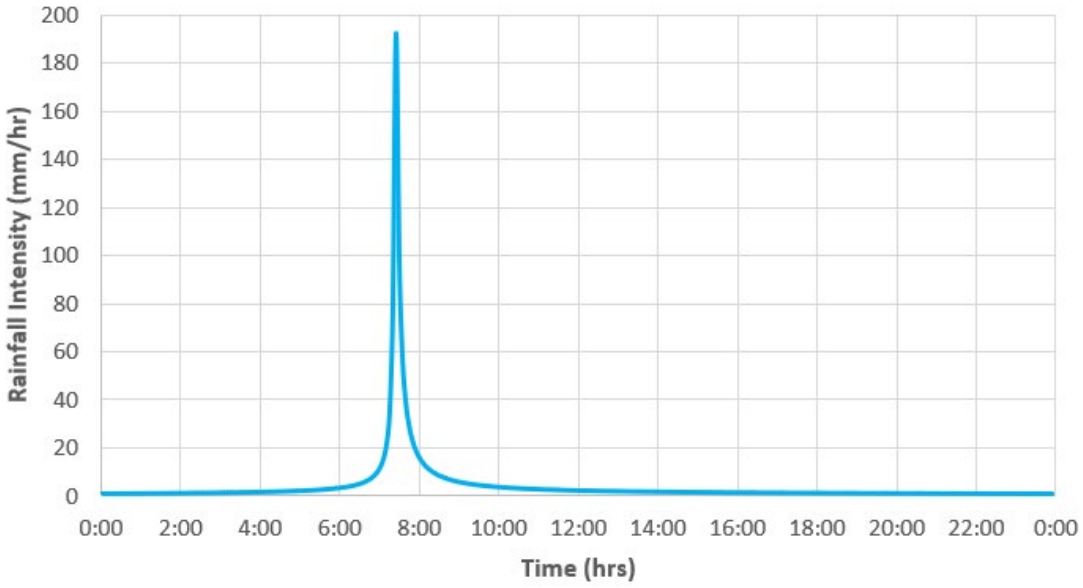


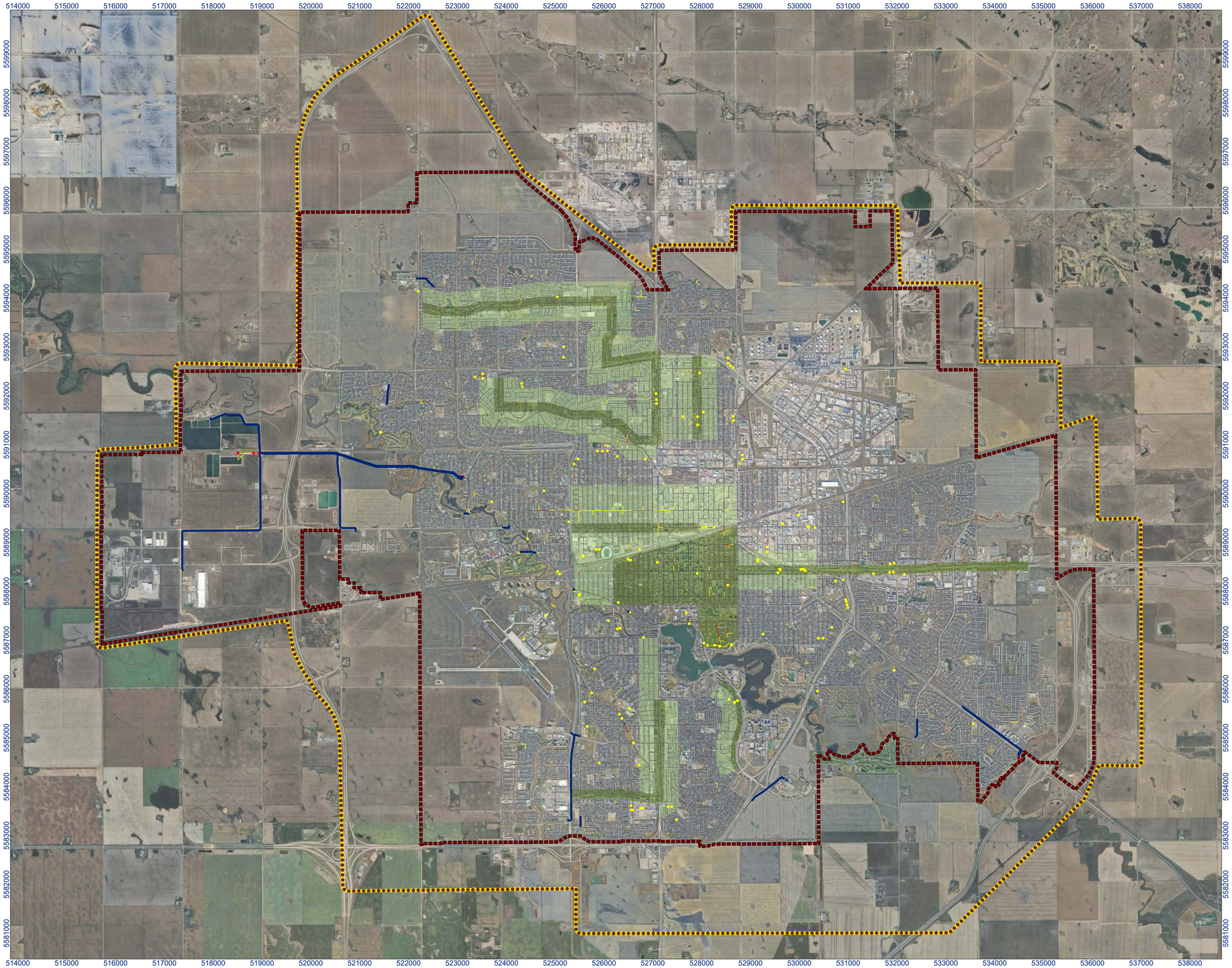
Figure 4-6: 1:25-Year, 24-Hour Rainfall Event

4.2.4 Existing System Plus Intensification Scenario Assessment

The Intensification Scenario was assessed first without including greenfield developments. The impact on the wastewater collection system is shown in Figure 4-7 and Figure 4-8 for DWF and WWF scenarios, respectively. The number of surcharging and flooding nodes is summarized in Table 4-1. The impact of intensification was found significant in the downtown areas including North Central, Warehouse District, Eastview, Downtown, and Core areas. For the WWF scenario, the intensification increased the number of surcharged (yellow) nodes by 336 and flooded nodes (red) by 52 mostly in central areas above what was modeled for the existing system without intensification applied to it. Intensification in the downtown area also caused overflow to the Garnet Street location as most south portion of the downtown area discharge through the Wascana Trunk that is connected to the Garnet Street overflow system.

The intensification north and south of the downtown areas did not cause any notable impact on sewer system in terms of number of surcharged and flooded nodes and overflow volumes. This is because intensification increases DWF only and not RDII since intensification only applies to existing developed areas. It is important to note that the City's calibrated ICM model shows the RDII component to be approximately two to six times greater than DWF component.

The peak flow rates immediately upstream of the MBPS were mostly unaffected by the intensification for the WWF scenario, as presented in Table 4-1. A temporary spike in flow rate was noticed which was possibly caused by pump operation. For the DWF scenario, the peak flow rate increased to 2.39 m^3/s from 1.12 m^3/s because of increased sewage generation from the increased population.



STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL

- HGL above ground
- HGL within 1.83m below surface
- Force Main

Max. Surcharge State

- Free Flow
- Backwater Condition
- Bottleneck

Intensification Areas

- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)
- City of Regina
- Project Boundary

N

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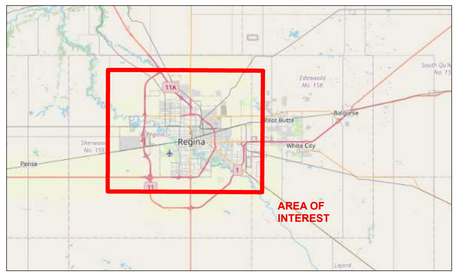

Project Location

City of Regina, SK

Prepared by DP on 2024-08-16
TR by FL on 2024-08-16

Client/Project

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City of Regina
Water and Wastewater Serviceability Study

Figure No.

4-7

Title

DWF Assessment for Existing plus Intensification Scenario

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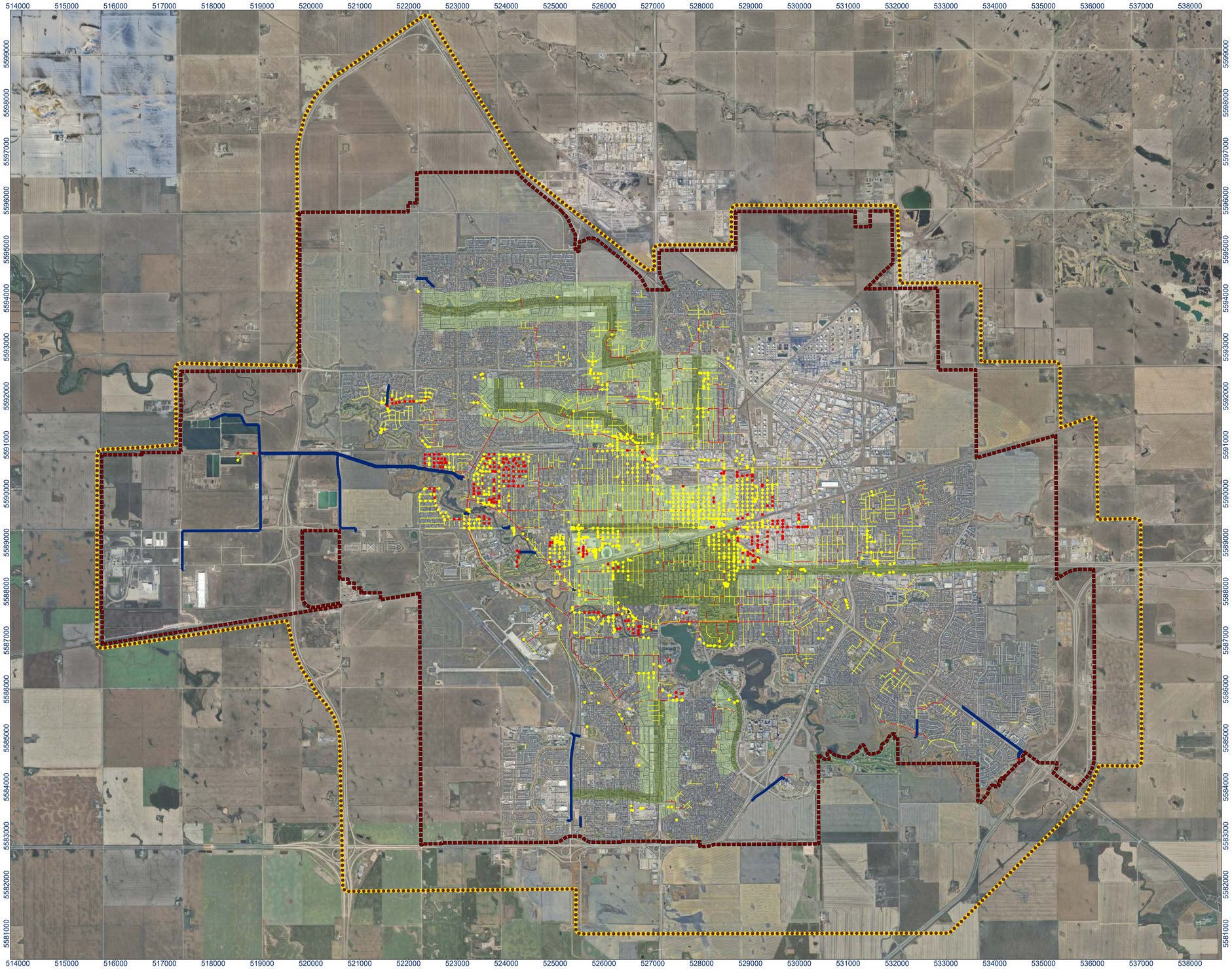

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL

- HGL above ground
- HGL within 1.83m below surface
- Force Main

Max. Surcharge State

- Free Flow
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- Bottleneck

Intensification Areas

- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)
- City of Regina
- Project Boundary

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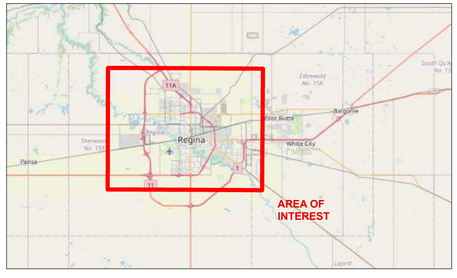

Project Location
City of Regina, SK

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City of Regina
Water and Wastewater Serviceability Study

Figure No.
4-8

Title
WWF Assessment for Existing plus Intensification Scenario

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4.2.5 Ultimate Scenario Assessment

The computed sewage generation rates from all greenfield and intensification areas are shown in Figure 4-9. Routing flows from greenfield developments through the City's existing collection system and then through the MBPS significantly impacts existing trunk and sewer systems. This is the approach that the City has followed historically and can trigger spilling sewage to Wascana Creek through several low-lying manholes located in the vicinity of the creek and Garnet Street overflow location. This spilling reduces the demand at the MBPS, and therefore peak flow rates to the MBPS were found to be rather insensitive to the increased flow rates from the greenfield developments.

To minimize impact to the existing wastewater trunks, it is recommended that the City develop a bypass system where most of the proposed greenfield developments be conveyed directly to the WWTP through new trunk systems, bypassing the MBPS. Because of flat topography, lift stations are proposed, where required, to limit the maximum depth of the trunk systems to 8.0 m as it is typically cost prohibitive to construct sewer mains below this depth.

A new trunk system with three new lift stations is proposed to service the southwest, south, and southeast areas of the City. This trunk and lift station system will convey sewage from lands east of Foxtail Grove, Muskowekwan First Nation, George Gordon First Nation, Sask Polytech, Harbour Landing West and Harbour Landing North areas. The proposed trunk upgrades and lift stations are shown in Figure 4-10 and Figure 4-11.

Similarly, sewage from the northwest greenfield areas will be conveyed to the WWTP through another proposed trunk system and lift station. This trunk system will convey sewage from Coopertown, the Employment Area, Westbrook, McCarthy North, Cowessess First Nation, Rosewood and Carry the Kettle First Nation areas.

The GTH and Dewdney West areas can be serviced by the existing GTH lift station which conveys sewage to the force main connected to the MBPS. The ICM model results showed that the pump station, as modelled in the ICM, has capacity for added flows but the 4.0 km long existing force main will need to be upgraded from 450 mm to 750 mm or twinned. It is understood that GTH pump station can accommodate a second pumping train and force main effectively doubling its capacity.

Westerra and Keeseekoose First Nation area will be connected to the Westerra Lift Station without any upgrades to the pump station and force main.

The Serviceability Study Wastewater Catchment Area and Water Network Expansion for North Regina (AE, 2023) recommended to twin portions of the Rochdale Trunk to service north and northeast greenfield developments. It is understood that the proposed rates from Viterra and FCL sites are 20 and 53.5 L/s, respectively. Therefore, sewage rates from these two sites of 460 ha were provided as constant flow rates in the ICM model. The Skyview, Hawkstone, Kensington Green, and Somerset areas will discharge to the Rochdale Trunk. Since these connections showed capacity deficiencies in the existing Hawkstone area, the Rochdale Trunk is proposed to be upgraded to 1200 mm from 600 mm from Devonshire Drive N to Pasqua Street N (2.0 km length). In addition, 1.5 km of new 600 mm diameter sewer will be required to tie-in Viterra's industrial site to the existing 600 mm stub on Kingbird Road.

On the east side of the City, Tower Crossing, Aurora, the Towns, and Eastbrook areas can be connected to a 750 mm sanitary sewer on Prince of Wales Drive which will then ultimately discharge to the 15th Avenue Trunk and then Wascana Trunk. It was observed in the ICM model results that the existing Haughton Road inline storage does not have capacity for additional sewage from either Aurora or Eastbrook development. Although direct connection to the 750 mm sanitary sewer did not worsen existing flooding scenario at the downstream areas, it increased overflow at the Garnet Street location. To eliminate overflow at the Garnet Street location, it is proposed to upsize a portion of the interconnector trunk system that connects Wascana Trunk and the twinned South Trunk. These upgrades are shown in Figure 4-10 and Figure 4-11.

Greens Gate areas may discharge to the existing 600 mm sewer main on Chuka Boulevard and then to Creeks PS. It was observed in the ICM model that the recently upgraded Creeks PS has capacity for these additional flows.

Fleet Street Business Park and Foxtail Grove residential area can be connected to the sanitary sewer on Redbear Avenue which will ultimately discharge to the McCarthy Trunk. However, existing capacity deficiencies on this trunk will worsen after adding flows from these greenfield areas and also from North Central, Warehouse District, and Eastview intensification areas. To provide serviceability of Fleet Street Business Park and Foxtail Grove residential areas and to resolve capacity issues in the central areas due to intensification, two options were developed, as described below:

Option 1

Under Option 1, 6.4 km length of existing McCarthy Boulevard Trunk will be upgraded to 1500 and 1800 mm in diameter. In addition, another 2.0 km length of sewers from Ring Road to Fleet Street will need to be upsized to 750 and 900 mm in diameter to convey added sewage and improve existing capacity deficiencies in this area. To improve capacity deficiencies in the North Central, Warehouse District and Eastview areas worsened by intensification, another 3.0 km length of sewer will need to be upgraded ranges from 600 mm to 1200 mm diameters in these areas. This proposed upgraded sewer system is connected to both the McCarthy and 7th Avenue Trunks. The proposed upgrades under Option 1 are shown in Figure 4-10.

Option 2

Another option (Option 2) to service Fleet Street Business Park and Foxtail Grove residential area and to improve capacity deficiencies in the North Central, Warehouse District and Eastview areas worsened by intensification is to upgrade the 7th Avenue Trunk system and then connect it to the Fleet Street Business Park and Foxtail Grove residential area. This would require upsizing 7.3 km of the 7th Avenue Trunk to 1200 mm diameter. Another 1.0 km of local sewers in the Eastview area would need to be upsized to 900 mm diameter to improve the existing capacity deficiencies in the central areas worsened by intensification. Another 4.3 km of new sewer would need to be constructed to tie-in 7th Avenue trunk to the Fleet Street Business Park and Foxtail Grove residential area. The proposed upgrades under Option 2 are shown in Figure 4-11.

It was observed that new service connections from the northeast and east developments cause spills from low-lying manholes at McCarthy Boulevard Bridge location. These spills and the Garnet Street overflow in turn limit the flow to the MBPS and therefore, MBPS remains mostly unaffected by the

increased flow rate from the new service connections. An offline storage tank with a lift station in the open area beside the creek near the MBPS could prevent these spills. The offline storage would be an underground vault with odour control system and will receive flows only during significant wet weather events. The stored sewage would then be pumped back to the system when the trunks regained capacity after the wet weather event.

Based on model results, the required storage capacity of the offline storage unit is 20,000 m^3 and 21,400 m^3, for Option 1 and 2, respectively. Note that, this offline local storage unit along with McCarthy or 7th Avenue trunk upgrades will supersede the necessity of a storage tunnel on CP Rail right-of-way as proposed in the Wastewater Masterplan (Stantec, 2019a). A comparison of performance of the system with the storage tunnel option is shown in Table 4-1. As seen in this table, the number of flooded and surcharged nodes are considerably higher compared to the options developed in this study. This is because the storage tunnel option developed in Stantec (2019a) report was for 91,000 population growth, which was much less compared to what was considered in this study. In addition, a 2.4 km long storage tunnel along the railway corridor will cause increased maintenance and expensive compared to a localized storage unit.

4.2.5.1 Inflow and Infiltration (I/I) Reduction

As observed in Figure 4-1, the peak DWF varied from 1.0 to 3.0 m^3/s, while the peak WWF stayed at 7.0 m^3/s in most scenarios. Although peak WWFs at the MBPS were limited by overflows and flooded nodes, peak WWFs were two to six times larger than peak DWFs. This implies that WWF is the primary contributor for capacity deficiencies in the sewer system. The primary contributors of inflows are holes in sanitary manhole lids, foundation drain connections, storm drain cross-connections, etc. The primary source of infiltration is cracks in sewers and manholes, faulty joints, and connections, etc. which typically increases as the system gets older. To increase capacity of the existing and proposed sanitary systems, I/I reduction strategy can be adopted. These include:

- Identify sources of I/I by CCTV inspection, smoke or dye testing.
- Rehabilitate or replace older pipes and manholes to reduce infiltration
- Avoid installing sanitary manholes in low lying areas
- Make sure foundation drains and roof leaders are not connected to the sanitary system, etc.

4.2.5.2 Performance Assessment

Capacity deficiencies, when the northeast and east development areas are connected to the City sewer system, are presented in **Error! Reference source not found.**. The number of flooded and surcharged nodes increase to 367 and 1,601, respectively for the WWF scenario. After adding upgrades, the flooded (red) and surcharged (yellow) node counts reduce significantly. For Option 1, the reduced numbers are less than or comparable to the existing scenario. For Option 2, the reduced numbers are significantly less than existing scenario. Capacity improvements under both Option 1 and 2 are shown in Figure 4-12 through Figure 4-15.

The peak flow rates for the WWF scenario immediately upstream of the MBPS were found insensitive to the new service connections and proposed upgrades. This is because of manhole overflows at the McCarthy Blvd bridge location which will be contained in an offline storage tank.

4.2.5.3 Overflow Volume

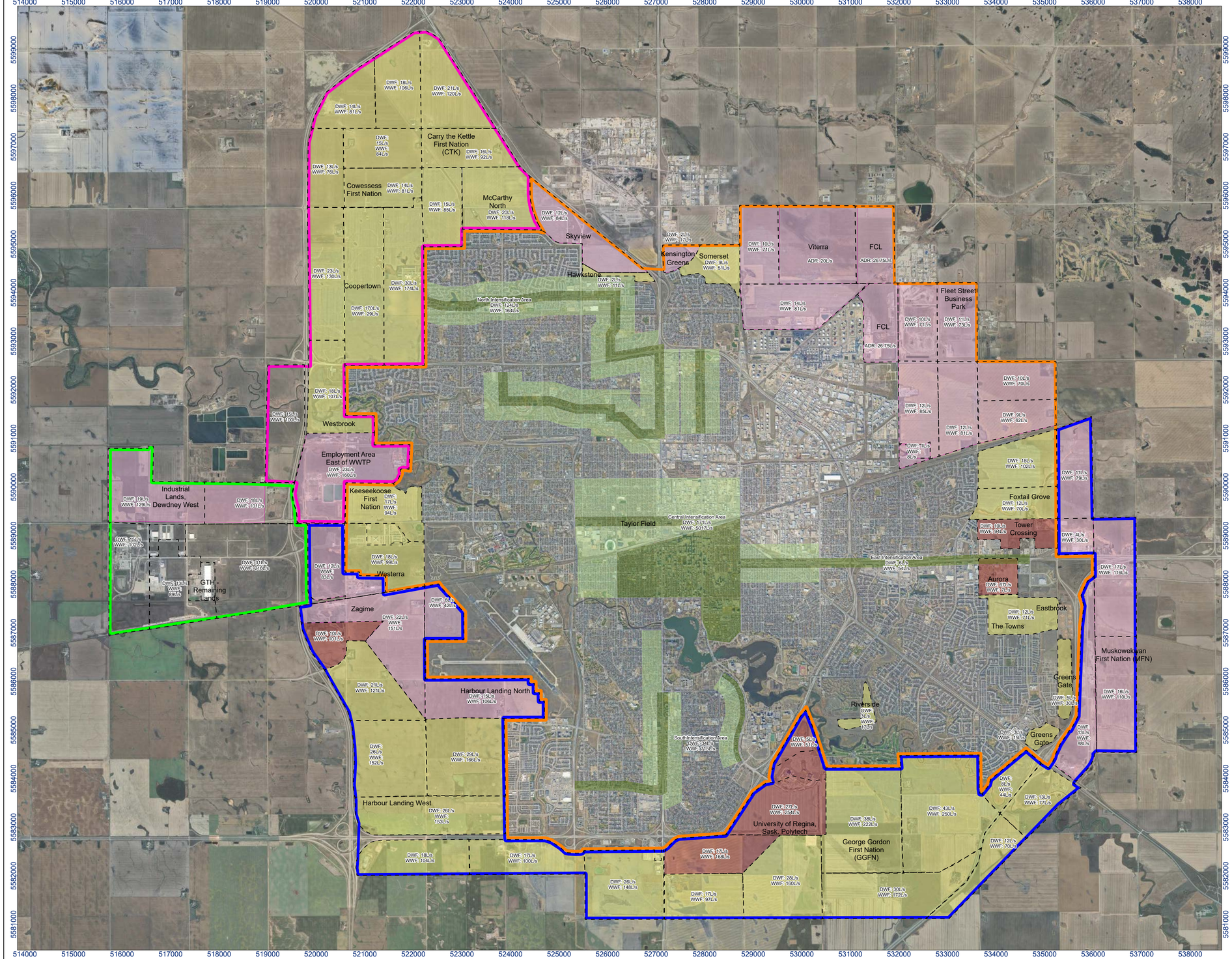
Overflow routes exist at the MBPS and the Creeks PS which overflow to Wascana Creek. Another overflow location exists at the Garnet Street PS that overflows sewage to the storm system from the Wascana Trunk. The force main at Harbour Landing PS overflows to a ditch system beside Lewvan Drive. The overflow volumes from these locations are shown in Table 4-2 for different scenarios. Table 4-2 also gives the total overflow volumes from the flooded manholes.

The proposed greenfield developments and intensification did not affect the catchment areas of the Harbour Landing PS. The force main of the Harbour Landing PS is found above the computed HGL of the downstream pipe where it discharges. Therefore, the overflow volumes shown in Table 4-2 should not vary between scenarios. The fluctuation on overflow volumes in between the scenarios is assumed to be caused by modeling limitations.

Table 4-2 Overflow Volumes from the Release Points

Release Location	Overflow Volume (m^3)			
	Existing Condition	**Existing plus Intensification (without Upgrades)**	**Ultimate Upgrades – Option 1**	**Ultimate Upgrades - Option 2**
MBPS Overflow	0	0	0	0
Creeks PS Overflow	0	0	0	0
Garnet Street Overflow	0	2,720	0	0
Harbour Landing PS Overflow	560	740	665	795
Overflow from Flooded Manholes*	5,107	6,360	5,288	4,049
Total	**5,667**	**9,820**	**5,953**	**4,844**

*It is important to distinguish between the volume of overflow from designed overflow conduits and overflow from flooded manholes. While 100% of the volume of sewage overflow occurring at designed overflow conduits is discharged to the environment, some or all the identified sewage from a flooded sanitary manhole may be reintroduced to the wastewater collection system depending on the topography of each specific manhole location.



STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

Intensification Areas
- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

Future Land Use
- Commercial (675 ha)
- Industrial (4991 ha)
- Residential (6277 ha)

Catchment Areas
- GTH Pump Station
- McCarthy Pump Station
- North Bypass
- South Bypass
- Subcatchment

N

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Notes
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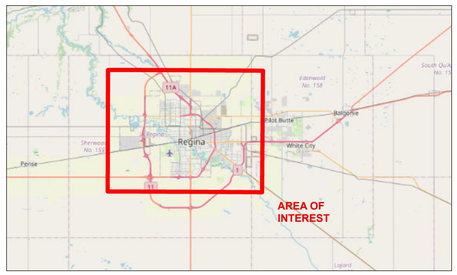
4. ADR = Allowable Discharge Rate



Project Location
City of Regina, SK

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111260018 REV0

City of Regina
Water and Wastewater Serviceability Study

Figure No.
4-9

Title
Greenfield and Intensification Subcatchment DWF and WWF

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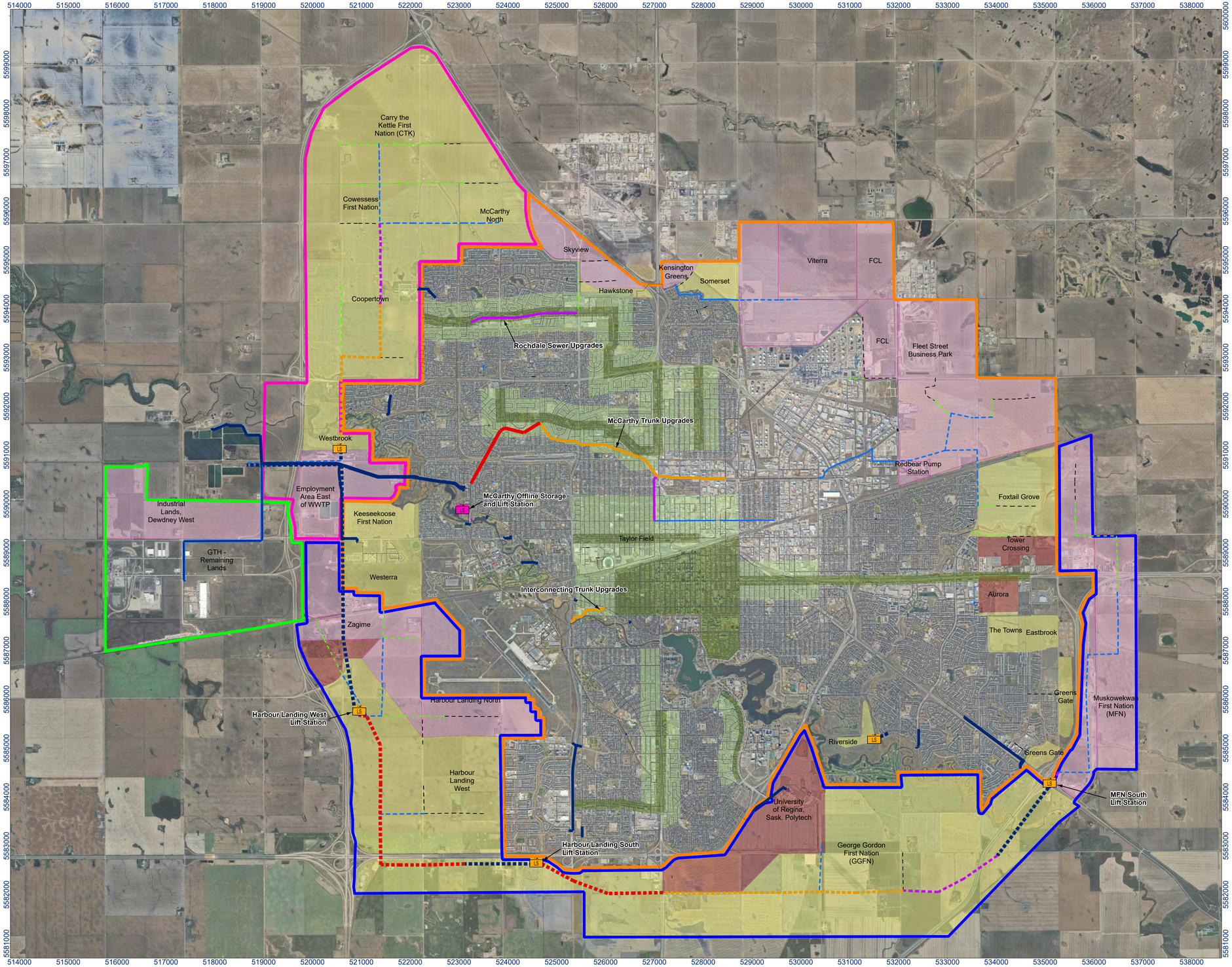

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

- Proposed Lift Station
- Proposed Offline Storage Tank With Lift Station
- Existing Sewer Line
- Existing Force Main Upgrades
- Existing Force Main
- Proposed Force Main

Intensification Areas

- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

Future Land Use

- Commercial (675 ha)
- Industrial (4991 ha)
- Residential (6277 ha)

Existing Sewer Upgrades Diameter

- 600mm - 900mm
- 1200mm
- 1500mm
- 1800mm

Proposed Sanitary Trunk Diameter

- 300mm
- 350mm - 525mm
- 600mm - 900mm
- 1050mm - 1200mm
- 1350mm - 1500mm
- 1650mm - 1800mm

Catchment Areas

- GTH Pump Station
- McCarthy Pump Station
- North Bypass
- South Bypass

N

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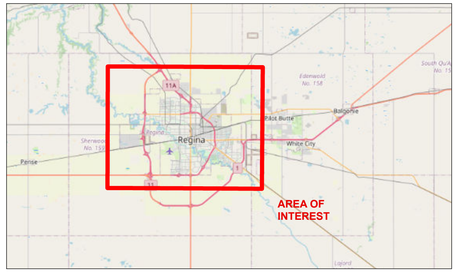

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Figure No.
4-10

Title
Proposed Sewer Network and System Upgrades - Option 1

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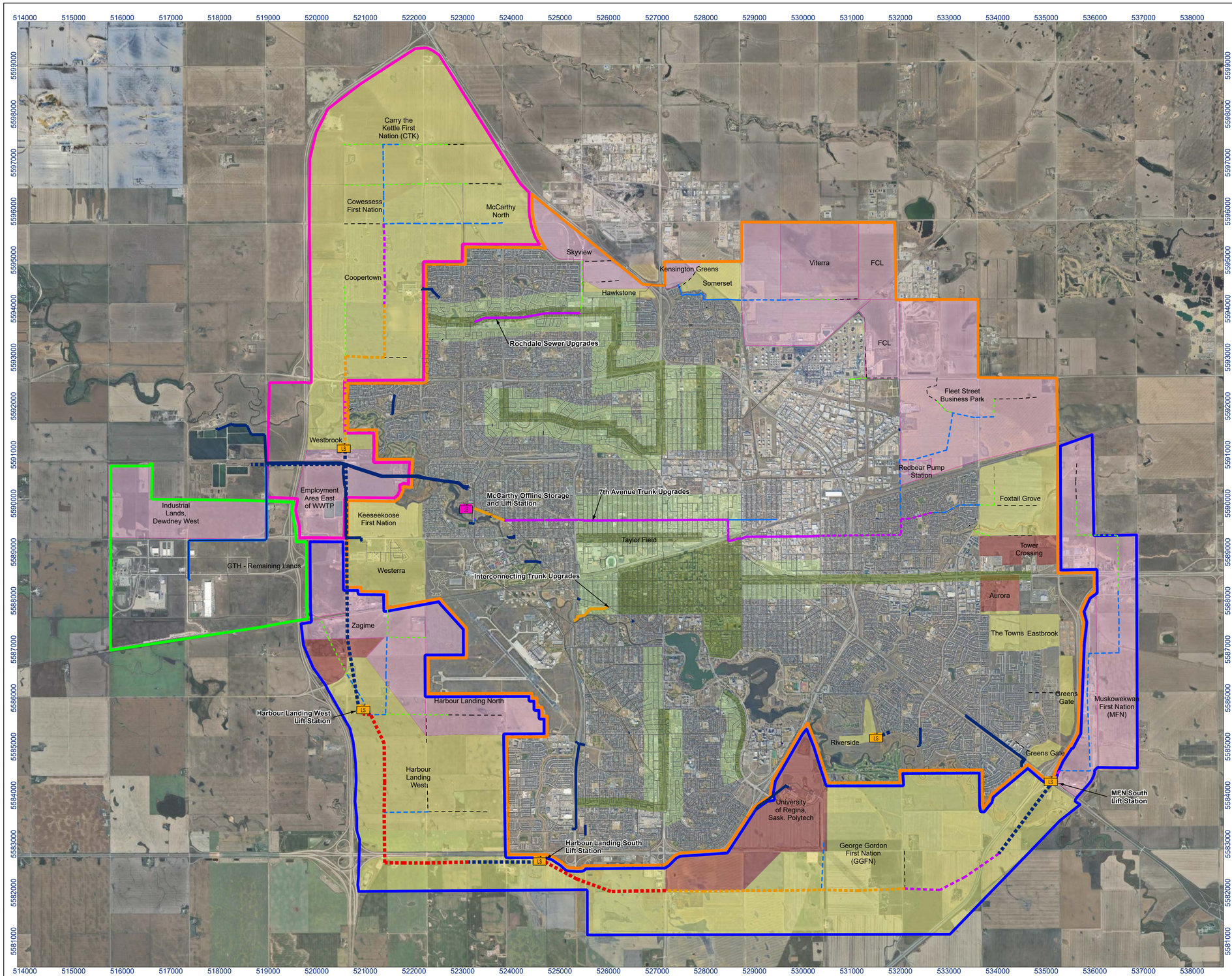

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

- Proposed Lift Station
- Proposed Offline Storage Tank With Lift Station
- Existing Sewer Line
- Existing Force Main Upgrades
- Existing Force Main
- Proposed Force Main

Intensification Areas

- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)
- Landuse

Existing Sewer Upgrades Diameter

- 600mm - 900mm
- 1200mm
- 1500mm
- 1800mm

Proposed Sanitary Trunk Diameter

- 300mm
- 350mm - 525mm
- 600mm - 900mm
- 1050mm - 1200mm
- 1350mm - 1500mm
- 1650mm - 1800mm

Catchment Areas

- GTH Pump Station
- McCarthy Pump Station
- North Bypass
- South Bypass

N

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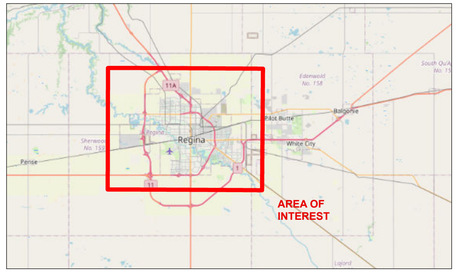

Project Location

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Figure No.

4-11

Title

Proposed Sewer Network and System Upgrades - Option 2

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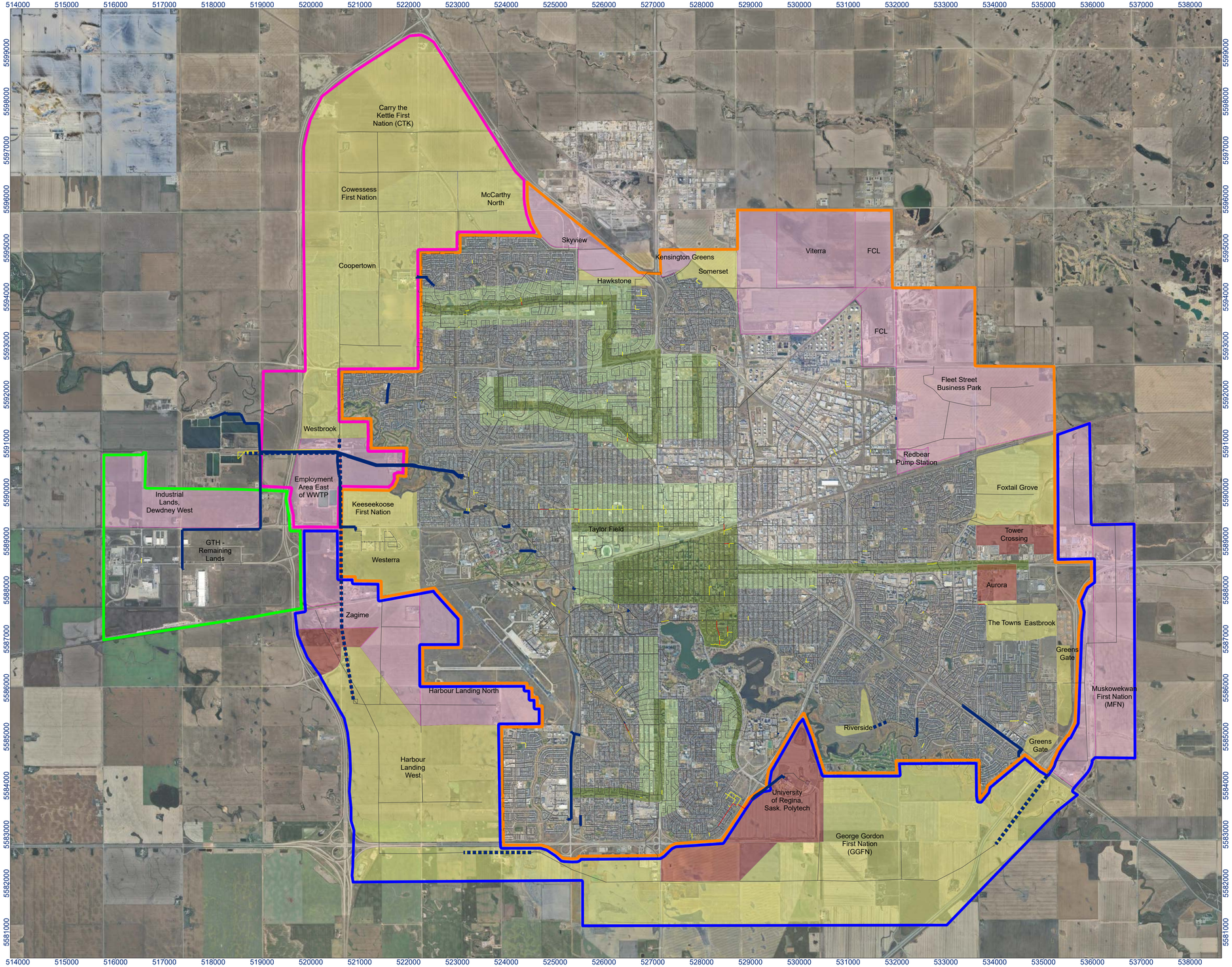

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL

- HGL above ground
- HGL within 1.83m below surface

Max. Surcharge State

- Free Flow
- Backwater Condition
- Bottleneck
- Proposed Force Main
- Force Main

Intensification Areas

- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

Future Land Use

- Commercial (675 ha)
- Industrial (4991 ha)
- Residential (6277 ha)

Catchment Areas

- GTH Pump Station
- McCarthy Pump Station
- North Bypass
- South Bypass

N

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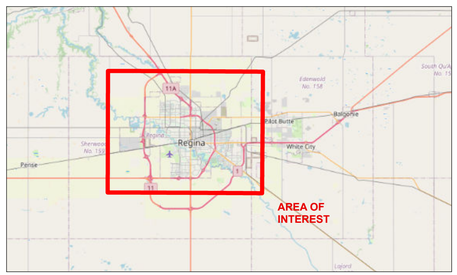

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Figure No.

4-12

Title

DWF Assessment for Ultimate Scenario - Option 1

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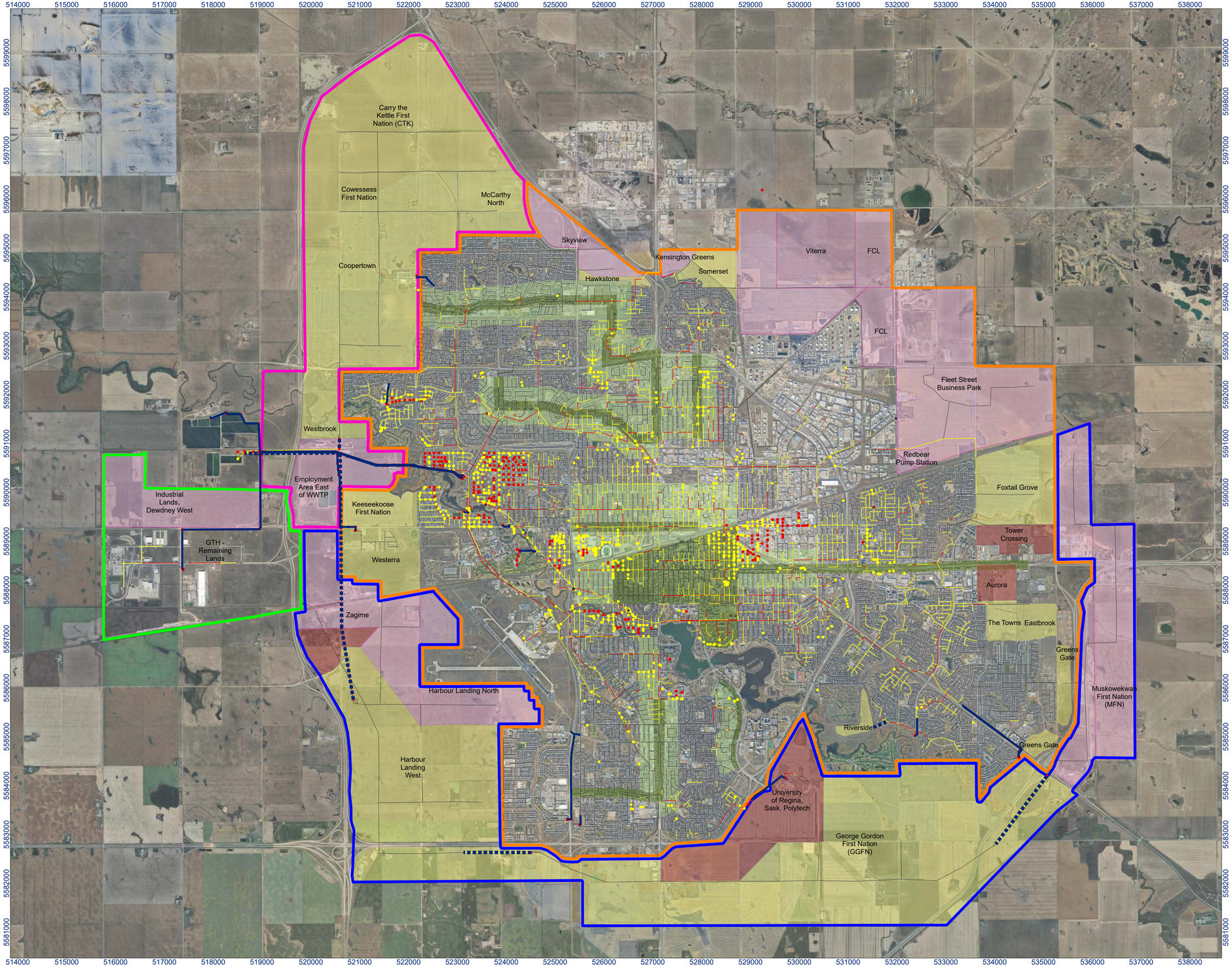


STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL
- HGL above ground
- HGL within 1.83m below surface

Max. Surcharge State
- Free Flow
- Backwater Condition
- Bottleneck
- Proposed Force Main
- Force Main

Intensification Areas
- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

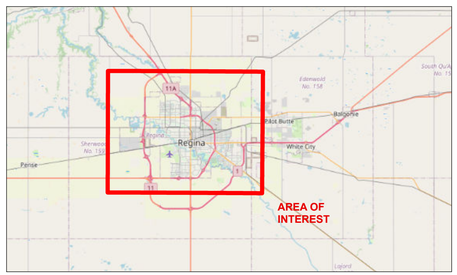
Future Land Use
- Commercial (675 ha)
- Industrial (4991 ha)
- Residential (6277 ha)

Catchment Areas
- GTH Pump Station
- McCarthy Pump Station
- North Bypass
- South Bypass

N

0 1 2 Kilometers
(At original document size of 22x34)
1:40,000

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Data Sources:
3. Background: Tiled service layer: © OpenStreetMap (and) contributors, CC-BY-SA
OpenStreetMap: © OpenStreetMap (and) contributors, CC-BY-SA, Google (2024)



Project Location
City of Regina, SK

Prepared by DP on 2024-08-16
TR by FL on 2024-08-16

Client/Project
111260018 REV0

City of Regina
Water and Wastewater Serviceability Study

Figure No.
4-13

Title
WWF Assessment for Ultimate Scenario - Option 1

\\ca0046-ppfss01\shared_projects\111260018\GIS\1566\400_data_mgmt_dp\gis\111260018_CofRegina_WWMP\111260018_Regina_WWMP.aprx Revised: 2024-11-07 By: alelee

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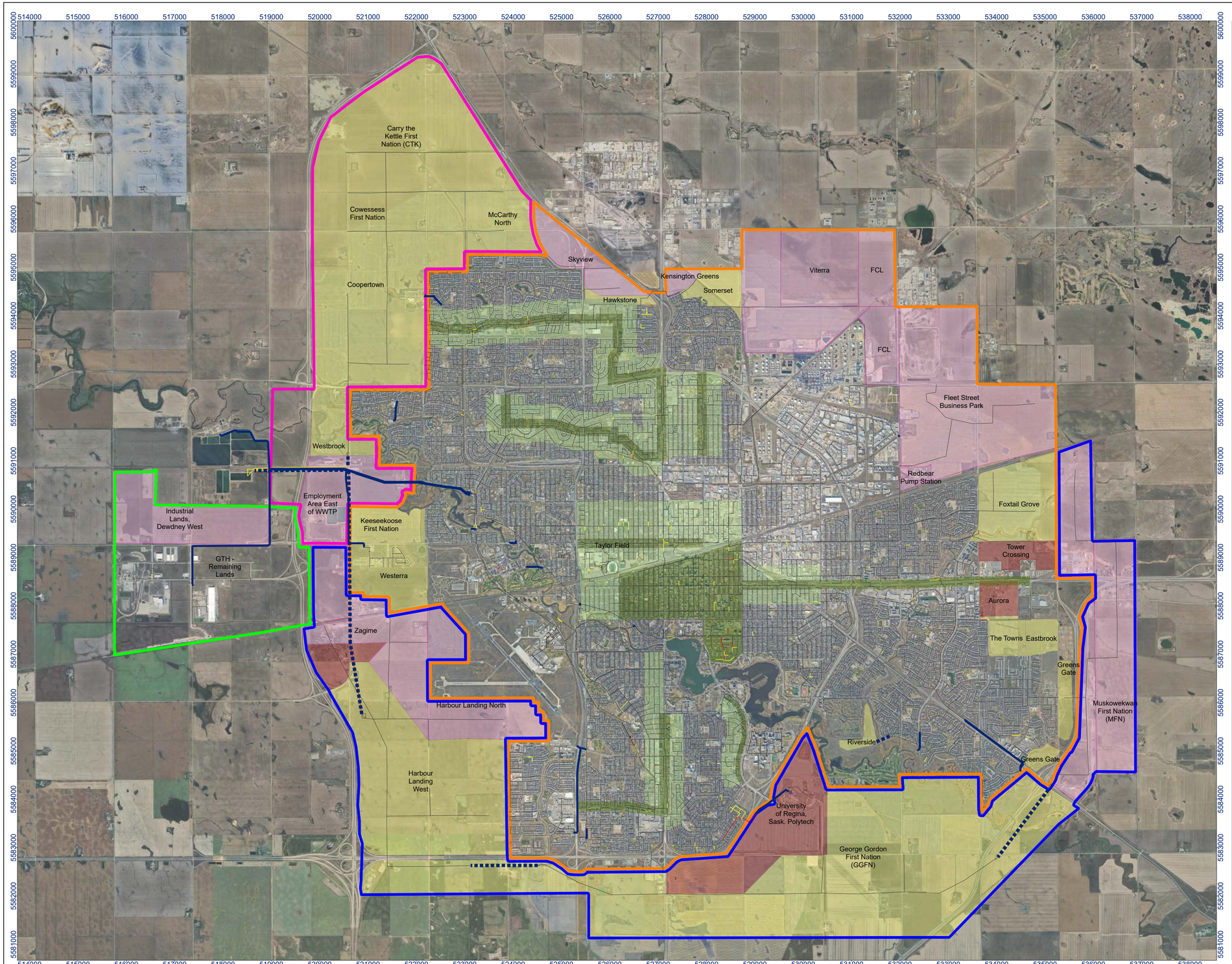


STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL
- HGL above ground
- HGL within 1.83m below surface

Max. Surcharge State
- Free Flow
- Backwater Condition
- Bottleneck
- Proposed Force Main
- Force Main

Intensification Areas
- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

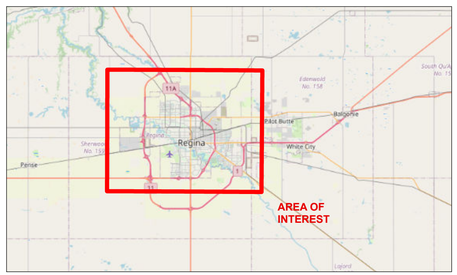
Future Land Use
- Commercial (675 ha)
- Industrial (4991 ha)
- Residential (6277 ha)

Catchment Areas
- GTH Pump Station
- McCarthy Pump Station
- North Bypass
- South Bypass

N

0 1 2 Kilometers
(At original document size of 22x34)
1:40,000

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Data Sources:
3. Background: Tiled service layer: © OpenStreetMap (and) contributors, CC-BY-SA
OpenStreetMap: © OpenStreetMap (and) contributors, CC-BY-SA, Google (2024)



Project Location
City of Regina, SK

Prepared by DP on 2024-08-16
TR by FL on 2024-08-16

Client/Project
111260018 REV0

City of Regina
Water and Wastewater Serviceability Study

Figure No.
4-14

Title
DWF Assessment for Ultimate Scenario - Option 2

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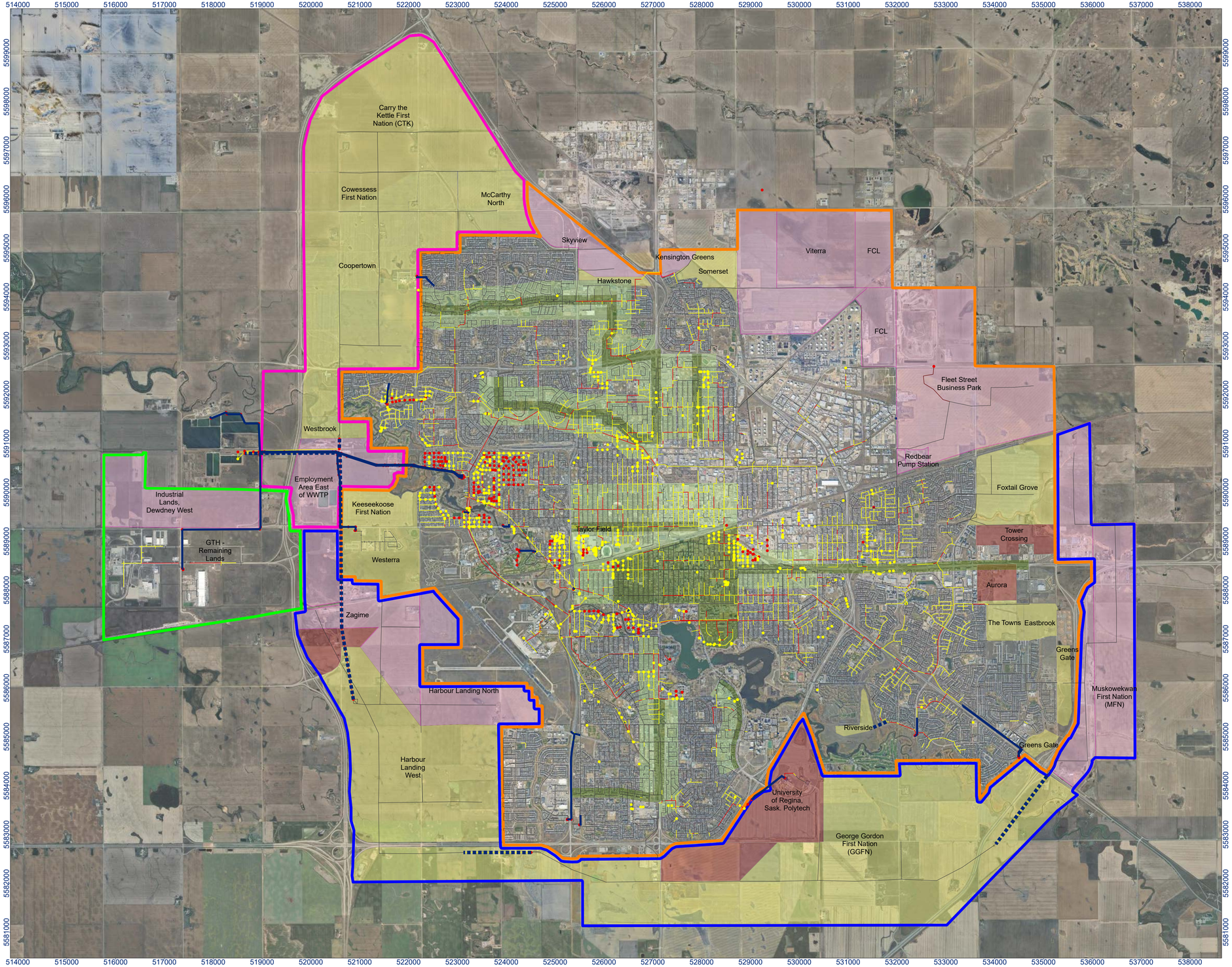

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

HGL
- HGL above ground
- HGL within 1.83m below surface

Max. Surcharge State
- Free Flow
- Backwater Condition
- Bottleneck
- Proposed Force Main
- Force Main

Intensification Areas
- 85 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

Future Land Use
- Commercial (675 ha)
- Industrial (4991 ha)
- Residential (6277 ha)

Catchment Areas
- GTH Pump Station
- McCarthy Pump Station
- North Bypass
- South Bypass

N

0 1 2 Kilometers
(At original document size of 22x34)
1:750,000

Notes
1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: Tiled service layer: © OpenStreetMap (and) contributors, CC-BY-SA
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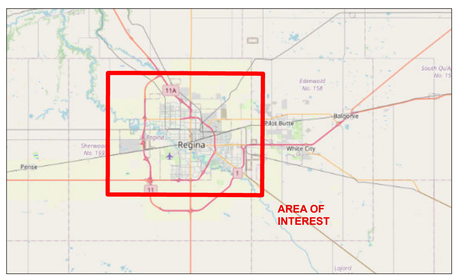

Project Location
City of Regina, SK

Prepared by DP on 2024-08-16
TR by FL on 2024-08-16

Client/Project
111260018 REV0

City of Regina
Water and Wastewater Serviceability Study

Figure No.
4-15

Title
WWF Assessment for Ultimate Scenario - Option 2

\\ca0046-ppfss01\shared_projects\111260018\GIS\15660400_data_mgmt_dp\gis\111260018_CofRegina_WWMP\111260018_Regina_WWMP.aprx Revised: 2024-11-07 By: alelee

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4.2.5.4 Impact on Existing McCarthy Boulevard Pump Station

The MBPS consists of five pumps in the MBPS and two pumps in the McCarthy Boulevard Secondary Station (MBSS). High flow testing was conducted to confirm satisfactory operation and performance of the MBPS as per the High Flow Pump Test Report (AE, 2002). The high flow testing predicted the MBPS has a firm capacity of approximately 520 ML/d (6.02 m³/s) to 535 ML/d (6.19 m³/s). However, if you include the non-firm capacity of the MBPS and MBSS combined is approximately 650 ML/d (7.50 m³/s), as observed in the ICM model.

As per Table 4-1, the DWF and WWF peak flow rates at the conduit before the MBPS for the ultimate scenario are approximately 3.07 m³/s and 7.0 m³/s respectively. Therefore, the MBPS appears to have sufficient capacity to accommodate the additional flows for the ultimate scenario.

Pump Control Philosophy

The MBPS functions as the primary pump station for the majority of the City's wastewater collection system. As identified above, the ultimate scenario will require the MBPS to operate to its maximum capacity to convey the WWF within its catchment. Allowing future development to tie-in to the existing force mains will impact future capacity of the MBPS. In general, limiting tie-ins to the MBPS force mains and other future force mains will improve the reliability, flexibility, and resilience of the City's wastewater collection system.

4.2.5.5 Impact on Existing WWTP

As per the Wastewater Masterplan (Stantec 2019b), the existing WWTP has capacity to treat sewage at a rate of 197 ML/day (2.28 m^3/s). In addition, approximately 162,000 m^3 of lagoon storage is available when peak discharge exceeds 197 ML/day.

Based on ICM results, the total WWF generation in a 24-hour period is approximately 650,500 m^3 considering contribution from all greenfield and intensification areas. The total peak DWF generation at the WWTP is 5.25 m^3/s that combines the peak DWF at the MBPS and two other proposed pump stations for the greenfield areas. Therefore, WWTP capacity will need to increase to accommodate the WWF derived from 25-year 24-hour rainfall event.

In addition to the WWTP upgrades, it is likely that upgrades to the force main switching station directly upstream of the WWTP will be required to accommodate the infrastructure identified to service the ultimate scenario.

Analysis of the upgrades to the WWTP and switching station are not included as part of this project.

4.2.5.6 Secondary WWTP Solution

As part of the Serviceability Study, the City has requested Stone & Arrow provide additional technical information to support the conclusion in the Wastewater Masterplan prepared by Stantec (Stantec 2019b), that a secondary WWTP is not a preferred solution to the wastewater servicing challenges for developing on the east side of the City. Refer to Appendix E for details.

5 Opinion of Probable Cost

The Opinion of Probable Cost (OPC) represents the total cost to complete the necessary upgrades to the water distribution system and wastewater collection system to service the Ultimate Scenario. For the water distribution system, all pipe sizes from 400 mm diameter and larger were quantified and applicable market rates were applied to estimate the capital cost required for the upgrades. For the wastewater collection system, all pipe sizes from 300 mm diameter and larger were quantified and applicable market rates were applied to estimate the capital cost required for the upgrades. It is assumed all water and wastewater pipes smaller than those listed will be paid for when specific local developments are approved, designed and constructed.

The OPC classification system used is the ASTM E 2516-06. It provides a five-level classification system based on several characteristics, with the primary characteristic being the level of project definition. For the purposes of this study, a Class 5 estimate based on the process industry accuracy range of -50% to +100% was selected. A Class 5 OPC is a conceptual level estimate intended for use in capital planning and comparative purposes of alternatives.

The OPC is split between the water distribution system and wastewater collection system. Each system includes a table summarizing the upgrades required to service the Ultimate Scenario as identified within this report. Each table includes the following:

- **Reference Figure / Location:** The number of the reference figure and the approximate location within the City of where the infrastructure is considered.
- **Infrastructure:** What is considered to be upgraded, i.e. pipes, pump station, or reservoir.
- **Sequence:** When the suggested upgrade(s) will be required in terms of planning and budget i.e. short-term (immediate need to improve level of service), medium-term (timing dependent on City priorities), or long-term (required to support the ultimate scenario).
- **Trigger:** The cause and effect for the required upgrades or improvement to take place in the system
- **Benefit / Purpose:** The improvement noted from the upgrade to the system.
- **Cost:** The estimated costs are inclusive of 15% Engineering, 50% Contingencies, and excludes PST and GST Taxes.

Unit prices for the OPC were based on recent capital costs for projects in each category. For some project components there were limited relevant historical examples. For older projects that were used, Bank of Canada historical inflation rates were used to bring historical costs to 2025 Canadian Dollars. The unit prices for pipe upgrades in built areas include surface restoration. Surface restoration is not included for greenfield pipe unit prices.

A 50% contingency has been identified to account for potential land acquisition, phasing / staging, and other indirect costs. A 15% engineering cost has been applied to account for preliminary design, detailed design, tendering, and construction.

For a detailed breakdown of the costs associated with each project, please refer to Appendix F.

5.1 Water Distribution System

The WaterCAD modelling results suggest that the areas depicted in Figure 2-1 can be effectively serviced through carefully planning the upgrades for the Ultimate Scenario. For the system to accommodate the residential intensification, the existing distribution network will require the addition of an eastern bypass loop as well as upsizing of mains within the downtown area. Furthermore, for the complete study area which includes greenfield development, new facilities will be required for the system to function at an acceptable level.

Table 5-1: Water Serviceability Summary summarizes the proposed water infrastructure. Figures 5-1 to Figure 5-8 illustrate the infrastructure needed for each of the eight serviceability areas which should be used as reference when reviewing Table 5-1.

Table 5-1: Water Serviceability Summary

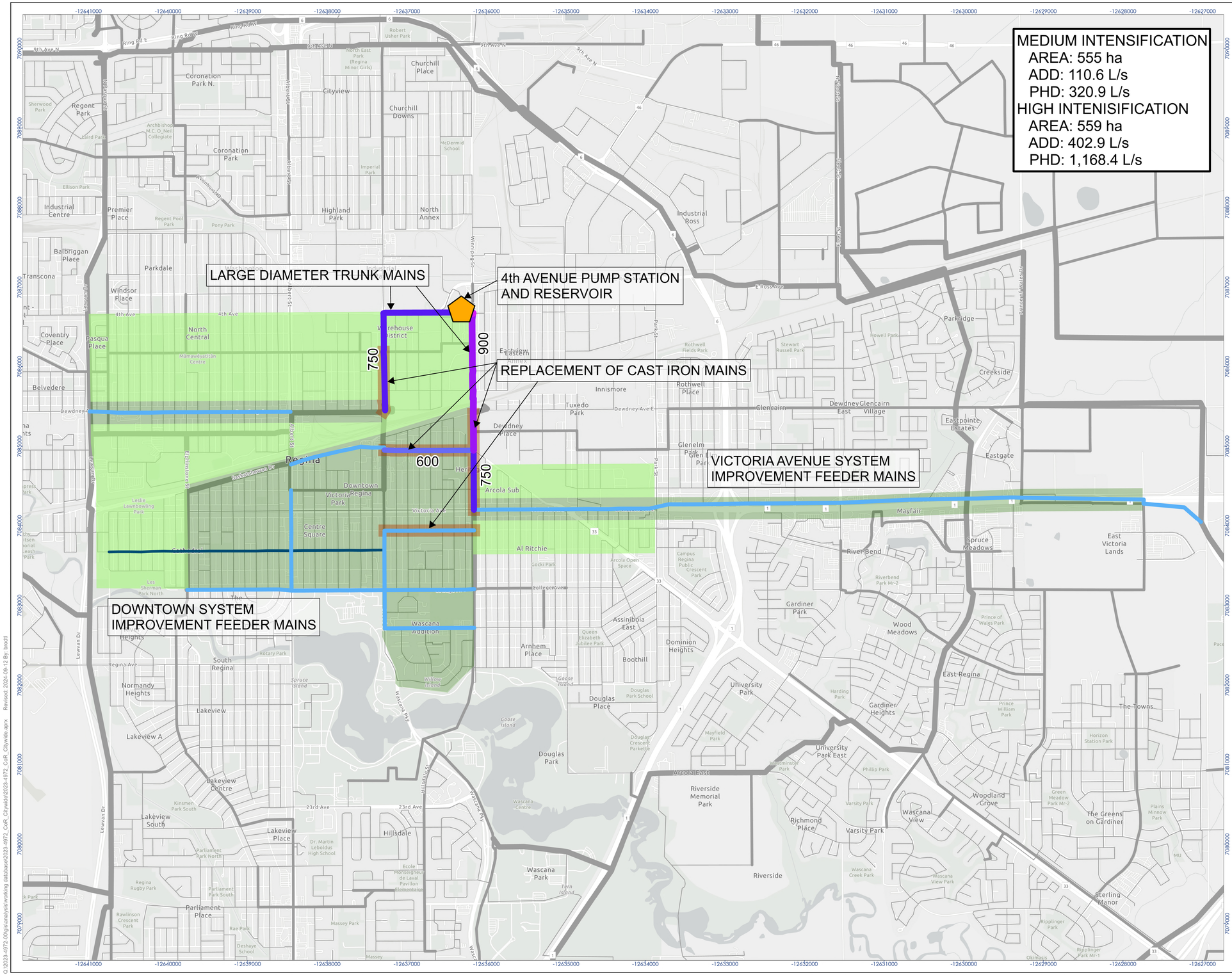
Reference Figure / Location	Infrastructure	Sequence	Trigger	Benefit / Purpose	Cost
5-1 / Downtown Intensification	4th Avenue Pump Station and Reservoir	Short-term	Replacement of Farrell Pump Station	A pump station dedicated to the supply of downtown and the surrounding areas will provide a consistent level of service allowing for intensification. If the 4th Ave Reservoir is not repairable, the existing reservoir could be demolished and a smaller underground reservoir could be constructed along with the 4th Ave Pump Station above the reservoir. The cost to construct a reduced reservoir is included into the estimate.	$ 54.5M
	Replacement of Cast Iron Mains	Short-term	Intensification and system improvements	The replacement and upsizing of cast iron mains can be strategically planned through the City's Cast Iron Pipe Rehabilitation and Renewal Program. The upsizing of pipes where feasible and planned will provide improved distribution flow, pressure, and fire flow capacity. Replacement of cast iron mains should be planned and coordinated with the Downtown Pressure Solution.	$ 21.1M
	Large Diameter Trunk Mains	Short-term	Planned Downtown Solution	Large diameter trunk mains will be required from the 4th Avenue pump station along Winnipeg Street, 4th Ave, and Broad Street to adequately convey water from the pump station to existing trunk mains near Farrell Pumping Station and Downtown.	$ 12.5M
	Downtown System Improvement Feeder Mains	Short-term	Downtown Intensification	Additional system improvements were modelled during the analysis, and these included the upsizing of the trunk main in Winnipeg Street as well as a new feeder in 14th Avenue. These suggested feeder mains will be required for looping to maintain levels of service required for the residential intensification in the downtown area.	$ 21M
	Victoria Avenue System Improvement Feeder Mains	Medium-term	Intensification of downtown and along Victoria Avenue	The installation of this pipeline along Victoria Avenue from the Bypass Loop into downtown will enhance the level of service along the Victoria Avenue intensification areas. It will also assist in supporting the downtown with flow from the east.	$ 23.8M

Reference Figure / Location	Infrastructure	Sequence	Trigger	Benefit / Purpose	Cost
5-2 / North Intensification	North System Improvement Trunk mains	Medium-term	Intensification North of Downtown	The intensification areas North of Downtown will require large diameter trunks. The renewal will accommodate the planned intensification and increased water demand.	$ 4.9M
	North System Improvement Feeder Mains	Medium-term	Intensification North of Downtown	The intensification areas North of Downtown will require upsizing of mains to accommodate the planned residential intensification and increase in water demand. Increasing the size of existing mains will be required due to the additional demand in the intensification areas.	$ 32.6M
5-3 / South Intensification	South System Improvement Trunk Mains	Medium-term	Intensification South of Downtown	The intensification areas South of Downtown will require large diameter trunks to distribute the areas. The renewal will accommodate the planned intensification and increased water demand.	$ 5.8M
	South System Improvement Feeder Mains	Medium-term	Intensification South of Downtown	The intensification areas South of Downtown will require upsizing of mains to accommodate the planned residential intensification and increase in water demand. Increasing the size of existing mains will be required due to the additional demand in the intensification areas.	$ 20.1M
5-4 / East	East Bypass Loop	Medium-term	Increased population due to growth and continued development in the East	The residential intensification negatively influences the distribution pressure in the east due to its slightly higher elevations. A new bypass loop from the Redbear Pump Station to Arcola Avenue will maintain distribution pressure in the east allowing for continued intensification and development in the east.	$ 63.3M
	North Pressure Zone Trunk Mains	Medium-term	Increased greenfield development	The extension of the North Pressure Zone to the east just north of Victoria Avenue and Highway No. 1 will improve the level of service in this area for potential industrial development	$ 22.8M
	Redbear Reservoir Expansion	Medium-term	Approximately 315,000 population	The additional storage reservoirs at the Redbear pump station will supply the city up to a potential population of 500,000 people.	$ 137.1M
	Primary Pressure Zone Feeder Mains	Medium-term	Increased greenfield development	Feeder mains 300 mm to 450 mm diameter will form the looping required to efficiently distribute to the development lands. Costing includes the cost of 400 mm and 450 mm diameter mains only.	$ 16M

Reference Figure / Location	Infrastructure	Sequence	Trigger	Benefit / Purpose	Cost
	North Pressure Zone Feeder Mains	Medium-term	Increased greenfield development	Feeder mains 300 mm to 450 mm diameter will form the looping required to efficiently distribute to the development lands. Costing includes the cost of 400 mm and 450 mm diameter mains only.	$ 16.2M
5-5 / Southeast	Bypass Loop	Medium-term	Increased greenfield development	The connection between the City Loop at Whitmore Park to the East Bypass Loop at Arcola Avenue will unlock the area for greenfield development.	$ 30.7M
	Southeast Trunk Mains	Medium-term	Increased greenfield development	The distribution trunks will loop in the greenfield areas to sustain efficient distribution.	$ 3.6M
	Southeast Feeder Mains	Medium-term	Increased greenfield development	Feeder mains 300 mm to 450 mm diameter will form the looping required to efficiently distribute to the developed lands. Costing includes the cost of 400 mm and 450 mm diameter mains only.	$ 11.9M
5-6 / Southwest	West Bypass Loop	Medium-term	Increased greenfield development	The Bypass Loop can connect to the existing 600 mm trunk mains in Harbour Landing and reconnect to the GTH trunk main. Construction of mains will be required as development is planned in the areas west of Harbour Landing and the industrial areas south of the WWTP.	$ 34M
	Southwest Trunk Mains	Medium-term	Increased greenfield development	The distribution trunk mains will connect to Harbour Landing to improve the system for the Greenfield developments	$ 24.1M
	Southwest Feeder Mains	Medium-term	Increased greenfield development	Feeder mains 300 mm to 450 mm diameter will form the looping required to efficiently distribute to the developed lands. Costing includes the cost of 400 mm and 450 mm diameter mains only.	$ 20.9M

Reference Figure / Location	Infrastructure	Sequence	Trigger	Benefit / Purpose	Cost
5-7 / West	West Pump Station and Reservoirs	Long-term	City expansion to the North and population approaching 500,000 when additional reservoir storage is needed	Storage reservoirs will be required when the City population is nearing 500,000 people. The location should be near the Buffalo Pound supply pipelines to reduce transfer costs. A pump station will be required to distribute the water from the reservoirs. Being located near the boundary between the North Pressure Zone and Primary Pressure Zone, this pump station can service both zones. Once the west reservoirs and pump station are in operation, the North Pump Station could serve as a transfer station to transfer water to other reservoirs east and north of the City.	$ 288.6M
	West Bypass Loop	Medium-term	Greenfield development planning in the area	The bypass loop will connect to the GTH line in the south and connect to the 9th Ave North trunk main. This will maintain level of service as the development proceeds.	$ 37.7M
	9th Avenue N Trunk Mains	Medium-term	Development requirements	The large diameter trunk main will be required along 9th Avenue N to connect the North Pump station with the West Bypass Loop until the West Pump Station is required.	$ 42.8M
	West Trunk Mains	Medium-term	Greenfield development in the area	The distribution trunk mains will connect to distribution in Westerra and GTH to improve the current system as well as the Greenfield developments.	$ 1.1M
	West Feeder Mains	Medium-term	Greenfield development in the area	Feeder mains 300 mm to 450 mm diameter will form the looping required to efficiently distribute to the developed lands. Costing includes the cost of 400 mm and 450 mm diameter mains only.	$ 23.3M
5-8 / Northwest	North Loop	Medium-term	Greenfield development in the area	The North Pressure Zone will be serviced from the West Pump Station via a large diameter trunk main from the West Pump Station to approximately Rochdale Boulevard. This North Loop will distribute to the North of the City and connect back to the City distribution at Pasqua street.	$ 46.1M

Reference Figure / Location	Infrastructure	Sequence	Trigger	Benefit / Purpose	Cost
	Northwest Trunk Mains	Medium-term	Greenfield development in the area	The distribution trunk mains will connect to the existing city distribution to improve the North Pressure Zone as well as the Greenfield developments	$ 9.9M
	Northwest Feeder Mains	Medium-term	Greenfield development in the area	Feeder mains 300 mm to 450 mm diameter will form the looping required to efficiently distribute to the developed lands. Costing includes the cost of 400 mm and 450 mm diameter mains only.	$ 44.9M
Total estimated cost for the Water Serviceability for the City of Regina					$1,071.3 M



STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

- MEDIUM INTENSIFICATION
- HIGH INTENSIFICATION
- 4th AVENUE PUMP STATION
- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)
- UTILIZED CAST IRON LOCATIONS

N

0 925 1,850 metres

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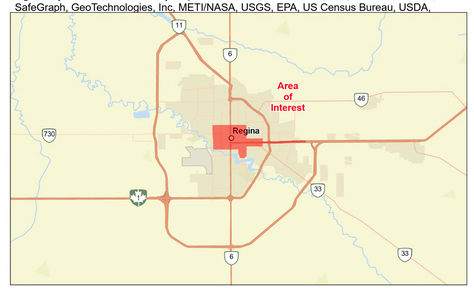
1:34,960,006

Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
Light Gray Base: Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA,



Project Location
Regina.
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

5-1

Title

DOWNTOWN INTENSIFICATION SERVICEABILITY

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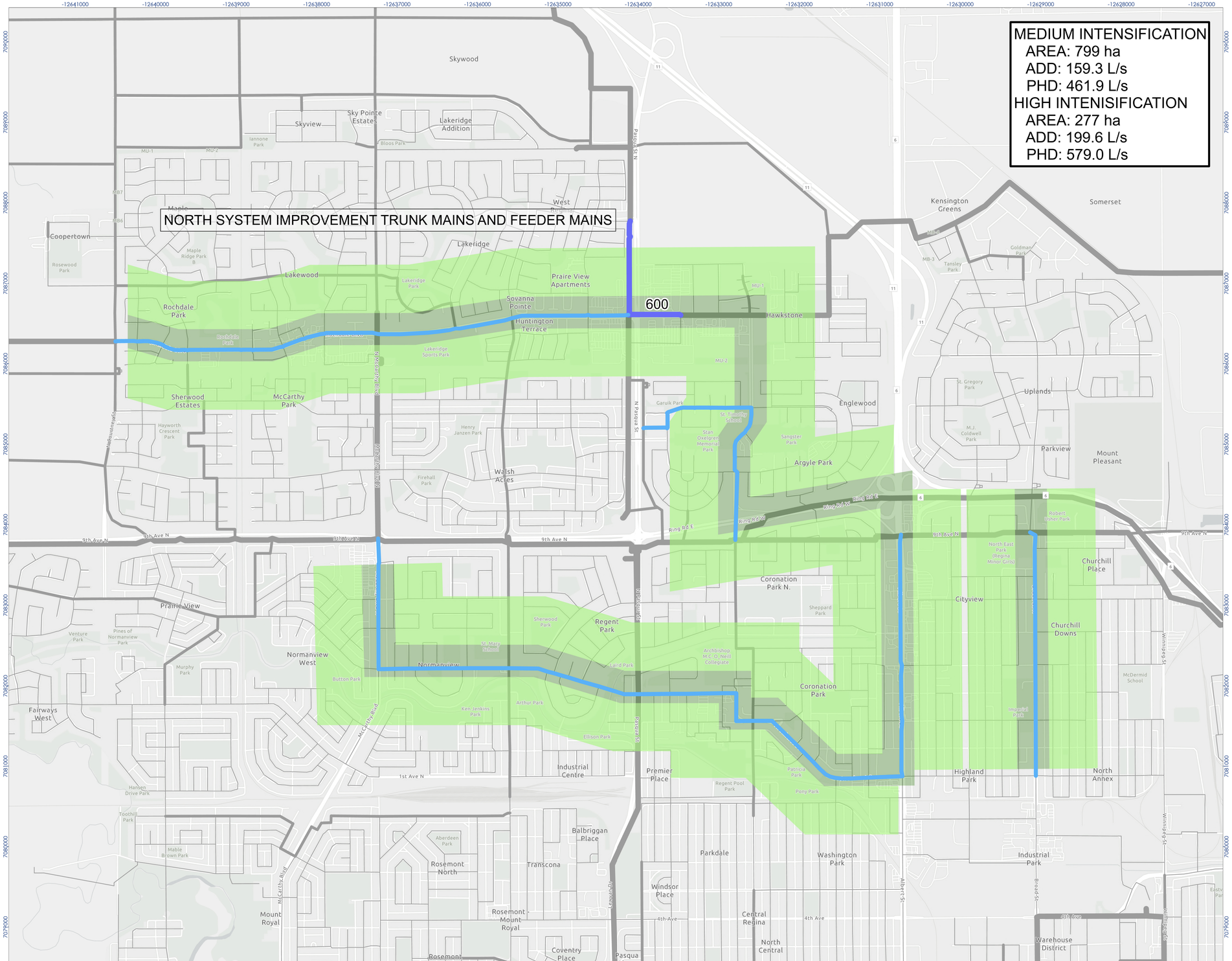


STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

- MEDIUM INTENSIFICATION
- HIGH INTENSIFICATION
- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

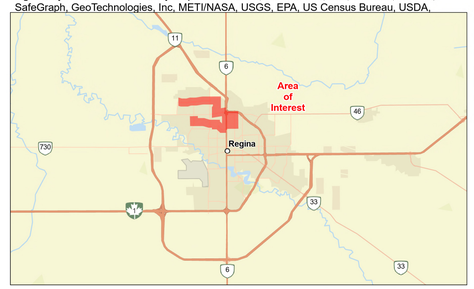
N

0 925 1,850 metres

(At original document size of 22x34)
1:34,960,006

Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
Light Gray Base: Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA,



Project Location
Regina.
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

5-2

Title

NORTH INTENSIFICATION SERVICEABILITY

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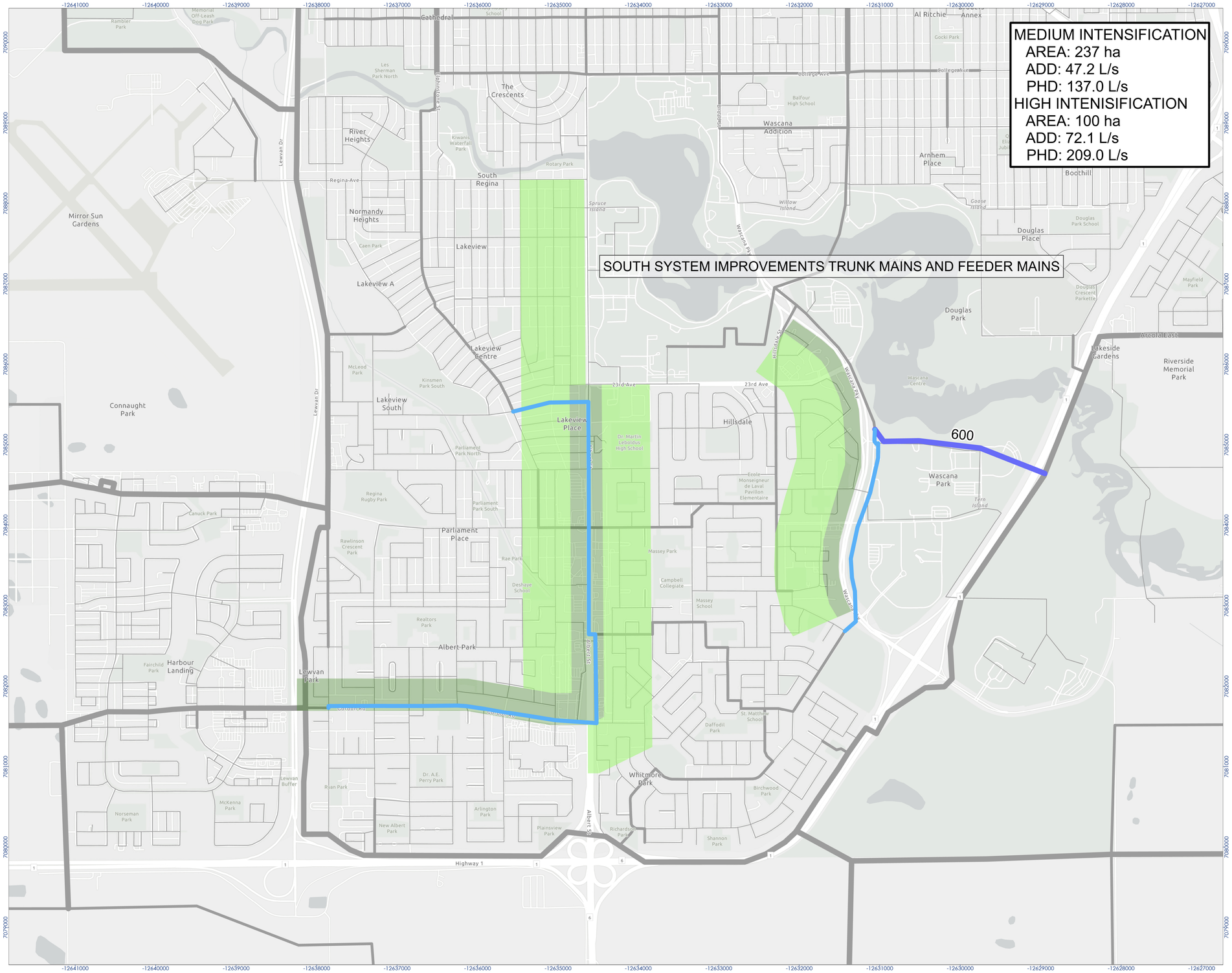


LEGEND

- MEDIUM INTENSIFICATION
- HIGH INTENSIFICATION
- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

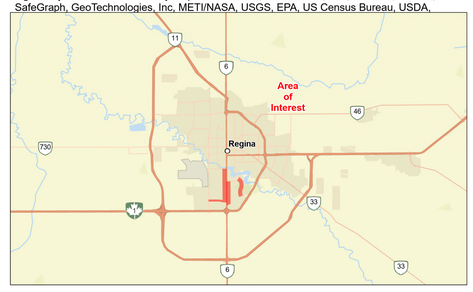
N

0 925 1,850 metres

(At original document size of 22x34)
1:34,960,006

Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
Light Gray Base: Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA,



Project Location
Regina.
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

5-3

Title

SOUTH INTENSIFICATION SERVICEABILITY

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COMMERCIAL LAND USE
AREA: 144 ha
ADD: 19.0 L/s
PHD: 55.2 L/s
INDUSTRIAL LAND USE
AREA: 1,017 ha
ADD: 51.5 L/s
PHD: 149.4 L/s
RESIDENTIAL LAND USE
AREA: 447 ha
ADD: 68.6 L/s
PHD: 199.1 L/s

243 ha
267 ha
600
1200
1050
84 ha
260 ha
60 ha
111 ha
900
46 ha
514 ha
23 ha

REDBEAR RESERVOIR EXPANSION

NORTH PRESSURE ZONE
TRUNK MAINS AND FEEDER MAINS

EAST BYPASS LOOP

PRIMARY PRESSURE ZONE FEEDER MAINS

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE
- REDBEAR PUMP STATION

LAND USE
- COMMERCIAL
- INDUSTRIAL
- RESIDENTIAL
- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

N

0 925 1,850 metres
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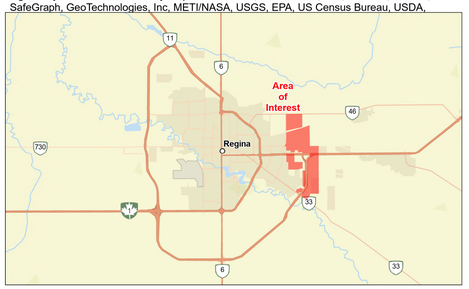
Notes
1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
Light Gray Base: Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA,



Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.
5-4

Title
EAST SERVICEABILITY

Q:\2023-4972-00\gis\analysis\working database\2023-4972_CoR_Citywide\2023-4972_CoR_Citywide.aprx Revised: 2024-09-12 By: bnotti

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COMMERCIAL LAND USE
AREA: 440 ha
ADD: 57.9 L/s
PHD: 167.9 L/s
RESIDENTIAL LAND USE
AREA: 1,726 ha
ADD: 264.7 L/s
PHD: 767.5 L/s

26 ha

750

BYPASS LOOP

600

SOUTHEAST TRUNK MAINS AND FEEDER MAINS

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

LAND USE
- COMMERCIAL
- INDUSTRIAL
- RESIDENTIAL

- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

N

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(At original document size of 22x34)
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Notes
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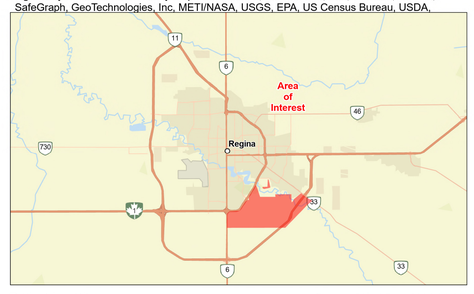
Light Gray Base: Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, US Census Bureau, USDA,



Project Location
Regina.
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.
5-5

Title
SOUTHEAST SERVICEABILITY

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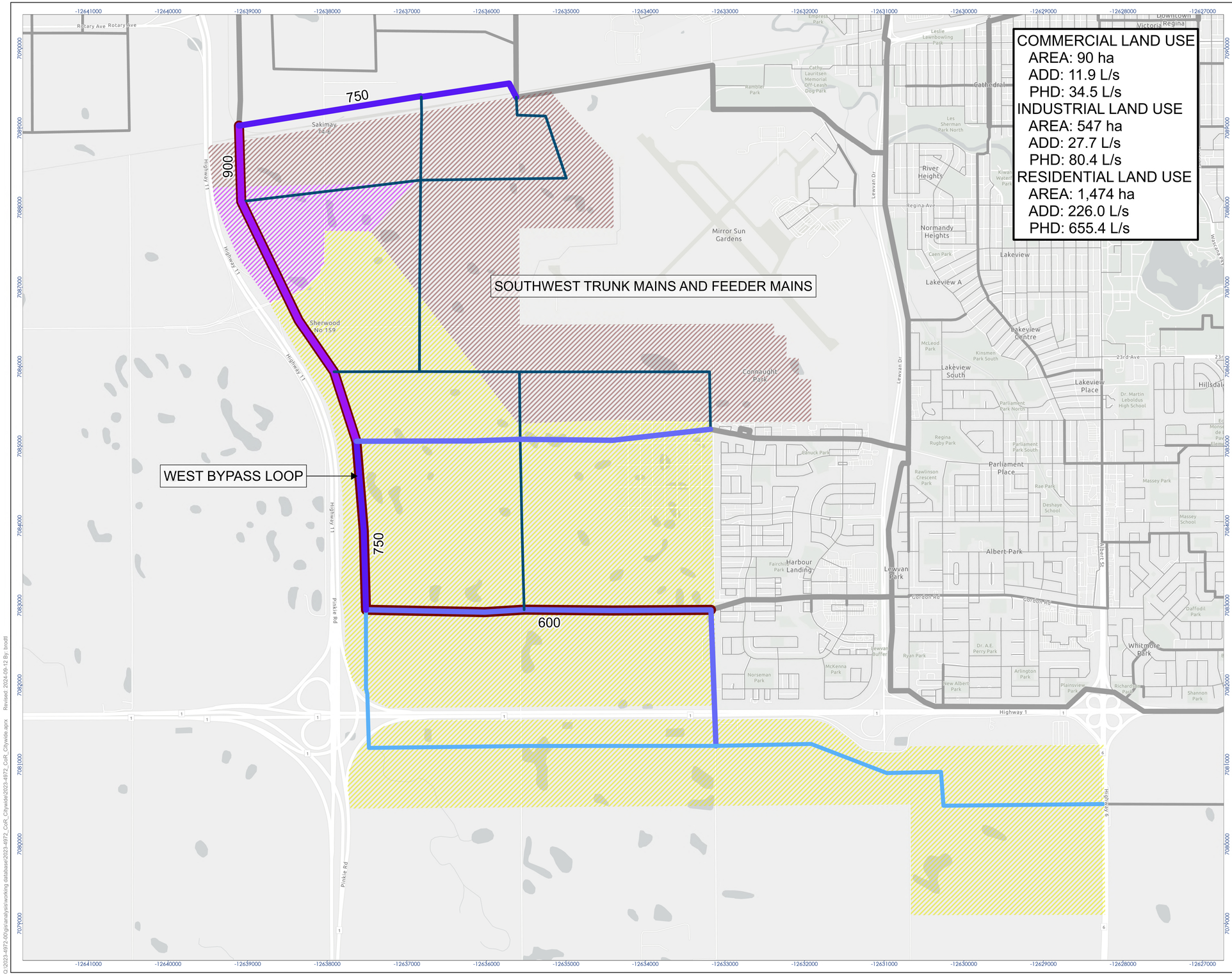

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

LAND USE
- COMMERCIAL
- INDUSTRIAL
- RESIDENTIAL

- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

N

0 925 1,850 metres

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Notes

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2. Data Sources:

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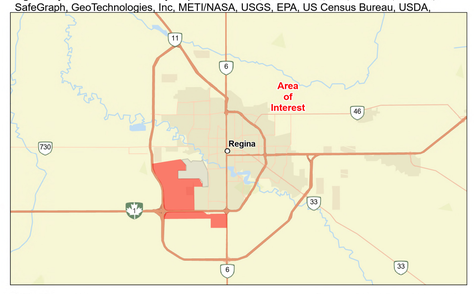

Project Location
Regina.
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

5-6

Title

SOUTHWEST SERVICEABILITY

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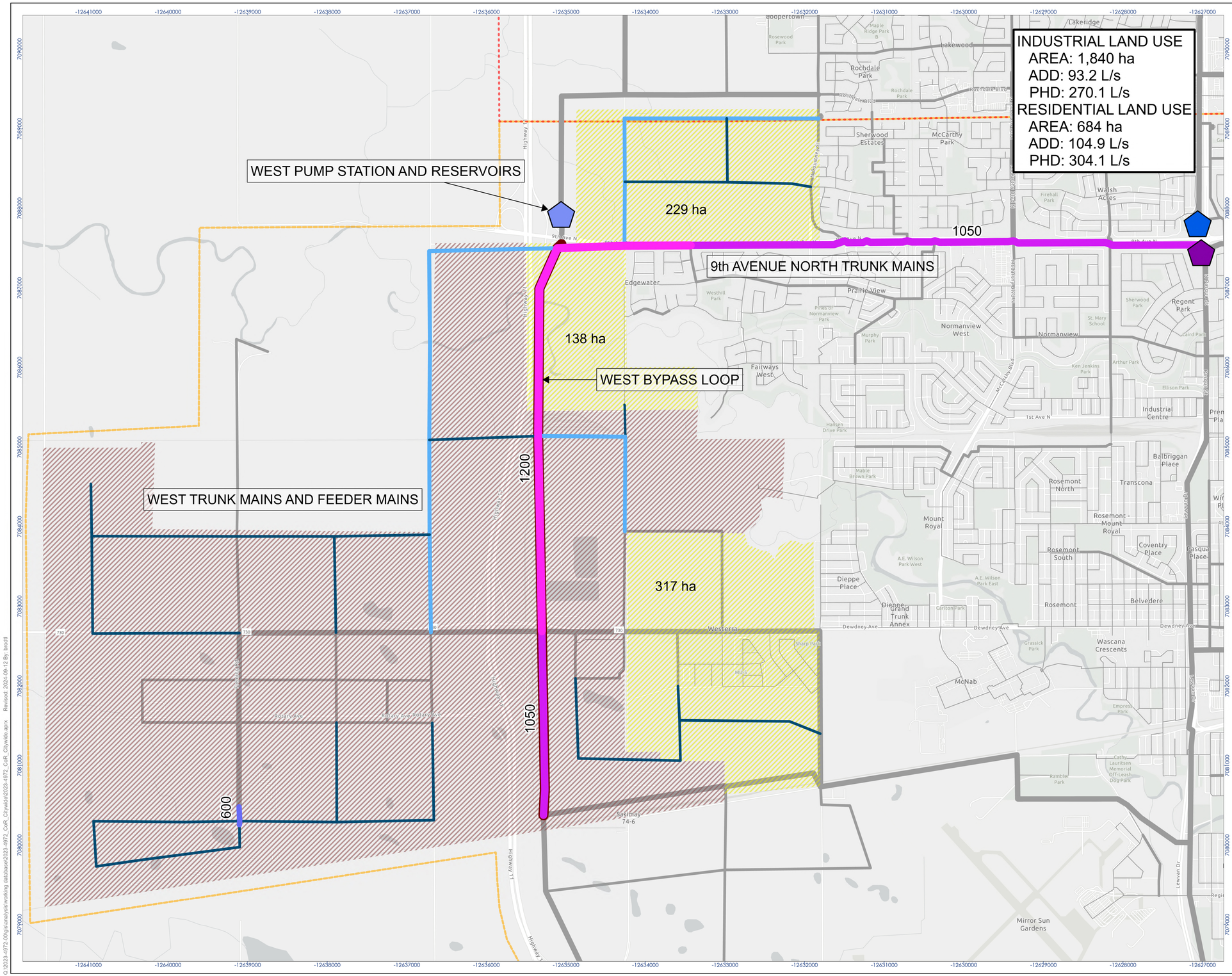

STONE & ARROW CONSULTING LP

Stantec

Associated Engineering

LEGEND

- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE
- WEST PUMP STATION
- NORTH ZONE PUMP STATION
- NORTH TRANSFER STATION

LAND USE

- COMMERCIAL
- INDUSTRIAL
- RESIDENTIAL
- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

N

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Notes

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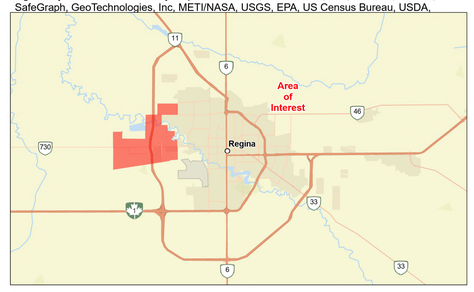

Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project

City of Regina
Water and Waste Water Serviceability

Figure No.

5-7

Title

WEST SERVICEABILITY

Q:\2023-4972-00\gis\analysis\working database\2023-4972_CoR_Citywide\2023-4972_CoR_Citywide.aprx Revised: 2024-09-12 By: brodfi

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INDUSTRIAL LAND USE
AREA: 153 ha
ADD: 7.8 L/s
PHD: 22.5 L/s
RESIDENTIAL LAND USE
AREA: 1876 ha
ADD: 287.7 L/s
PHD: 834.2 L/s

NORTHWEST TRUNK MAINS AND FEEDER MAINS

NORTH LOOP

600

750

900

WEST PUMP STATION AND RESERVOIRS

Albatross
Highway 11
Skywood
Skyview
Sky Pointe Estates
Lakeridge Addition
Maple Ridge
Goopertown
Lakewood
West Regina
Lakeridge
Rochdale Park
Sovanna Pointe
Kensington Greens
Hawkstone
Englewood
Argyle Park
Sherwood Estates
McCarthy Park
Walsh Acres
Edgewater
Prairie View
Coronation Park N.
Cityview

-12641000 -12640000 -12639000 -12638000 -12637000 -12636000 -12635000 -12634000 -12633000 -12632000 -12631000 -12630000 -12629000 -12628000 -12627000

7090000 7089000 7088000 7087000 7086000 7085000 7084000 7083000 7082000 7081000 7080000 7079000

LEGEND
- PRIMARY PRESSURE ZONE
- NORTH PRESSURE ZONE
- WEST PUMP STATION

LAND USE
- COMMERCIAL
- INDUSTRIAL
- RESIDENTIAL
- 300 mm
- 400 mm
- 600 mm
- 750 mm
- 900 mm
- 1050 mm
- 1200 mm
- SMALL DIAMETER (LESS THAN 300)
- FEEDER MAINS (300 - 450)
- TRUNK MAINS (GREATER THAN 450)

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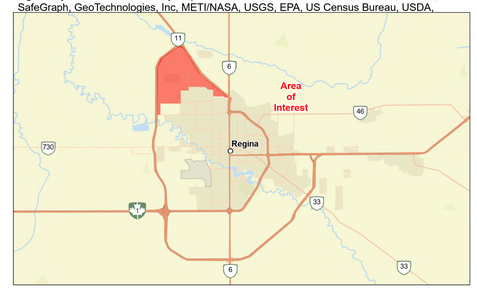

Project Location
Regina
Saskatchewan

Prepared by LB on 2024-04-22

Client/Project
City of Regina
Water and Waste Water Serviceability

Figure No.
5-8

Title
NORTHWEST SERVICEABILITY

Q:\2023-4972-00\gis\arcgis\working database\2023-4972_CoR_Citywide\2023-4972_CoR_Citywide.aprx Revised: 2024-09-12 By: brodtl

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5.2 Wastewater Collection System

The OPC for wastewater collection infrastructure suggest that the areas depicted in Figure 2-1 can be effectively serviced through carefully planning the upgrades for the Ultimate Scenario. For the system to accommodate the residential intensification, the existing wastewater collection system will require upgrades to either the McCarthy Boulevard or 7th Avenue Trunk Mains. For the complete study area which includes greenfield development, new catchments are proposed in the northwest and southwest, south, and southeast to bypass the existing wastewater collection system to minimize impacts of adding greenfield development to the existing system.

Table 5-2 summarizes the proposed wastewater infrastructure. Figure 4-10 and Figure 4-11 illustrate the infrastructure needed and should be used as reference when reviewing Table 5-2.

Table 5-2: Serviceability Summary of the Existing with Intensification

Reference Figure / Location	Infrastructure	Sequence	Trigger	Benefit / Purpose	Cost *
4-10 / North of Downtown and Downtown	Option 1 - McCarthy Trunk Upgrades	Short-term	North and Downtown Intensification and greenfield development in the northeast	To service intensification downtown and north of downtown and greenfield development in northeast including Fleet Street Business Park and Foxtail Grove. Only includes upgrades up to existing City limits. Upgrades to McCarthy trunk and storage tank improve existing levels of service and allow for both intensification and greenfield development.	$ 152M
4-11 / North of Downtown and Downtown	Option 2 - 7th Avenue Trunk Upgrades	Short-term	North and Downtown Intensification and greenfield development in the northeast	To service intensification downtown and north of downtown and greenfield development in northeast including Fleet Street Business Park and Foxtail Grove. Only includes upgrades up to existing City limits. Upgrades to 7th Avenue trunk and storage tank improve existing levels of service and allow for both intensification and greenfield development.	$ 172M
4-10 / 4-11 / Northwest	Coopertown Pump Station and Associated Trunk Mains	Medium-term	Greenfield development in the northwest	To service greenfield development in the northwest. Bypassing the MBPS significantly reduces impacts on the existing trunk and sewer systems.	$ 167M
4-10 / 4-11 / Southwest, South, and Southeast	Harbour Landing West, South, and East Pump Stations and Associated Trunk Mains	Medium-term	Greenfield development in the southwest, south, and southeast	To service greenfield development in the southwest, south, and southeast. Bypassing the MBPS significantly reduces impacts on the existing trunk and sewer systems.	$ 434M
4-10 / 4-11 / North	Rochdale Trunk Main Upgrade	Medium-term	Greenfield development in the north and northeast	To service greenfield development in the north and northeast. Includes Skyview, Hawkstone, Kensington Greens, Somerset, Viterra, and FCL. Upgrades are based off of the Serviceability Study Wastewater Catchment Area and Water Network Expansion for North Regina Report.	$ 45M

4-10 / 4-11 / Northeast	Northeast Trunk Mains	Medium-term	Greenfield development in the northeast	To service greenfield development in the northeast. Includes Fleet Street Business Park and Foxtail Grove. With upgrades to the McCarthy Trunk or 7th Avenue Trunk there is capacity to extend service to the northeast.	$ 37M
4-10 / 4-11 / East	Interconnection Upgrade	Medium-term	Greenfield development in the east	To service greenfield development in the east. Includes Tower Crossing, Aurora, The Towns, and Eastbrook. Upgrades to the Inter-connection eliminates the need for storage beyond what already exists within the Towns, Eastbrook, and Aurora.	$ 7M
Total estimated cost for the Wastewater Serviceability for the City of Regina*					$ 861M

* Does not include cost of Option 1

6 Conclusions

The Serviceability Study developed a strategy for the city to service the planned intensification and greenfield development areas which includes residential, commercial, and industrial developments as shown in Figure 2-1. The infrastructure that will be required for the City's system to function will be significant and will require sequential planning for the system to maintain the levels of service, established by the City.

The infrastructure improvements identified in the Serviceability Study differ from previous studies as the scope and scale of this study greatly exceeds any of the previous individual serviceability studies completed on behalf of the City. Previous studies were generally limited to a maximum population threshold of 300,000 people and were typically limited to specific geographic areas of the City.

Following the analysis and serviceability assessment completed herein, the following conclusions can be drawn.

6.1 Water Distribution System

The analysis considered the increase in water demand from the current 88 ML/d to a future projected demand of 260 ML/d. The study found several areas with deficiencies in system capacity to accommodate planned of residential intensification and greenfield development. Other findings demonstrated components of the water system that are functioning well or will be functioning well in the near term to accommodate future demands. One of the most significant findings of the study was the need for a downtown pressure solution given the aging infrastructure in this area and the increased demand resulting from planned intensification. The following summarizes our conclusions:

- Completion of the Redbear Pump Station and the implementation of the East Pressure Solution Project will provide significant improvement of distribution pressures and level of service within the eastern areas of the water distribution system.
- The completion of the Redbear Pump Station and Reservoirs and East Pressure Solution Project will provide the City some flexibility for residential intensification to commence. However, as intensification proceeds, pressures will begin to drop downtown, east, and southeast requiring further improvements within the downtown and in the east.
- The analysis found that with the aging condition of the Farrell Pump Station and the fact that the 4th Avenue Reservoir is currently leaking, a Downtown Pressure Solution is needed to meet both current demands and further intensification. Analysis identified two potential options for a Downtown Pressure Solution including:
    - Option 1: A downtown pumping facility and replacing the 4th Ave Reservoir; or
    - Option 2: Reroute flow and connections to supply downtown.
        - Repurposing the Tor Hill and Albert Street Reservoir supply pipelines to the downtown for water distribution.

  - This may include direct connection of the Tor Hill supply pipeline to the Redbear Pump Station and the Albert Street supply pipeline to the City Loop.
  - The Albert and Tor Hill Reservoirs would need to be redirected to the North Pump Station and Red Bear Pump Station respectively.

- As part of the Downtown Pressure Solution and the need to support future intensification, there is a need to upsize some existing mains in the downtown. Given the City has a Cast Iron Replacement Program, planning should incorporate adequate pipeline sizing within this program in order to coincide with a future Downtown Pressure Solution
- Analysis of the Ultimate Scenario identified the need for a large diameter trunk main along the Regina Bypass (Bypass Loop), within the future development areas. This trunk will allow the City to expand development in the Southeast, Southwest as well as the West.
- Due to higher elevations in the City's northwest, pressure deficiencies in the northwest will occur as greenfield development proceeds in this area and a solution is needed which includes a combination of a pump station and trunk mains to service the northwest reaches of the distribution system.
- As population grows and demands increase throughout the city, additional reservoir storage is required. Given the amount of growth planned in the west and limited space at existing pump stations for additional reservoir storage, the study concluded that a reservoir and a pump station in the west will be a benefit. If this facility is situated near the Buffalo Pound Supply Pipeline the reservoirs can be filled without the need for transfer pumping as is the case with other reservoirs such as the Albert Street Reservoir, 4th Avenue Reservoir, and Red Bear Reservoirs. This will reduce operating costs. If the reservoirs and pump station are also situated near the boundary between the North Pressure Zone and Primary Pressure Zone, the pump station would have the ability to service both pressure zone reducing the need for additional infrastructure.
- With the installation of adequate trunk mains, the existing North Pump Station can serve the west development over the short to medium term. Once the west reservoirs and pump station are constructed, the North Pump Station could be repurposed to be a transfer station to transfer water to other reservoirs in the City.

6.2 Wastewater Collection System

The greenfield developments will add approximately 12,000 hectares that includes residential, commercial, and industrial developments and 314,000 residential population. Another 328,000 adjusted residential population will be added to the intensification areas. The following summarizes our conclusions:

- As part of the analysis available as-built drawings of recent upgrades to the City's wastewater collection system were reviewed. The City's ICM model was updated to incorporate recent upgrades. For example, the Creek PS was updated to incorporate three additional pumps based on record drawings. In addition, the South Trunk was twinned based on preliminary drawings provided by the City. All existing results presented in this report are based on these two updates.

It was also verified that the existing MBPS and its force main, GTH PS, storage tank and force main of the Creeks PS, etc. were already incorporated to the City's ICM model.

- The impact of intensification on the wastewater collection system before any upgrades was found significant in the central intensification areas that include North Central, Warehouse District, and Eastview areas. The north and south intensification areas did not show noticeable impact to the collection system in terms of pipe capacity and overflow volumes.

- To service the majority of greenfield areas in the east, southeast, south, southwest, and northwest of the City, new trunk systems were added. The new trunk systems will discharge to the WWTP through new pump stations instead of using the MBPS. The new trunk system for the southeast, south, and southwest will need three lift stations south of the City to limit the sewer depth to 8.0 m. The new trunk system for the northwest will require one lift station.

- To service north industrial areas including Viterra and FCL, the existing Rochdale trunk will need to be upsized to 1200 mm from Devonshire Drive N to Pasqua Street N.

- The proposed intensification at central areas south of the CP Railway and developments at Aurora, The Towns, Eastbrook and Tower Crossing caused Garnet Street overflow to spill. To mitigate that, approximately 840 m length of interconnection trunk connecting Wascana Trunk and twinned South Trunk will need to be upsized to 1500 mm diameter sewer. This upgrade helped to eliminate overflow at Garnet Street directing more sewage to the twinned South Trunk. While this differs from the recommendations in the Southeast Lands Wastewater Serviceability Report (Stantec, 2016) it provides a more wholistic solution for the City's wastewater collection system.

- To service industrial and residential greenfield areas northeast of the City and to resolve existing capacity issues in the North Central, Warehouse, and Eastview areas impacted by intensification, two upgrade options were proposed: Option 1 and Option 2.

    - As per Option 1, the McCarthy trunk will be upsized to 1500 mm and 1800 mm diameter sewer for 6.4 km of its length. Another 2.0 km length will be upsized at tie-in locations to the greenfield developments. To resolve capacity issues in the downtown area due to intensification, another 3.0 km length of sewer will need to be upsized on Angus Street and 7th Avenue.

    - As per Option 2, the 7th Avenue trunk will be upsized to 1200 mm diameter sewer to 7.3 km of its length. Another 4.3 km new sewer will need to be installed to tie-in greenfield areas to the 7th Avenue Trunk.

- The proposed trunk upgrades and added flows appear to increase the HGL in the low-lying manholes at the McCarthy Boulevard Bridge location near Wascana Creek, which in turn triggers spilling to the creek. This spilling and Garnet Street overflows limit flow to the MBPS to approximately 7.0 m^3/s. To avoid spilling to the creek, an offline storage unit will be recommended in the floodplain area in the vicinity of the MBPS, which will get sewage only in significant wet weather events. The storage unit will be an underground vault with a dedicated

pump station and odour control device installed. The required storage volume is 20,000 and 21,400 m^3 for Option 1 and Option 2, respectively.

- Analysis of the Ultimate Scenario identified the MBPS has sufficient capacity to service the new intensification and greenfield development based on both Option 1 and Option 2 for the Ultimate Solution Development and assumption that new greenfield development bypasses MBPS as identified.
- The existing WWTP does not have sufficient capacity to manage peak DWF for the Ultimate Development Scenario. The City will need to increase the capacity of the WWTP from 197 ML/day to approximately 454 ML/day. Treatment capacity (targeted at typical DWF plus an appropriate safety factor) and storage capacity (i.e. lagoons sized to accommodate the appropriate WWF design event) will need to increase significantly to accommodate the flows generated in the Ultimate Scenario.

7 Recommendations

Based on the conclusions noted herein, the following recommendations have been prepared with the acknowledgement that development of the identified scenarios is expected to take decades and that the intent of the Serviceability Study is to provide guidance to the City and developers with respect to the water and wastewater infrastructure required to meet the objectives of the OCP, Housing Accelerator Fund commitments, Energy and Sustainability Framework and other key guiding policy documents.

It is understood the resources of the recommended infrastructure will likely limit the City's ability to proceed with multiple recommendations concurrently. Therefore, prior to proceeding with any of the below recommendations in part or whole, it is recommended that as a next step, the City review all of the recommendations identified below and prioritize them in alignment with the City's objectives.

The analysis identified three general themes:

Existing Level of Service

- The City should continue to prioritize rehabilitation of existing infrastructure to maintain existing levels of service. Opportunity exists to strategically upsize water and sewer mains in support of intensification as part of existing infrastructure replacement programs such as the Cast Iron Replacement and Rehabilitation Program.

Intensification

- The existing water and wastewater infrastructure can generally support the immediate development of intensification in certain areas without negatively impacting existing levels of service. Therefore, the City should prioritize intensification to maximize the use of existing infrastructure. However, applying the current development standards on intensification development will limit the City's ability to achieve the desired intensification goals as the water and wastewater systems in intensification areas were not designed to meet current development standards. Intensification development should be reviewed on a case-by-case basis with it's impact on the City's existing infrastructure compared to its overall socio-economic benefit to the City.

Greenfield

- Based on the location of the WTP, WWTP, associated water and wastewater infrastructure and the general topography of the City, it is likely more cost-effective to prioritize greenfield development on the west side of the City.

7.1 Water Distribution System

The following short-term recommendations are needed to maintain or improve upon the current level of service with proposed intensification:

- A dedicated pressure solution is required for Downtown. This can be achieved through two possible options:
    - Option 1: a new downtown reservoir and 4th Avenue pump station for an estimated cost of $54.5M.
    - Option 2: repurpose the Tor Hill and Albert Street Supply pipelines as water distribution mains from the Redbear pump station for an estimated cost of $84.2M.

  Based on the capital cost analyses, a 4th Avenue pump station with reduced reservoir size is the more cost-effective option for the City. We recommend that these options be studied further to confirm the best solution for the City including a life cycle cost analysis. Given the age of the Farrell Pump Station, the planning for the Downtown Pressure Solution should commence immediately to allow for water system planning and budgeting.

- The existing cast iron mains in downtown be upsized through the City's rehabilitation and renewal programs. Predesign studies of these proposed trunk main rehabilitation or replacement needs to consider the plan for future intensification and the Downtown Pressure Solution. Estimated cost is $21.1M.

The water distribution infrastructure required for the Ultimate Scenario is development driven and can be implemented in stages to service areas as development proceeds. This will require planning from the City to ensure that infrastructure is available when needed. The following are medium to long term recommendations which the City needs to consider for the Ultimate Scenario:

- The existing mains north and south of downtown be upsized to allow for intensification of these areas. The sizing of these mains will be required as intensification proceeds and should be planned accordingly. The estimated cost is $63.4M.

- As intensification and development in the east continues, distribution pressures in the east and southeast will begin to drop. To rectify this, a large diameter trunk main should be installed from the Redbear site to Arcola Avenue (i.e. East Bypass Loop) to ensure an adequate level of service to the southeast. The estimated cost is $63.3M.

- A large diameter trunk (Bypass Loop) that follows the alignment of the Bypass will be required to service the planned Ultimate Scenario greenfield developments. This trunk can be constructed in sections as development proceeds. This will allow the City to stage the construction of the Bypass Loop as needed and where development is planned. The Bypass Loop will extend from the East Bypass loop around the south side and west side of the City ending near 9th Avenue North. The estimated cost is $ 102.4M.

- Prior to the construction of the West pump station, the North Pump Station will continue to service the west development. When needed to meet increased growth in the west and when portions of the West Bypass Loop have been or are being constructed, a large diameter trunk from the North Pump Station shall be constructed along 9th Avenue N to the West Bypass Loop. The estimated cost of the 9th Ave N trunk main is $42.8M.

- The North Pressure Zone is to be extended to the east along the Regina Bypass up to Victoria Avenue and Highway No. 1. This will meet the servicing requirements and allow additional industrial development to take place in the northeast. The estimated cost for this extension into the east is $22.8M.

- The construction of additional storage reservoirs will be required prior to the City population reaching 500,000 people. The additional reservoirs could be constructed in either the west or the east at the Red Bear location.
    - Expansion of the Redbear storage by 150 ML. The estimated cost is $137.1M.

    - New reservoirs shall be constructed in the adjacent to the Buffalo Pound Supply Pipelines near the West Regina Bypass at an estimated size of 150 ML. The estimated cost of the reservoirs is $136.1M.

- When the west reservoirs are constructed, a West pump station shall be constructed with the purpose of servicing both the Primary Pressure Zone and the North Pressure Zone. The pump station would be connected to the West Bypass loop and the 9th Avenue N trunk main. The estimated cost of the West Pump Station is $152.5M.

- The estimated cost to connect the North Pressure Zone with a trunk main from the West Pump Station is approximately $46.1M.

- Once a West Pump Station is constructed; consider utilizing the North Pump Station as a transfer station to transfer to the Albert Street Reservoirs, the Redbear Reservoirs and potentially the 4th Avenue Reservoir.

7.2 Wastewater Collection System

- Since the existing trunk and sewer system within the City has capacity deficiencies, it is recommended that the City install new trunk sewers and pump stations for the greenfield areas to bypass the existing system as much as possible. This approach will minimize the impact of greenfield development on the existing system. Installation of the new trunk sewers and pump stations can be implemented in stages to service development as development proceeds. The estimated cost is $683M.

    - It is recommended the City create a separate wastewater catchment for the northwest (North Bypass)

    - It is recommended the City create a separate wastewater catchment for the southwest, south, and southeast (South Bypass)

- The intensification demand added in this study does not appear to increase capacity deficiencies to the existing trunk and sewer system, except somewhat (see Figure 4-4, Figure 4-8 and Table 4-1 in the central intensification areas that include North Central, Warehouse District, and Eastview areas and only for the WWF scenario. The north and south intensification areas did not make any notable impact on the collection system in terms of capacity and overflow volume. Therefore, intensification should be prioritized.

- Upgrades to the existing collection system are required to service industrial and residential areas northeast of the City, to resolve existing capacity issues in the central areas impacted by intensification, and to avoid overflow at Garnet Street location. This can be achieved through two possible options:
    - Option 1: the McCarthy trunk will be upsized to 1500 mm and 1800 mm diameter sewer for 6.4 km of its length. Another 2.0 km length will be upsized at tie-in locations to the greenfield developments. To resolve capacity issues in the central areas due to intensification, another 3.0 km length of sewer will need to be upsized on Angus Street and 7th Avenue. The estimated cost is $152M.
    - Option 2: the 7th Avenue trunk will be upsized to 1200 mm diameter sewer to 7.3 km of its length. Another 4.3 km new sewer will need to be installed to tie-in greenfield areas to the 7th Avenue Trunk. The estimated cost is $172M.

Based on the cost analyses, while the 7th Avenue trunk upgrades is more expensive, it provides a greater level of service as identified in Table 4-1.

    - We recommend that these options be studied further to confirm the best solution for the City. Given the City's policies prioritizing intensification, the planning should commence immediately to allow for wastewater system planning and budgeting.

- To avoid overflows at the Garnet Street overflow location, 870 m length of trunk connecting the Wascana Trunk and the twinned South Trunk should be upsized. The estimated cost is $7M.
- An offline storage unit at Wascana Creek flood plain area in the vicinity of the MBPS should be considered as part of the Ultimate Development Scenario. This will minimize the risk of spilling sewage to the creek and eliminate the need to upgrade MBPS beyond its current capacity. Estimated cost of the storage is included in Option 1 and Option 2 costing.
- Expansion of the treatment and storage capacity of the WWTP and its lagoons will be required as the WWTP and lagoons do not have sufficient capacity for the ultimate full buildout scenario DWF or WWF.

8 Closing

As identified above, the Serviceability Study provides water and wastewater servicing recommendations for the City to grow well beyond the 500,000-population target identified in the OCP. This is intended to create a long-term vision for the City to allow the City ultimate flexibility in its planning and financing of long-term infrastructure solutions to support growth.

The conclusions and recommendations in the Serviceability Study identify the necessary water and wastewater infrastructure to service new growth with a total cost of approximately $2B. These costs will require a combination of municipal, provincial, federal, and private development investment over the next several decades to plan, design, and build the infrastructure needed to support the new growth identified in the Serviceability Study.

We look forward to having further discussions with the City.

Appendix A Background Information Review and Gaps Analysis

Memo

To:	Stacey Kaminski, P.Eng. City of Regina	From:	Curtis Wiebe, P.Eng. Stone & Arrow Consulting LP
Project/File:	Water and Wastewater Serviceability Study – East, City Center and West 111260018	Date:	March 14, 2024

Reference: Water and Wastewater Serviceability Study – East, City Center and West Background Information Review and Gaps Analysis

Objective

The purpose of this memo is to present a summary of the background information provided by the City of Regina (City) to date and identify any gaps that would impact the water and wastewater serviceability study that will be based significantly on this background information.

Information Provided to Date

Attached is an Excel spreadsheet bibliography ("Information Provided" tab) listing all the information that the City has provided to date. Each entry in the bibliography contains the following fields:

- Document Title
- Published Date
- Author / Publisher
- Infrastructure Type
- Comments
- Action Required
- Link to Document
- City of Regina Input

This final field provides the City team to respond to requests in the "Action Required" field.

Some entries describe a large category or set of documents (e.g., "Water Model Files"), but most refer to single reports and similar documents.

There are some gaps within and between these documents and the "Action Required" field in the bibliography draws attention to the gaps to be addressed in the information provided to date.

Reference: Water and Wastewater Serviceability Study

Required Information

Based on our team's understanding of the available information that could support our work on this project, the following categories of information still need to be obtained:

- LiDAR of the project extents
    - Known LiDAR requirements are included on the "LiDAR Required" tab in the spreadsheet linked to previously; additional follow-up required
- Relevant GIS data not currently available publicly
- Neighbourhood Plans not currently constructed and recorded
- Concept Plans (in AutoCAD format if available)
- Recent utility record information not yet incorporated into other larger datasets
- Proposed infrastructure upgrades not included in other datasets

If the City has information to provide in these categories, it can be added in new folders on the SharePoint/Teams site here.

Closure

PDF printouts of the referenced spreadsheets are attached to this memo for your information.

Please do not hesitate to contact the undersigned with questions about this memo or if you have trouble getting access to the shared file locations.

Respectfully,

STONE AND ARROW CONSULTING LP

on behalf of,

Curtis Wiebe P.Eng.
Senior Associate, Water
Phone: 306-781-6487
Mobile: 306-533-7441
curtis.wiebe@stantec.com

Attachment: Bibliography of Background Information, LiDAR Required

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Water and Wastewater Serviceability - Bibliography of Background Information

Document Title	Published Date (YYYY-MM-DD)	Author / Publisher	Study Area	Infrastructure Type (Water, Wastewater, Both)	Comments	Action Required? (Description/No)	Link to Document	City of Regina Input
Yards Neighbouhood Plan; OCP - Part B.18	1/29/2020	City of Regina	City Centre	Both	Neighbourhood Plan	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
Saskatchewan Drive Corridor Plan; OCP - Part B.21	7/4/2023	City of Regina; Karen Gasmo; Deborah Bryden; Tyler Yuhasz	City Centre	Both	Neighbourhood Plan	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	Project timeline deferred.
Catalyst Committee Report	3/1/2023	City of Regina; Amber Ackerman; Jim Nicol	City Centre	Both	Catalyst Committee Report identifying projects and project priorities	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No aditional information at this time.
Report - Cast Iron Trunkmain Rehabilitation - Evaluation of Renewal Methods	1/1/2020	Associated Engineering; Michael Binns	City Centre	Water	Engineering report with renewal methodology recommendations	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information at this time.
Design Basis Memorandum - 4th Avenue Pumping Station - 4th Avenue Primary Trunk	9/23/2023	Associated Engineering; Rahim Ahmad; Cory Wihlidahl; Keith Kingsbury	City Centre	Water	Design basis memorandum with recommendations for routing and timing of new trunk main construction.	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	Project timeline deferred, indefinitely. Review the need for the 4th Avenue PS through the Serviceability Study Project.
City Centre - Underutilized Lands - GIS Files	5/16/2018	City of Regina	City Centre	Both	No explanation accompanied this. Some concern given that the files seem to have been generated in 2018. This date just the modified date from the files provided by the City.	Please provide accompanying documents or explanation	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/City%20Center/Underutilized%20Land?csf=1&	The data on the ULIS lots are obtained by annual permitting data. The data provided would include the permits in 2022. If the data for 2023 is completed early in the new year, the city will update that information as required. Confirming if additional assumptions were considered
Taylor Field - Water Design Brief (Draft)	1/1/2019	City of Regina	City Centre	Water	Document in "Draft" status - need to request Final version if available	Please provide "Final" document	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	The first serviceability study draft has been recently submitted to the city. The city would like to formally review this submission prior to being distributed. Follow up required.
Taylor Field - Wastewater Design Brief (Draft)	1/1/2019	City of Regina	City Centre	Wastewater	Document in "Draft" status - need to request Final version if available	Please provide "Final" document	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	The first serviceability study draft has been recently submitted to the city. The city would like to formally review this submission prior to being distributed. Follow up required.
Downtown Serviceability Study Figure 1.2 Shape File	N/A	City of Regina	City Centre	Both	GIS files without accompanying documentation.	Please provide accompanying documents or explanation	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	Accompanying information can be found in Appendix A of the Downtown Serviceability Study in the pre-submission documents folder.
Dewdney Avenue Rehabilitation Project - Preliminary Design Final Report	10/7/2022	KGS Group; Nathan Gray; Sean Bayer	City Centre	Both	Pre-Design Report	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
Dewdney Avenue Rehabilitation Project - Preliminary Design Final Report - Technical Appendices	10/7/2022	KGS Group; Nathan Gray; Sean Bayer; Destiny Piper; Jenae Nixon; Michael Badger; Lee Peters	City Centre	Both	Pre-Design Report	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
11th Ave Corridor Folder	11/7/2022	City of Regina	City Centre	Both	Empty folder - no files included	Please provide documents or explanation	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/City%20Center/11th%20Ave%20Corridor?csf=1&web=1&e=eNTa8k	Project deferred. Still moving forward with predesign completion date of end of January/early February. S&A required to confirm servicing information on 11th Ave for this work to proceed. Deadline for information, the second week of January. The most recent information has been included in the 11th Ave Corridor folder, however, this information is being reviewed, confirmed, and updated through the predesign process.
Wascana Centre 2016 Master Plan	3/10/2016	DTAH; Wascana Centre Authority; Roger du Toit; Brent Raymond; Peter Fletcher Smith; Robert N. Allsopp	East	Both	Recent master plan	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	Most recent Master Plan. An updated Master Plan is currently being drafted, has not been circulated to the City of Regina to our knowledge.
Design Brief - Draft Eastern Pressure Solution Water Suppy Main	2/14/2023	AECOM; Kevin Ness	East	Water	Draft version (document says "Note: The final version is expected to be submitted by end of October 2023) - need to request final version.	Please provide "Final" document	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	The final report has been provided in the following folder Background Information > East > EPS > Final.
Design Brief - Final Eastern Pressure Solution Redbear Avenue Pumping Station and Reservoirs	8/25/2023	AECOM; Kevin Ness	East	Water	N/A	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
Wastewater Capacity Upgrades - South Trunk Preliminary Design Report - Final	5/9/2023	AECOM; David Enns; Keith Fitchett	East	Wastewater	N/A	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.

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Water and Wastewater Serviceability - Bibliography of Background Information

Document Title	Published Date (YYYY-MM-DD)	Author / Publisher	Study Area	Infrastructure Type (Water, Wastewater, Both)	Comments	Action Required? (Description/No)	Link to Document	City of Regina Input
Hydrant Flow	N/A	City of Regina	All	Water	hydrant flow data from various locations from 2010 to 2020 - each Excel file is a single hydrant test	Please provide GIS location information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Hydrant%20Flow?csf=1&web=1&e=3uH2z7	Infrastructure records via shape file have been provided in the project sharepoint folder under Background Information> Infrastructure Records - City>Water and Wastewater Serviceability Study.gdb.zip. The hydrant flow test should have a hydrant ID associated. The infrastructure records data can be used to determine hydrant location based on the Hydrant ID.
Water Model Files	N/A	City of Regina	All	Water	Water model files; link is to folder	Please provide model version information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Regina%20Growth%20Analysis%20-%20Allocations%20and%20Land%20Needs%20Analysis%20-%20October%202023%20Presentation.pdf?csf=1&web=1&e=fUZd02	Model version 10.4.0.108. Confirm if any additional information is required.
Wastewater Model Files	N/A	City of Regina	All	Wastewater	Wastewater model files; link is to folder	Please provide model version information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Regina%20Growth%20Analysis%20-%20Allocations%20and%20Land%20Needs%20Analysis%20-%20October%202023%20Presentation.pdf?csf=1&web=1&e=fUZd02	Model version is 2024.3. Confirm if any additional information is required.
CR22-107 Intensification Annual Report & Initiatives Update	9/28/2022	City of Regina	All	Both	record of council motion	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Regina%20Growth%20Analysis%20-%20Allocations%20and%20Land%20Needs%20Analysis%20-%20October%202023%20Presentation.pdf?csf=1&web=1&e=fUZd02	No additional information at this time.
Map of "Development Awareness"	N/A	City of Regina	All	Both	Legend titled, "Regina Developments Legend"; map seems to show current lands open for development	Please provide accompanying documents or explanation	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Regina%20Growth%20Analysis%20-%20Allocations%20and%20Land%20Needs%20Analysis%20-%20October%202023%20Presentation.pdf?csf=1&web=1&e=fUZd02	Development Awareness Map & Land Use Info added to Background Information>Planning?Development Awareness & Land Uses.
EX23-51 Housing Accelerator Fund	5/31/2023	City of Regina	All	Both	Recommendation from City Manager to Executive Committee to approve action plan to pursue funding through Housing Accelerator Fund	Please provide accompanying documents or explanation	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/EX23-51%20Housing%20Accelerator%20Fund%20-%20Wednesday,%20June%207,%202023.pdf?csf=1&web=1&e	City of Regina Council minutes document added to Background Information>Planning>Housing>Accelerator Fund (HAF) titled MN23-9-Accelerating Housing - Council Minutes. Amended requirements noted in minutes. Updated buffer zone map and corresponding shapefiles added to folder. Current understanding of main transit routes align with the Map 1 Growth Plan - Urban Corridors and Express Transit Corridors. The routes are: 01 - Dieppe/Westerra - Broad N, 30 - University - Rochdale, 40 - Albert express, 50 - Victoria Express, 60 - Arcola Express.
Map 1 - Growth Plan	N/A	City of Regina	All	Both	Map clipped from OCP	No	https://stantec.sharepoint.com/:i:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Regina%20Growth%20Analysis%20-%20Allocations%20and%20Land%20Needs%20Analysis%20-%20October%202023%20Presentation.pdf?csf=1&web=1&e=fUZd02	No additional information required.
Regina Growth Analysis Presentation	10/6/2023	Watson & Associates Economists Ltd.	All	Both	Note on all slides of presentation: "Note: This is the current information as of October 6, 2023, however, there will be slight adjustments made to the density projections, specifically to Sask Dr."	See comments; please provide current information if available	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Regina%20Growth%20Analysis%20-%20Allocations%20and%20Land%20Needs%20Analysis%20-%20October%202023%20Presentation.pdf?csf=1&web=1&e=fUZd02	Updated slideshow dated November 2023 added to Background Information>Planning>Regina Growth Analysis. Slide 11 - Updated timeline for when all three phases of residential growth might be built out. Key Narrative from Watson - Data incicates that the timeline for achieving a population of 300,000 and building out the residential neighborhoods in the growth plan does not line up. That is, we will achieve a population of 300,000 before all three phases of residential neighborhoods from the OCP growth and phasing plans are built out. This differs from the current version of the growth plan which is premised on the notion that building out the three phases of residential neighborhoods is needed to reach a population of 300,000 (i.e. 300,000 population and build out of the growth plan will occur the same time). Slide 12 - Suggests an additional 365 gross hectares to accommodate the projected 2051 population. Slide 24 - Indicates surplus of employment land needed to handle projected 2051 employment growth. Note - Final draft will be presented to the City in early February. No major changes anticipated that would effect the stufy.
Southeast Lands Neighbourhood Plan WaterCAD Model Analysis and Summary	8/30/2016	Stantec; Troy Libke; Karen Cossitt	East	Water	Pre-Submission Documents	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Southeast%20Lands%20Neighbourhood%20Plan%20WaterCAD%20Model%20Analysis%20and%20Summary.pdf?csf=1&web=1&e=Ka1Ffe	No additional information required at this time.
Southeast Lands: Wastewater Serviceability Concept Report	8/30/2016	Stantec; George Tsougrianis; Chad Bialobzyski	East	Wastewater	Pre-Submission Documents	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Planning/Southeast%20Lands%20Wastewater%20Serviceability%20Concept%20Report.pdf?csf=1&web=1&e=Ka1Ffe	No additional information required at this time.

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Water and Wastewater Serviceability - Bibliography of Background Information

Document Title	Published Date (YYYY-MM-DD)	Author / Publisher	Study Area	Infrastructure Type (Water, Wastewater, Both)	Comments	Action Required? (Description/No)	Link to Document	City of Regina Input
City of Regina Southeast Serviceability Study Final Report	12/4/2012	AECOM; Rob Mosiondz; Rob Jollimore; Arnold Raisi; Michael Moncrief	East	Both	Pre-Submission Documents	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
City of Regina Southwest Serviceability Study Final Report	3/1/2013	City of Regina; Kevin Syrnick; Saleem Memon; David Milliken; Peter Liu; Geoff Brown; Kelly Scherr	East	Both	Pre-Submission Documents; assumed date (only month given on report title page)	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
City of Regina Downtown Serviceability Study Final Report	1/1/2014	AECOM; Rob Mosiondz; Rob Jollimore; Arnold Raisi; Michael Moncrief; Eymond Toupin	City Centre	Both	Pre-Submission Documents; signature page not signed, seals not signed; some highlighting and markups by S. Kaminsky; assumed date (only month given on report title page)	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
City of Regina Northeast Serviceability Study Final Report	5/1/2012	AECOM; Rob Mosiondz; Rob Jollimore; Eymond Toupin, Garry Mak	East	Both	Pre-Submission Documents	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
City of Regina Water Master Plan Final Report	2/20/2019	AECOM; Michael Moncrief; Ray Bilevicius; Chris Macey	All	Water	Pre-Submission Documents	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
City of Regina Wastewater Master Plan Phase 1: System Response	6/28/2017	Stantec; Erika McEachran; Stephane D'Aoust	All	Wastewater	Pre-Submission Documents	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information at this time.
City of Regina: Wastewater Master Plan Phase 2: System Renewal	6/5/2019	Stantec, Marc Telmosse, Robert J. Campbell; Jeffrey L. Halliday; Allison Hahn	All	Wastewater	Pre-Submission Documents	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information at this time.
City of Regina Serviceability Study Wastewater Catchment Area and Water Network Expansion for North Regina	1/1/2023	Associated Engineering (Sask) Ltd.; Cory Wihlidahl; Ryan Karsgaard; Candice Gottstein; Alicia Masserey	West	Wastewater	Pre-Submission Documents; Draft Version - need Final; assumed date (only month given on report title page)	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	Final version dated March 2023 has been added to the project folder in Background Information > North.
Design Standard - Water - May 2022	5/1/2022	City of Regina	All	Water	assumed date (only month given on report title page)	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
Design Standard - Wastewater - January 2021	1/1/2021	City of Regina	All	Wastewater	assumed date (only month given on report title page)	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information required.
2021 Rainfall Data	11/15/2021	City of Regina	All	Wastewater	Rainfall data from May to October 2021; assumed date after typical rainfall season	Please provide GIS location information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	City of Regina Rain Fall Gauage Location & Coordinates added to Background Information> Rainfall Monitoring titled COR Rain Gauge Locations & Coordinates - 2023.
2022 Rainfall Data	11/15/2022	City of Regina	All	Wastewater	Rainfall data from May to September 2022; assumed date after typical rainfall season	Please provide GIS location information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	See above. #39
2023 Rainfall Data	11/15/2023	City of Regina	All	Wastewater	Rainfall data from May to August 2023; request remainder of 2023 data; includes rain gauge map - request gauge radius indicated on map; assumed date after typical rainfall season	Please provide GIS location information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	See above. #39
2022 Wastewater Flow Monitoring Data	10/15/2022	City of Regina; BOT Corp	All	Wastewater	Wastewater flow monitoring data; assumed date after typical rainfall/monitoring season; folders per month and location; various reports including .xlsx data, installation reports, hazard reports, confined entry permits, verification reports, etc. Reports include GPS location (N, E); map with all locations would be useful	Please provide GIS location information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Wastewater%20Flow%20Monitoring/2022?csf=	Two documents have been added to the project folder in Backgrounf Information >Wastewater Flow Monitoring. 1) Average Daily Flow and Flow Monitor Manhole GIS ID and 2) Wastewater Flow Monitoring Summary_2023_v2. Flow monitor location is associated with a Wastewater Manhole ID. Please reference the infrastructure records to match location.
2023 Wastewater Flow Monitoring Data	10/15/2023	City of Regina; BOT Corp	All	Wastewater	Wastewater flow monitoring data; assumed date after typical rainfall/monitoring season; folders per month and location; various reports including .xlsx data, installation reports, hazard reports, confined entry permits, verification reports, etc. Reports include GPS location (N, E); map with all locations would be useful	Please provide GIS location information	https://stantec.sharepoint.com/:f:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/General/background_information/Wastewater%20Flow%20Monitoring/2023?csf=	See above. #42.
Excerpt from Regina International Airport (YQR) Master Plan 2037 (Draft)	4/15/2018	Regina Airport Authority, Stantec	West	Both	Only an excerpt of the document is included; date is estimated based on last open house date.	Please provide complete document	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	Assumed full version document found from https://www.yqr.ca/en/regina-airport-authority/corporate-library/master-plan titled YQR Master Plan 2037 Draft has been added to the folder.

Document Title	Published Date (YYYY-MM-DD)	Author / Publisher	Study Area	Infrastructure Type (Water, Wastewater, Both)	Comments	Action Required? (Description/No)	Link to Document	City of Regina Input
Airport Propose Study Area Image (Draft)	N/A	City of Regina	West	Both	origin and relevance is not clear	Please provide accompanying documents or explanation	https://stantec.sharepoint.com/:i:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	This image was prepared internally and is for awareness only. As the Airport is out of scope, high level assumptions will need to be made regarding existing and future water and wastewater demands.
Regina International Airport Area Land-Use Planning Collaboration - Stakeholder Engagement Presentation	4/15/2023	InterVISTAS; MXD Development Strategists; Stantec; KGS	West	Both	Stakeholder Engagement Presentation - not meeting notes; estimated date; final report is likely available	No	https://stantec.sharepoint.com/:b:/r/teams/111260017-Regina-WandWWServiceability/Shared%20Docum	No additional information at this time.
LiDAR Data	N/A	City of Regina	All	Both	Requested as per Sheet 2	Missing information based on revised project boundary. City to provide missing LiDAR.	https://stantec.sharepoint.com/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/Forms/AllItems.aspx?id=%2Fteams%2F11126	New Folder created in Background Information>LiDAR Available information has been added to the folder. Please indicate which tiles may be missing and would be required and the City can obtain that information.
CCTV Data	N/A	City of Regina	All	Wastewater	New folder created in Background Information > CCTV	No	https://stantec.sharepoint.com/teams/111260017-Regina-WandWWServiceability/Shared%20Documents/Forms/AllItems.aspx?id=%2Fteams%2F111260017%2DRegina%2DW	New folder created in Background Information> CCTV. CCTV information added as well as the Risk Based Rehabilitation presentation titled CNAM 2023 Risk Based Rehabilitation.
Global Transportation Hub (GTH) Agreement	4-Dec-18	City of Regina	West	Both	New folder created in Background Information > West > GTH	No	111260018 - Regina - W and WW Serviceability - 12.4.2018 - GTH_MSA.pdf - All Documents (sharepoint.com)	New folder created in Background Information > West > GTH. The sections of the MSA likely most applicable to this project include: 4.3 – Available Water Capacity 4.5 – Available Wastewater Capacity Schedule F – Water Connection Fee Rate Calculation and Capital Contribution Model (page 100 of 129) Schedule G – Wastewater Connection Fee Rate Calculation and Capital Contribution Model (Page 110 of 129)
Utility Easements & Pipeline Corridors	N/A	City of Regina	All	Both		No	n/a	The City has available data that can be shared via shapefile if needed.

STONE & ARROW CONSULTING LP

Water and Wastewater Serviceability - LiDAR Required

Quarter	Section	Township	Range	Meridian
SE	10	18	19	2
NE	3	18	19	2
SE	3	18	19	2
SW	11	18	19	2
NW	2	18	19	2
SW	2	18	19	2
SW	36	17	19	2
SE	36	17	19	2
NW	25	17	19	2
NE	25	17	19	2
SW	25	17	19	2
SE	25	17	19	2
NW	24	17	19	2
NE	24	17	19	2
SW	24	17	19	2
SE	24	17	19	2
SW	19	17	18	2
NW	13	17	19	2
NE	13	17	19	2
SW	13	17	19	2
SE	13	17	19	2
NW	18	17	18	2
NE	18	17	18	2
NW	12	17	19	2
NE	12	17	19	2
NW	7	17	18	2
SW	12	17	19	2
SE	12	17	19	2
SW	7	17	18	2
NW	1	17	19	2
NE	1	17	19	2
SE	2	17	19	2
SW	1	17	19	2
SW	2	17	19	2
NW	35	16	19	2
NE	35	16	19	2
NW	32	16	19	2
SW	32	16	19	2
NW	31	16	19	2
NE	31	16	19	2
SW	31	16	19	2
SE	31	16	19	2
NW	36	16	20	2
NE	36	16	20	2
SW	36	16	20	2
SE	36	16	20	2
NW	35	16	20	2
NE	35	16	20	2
SW	35	16	20	2
SE	35	16	20	2
NW	34	16	20	2
NE	34	16	20	2
SW	34	16	20	2

STONE & ARROW CONSULTING LP

Water and Wastewater Serviceability - LiDAR Required

Quarter	Section	Township	Range	Meridian
SE	34	16	20	2
NE	33	16	20	2
SE	33	16	20	2
NW	33	16	20	2
SW	4	17	20	2
SE	5	17	20	2
NW	4	17	20	2
NE	5	17	20	2
SW	9	17	20	2
SE	8	17	20	2
NW	9	17	20	2
NE	8	17	20	2
SW	16	17	20	2
SE	17	17	20	2
NW	16	17	20	2
NE	17	17	20	2
NW	17	17	20	2
SW	21	17	20	2
SE	20	17	20	2
SW	20	17	20	2
NE	20	17	20	2
NW	20	17	20	2
NW	19	17	20	2
NE	19	17	20	2
SE	25	17	21	2
NE	24	17	21	2
NW	24	17	21	2
NE	23	17	21	2
SW	25	17	21	2
SE	26	17	21	2
NE	25	17	21	2
NW	25	17	21	2
NE	26	17	21	2
SE	36	17	21	2
SW	36	17	21	2
SE	35	17	21	2
NE	36	17	21	2
NW	31	17	20	2
NE	31	17	20	2
NW	32	17	20	2
NE	32	17	20	2
SE	1	18	21	2
SW	6	18	20	2
SE	6	18	20	2
SW	5	18	20	2
SE	5	18	20	2
NW	5	18	20	2
NE	5	18	20	2
NW	8	18	20	2
NE	8	18	20	2
SW	8	18	20	2
SE	8	18	20	2
SW	17	18	20	2

Water and Wastewater Serviceability - LiDAR Required

Quarter	Section	Township	Range	Meridian
SE	17	18	20	2
SW	16	18	20	2
SE	16	18	20	2
NW	15	18	20	2
NE	15	18	20	2
SW	15	18	20	2
SE	15	18	20	2
NE	16	18	20	2

Appendix B Land Use Plan

STONE & ARROW
CONSULTING LP

Memo

To:	Stacey Kaminski, P.Eng. City of Regina	From:	Jeff Blyth, P.Eng. Stone & Arrow Consulting LP
Project/File:	Water and Wastewater Serviceability Study – East, City Center and West 111260018	Date:	March 14, 2024

Reference: Water and Wastewater Serviceability Study – East, City Center and West Land Use Plan

1 Objective

The purposes of this memo are the following:

1. Confirm the project boundary
2. Assign future land uses to all undeveloped areas within the project boundary
3. Identify areas for intensification (i.e. increased population density or densification)
4. Assign future population densities to the identified intensification areas

2 Understanding

Stone & Arrow Consulting LP (Stone & Arrow) has been commissioned by the City of Regina (City) to complete a water and wastewater serviceability study for the east, west, and city centre areas of Regina. Prior to commencing the analysis, the overall project boundary, future land uses, intensification areas, and population densities for future development and intensification areas need to be confirmed.

The City is shifting from servicing planned areas to providing servicing in advance of development. Identifying an appropriate boundary will support the City in moving towards this approach. If the project boundary is too small, it will limit the City's flexibility in achieving its growth targets. However, if the project boundary is too large, it is likely that assumptions for future areas will change before the areas are developed, lessening the utility of the serviceability recommendations.

The intent of the land use plan is to identify future development of areas between existing and or approved developments and the project boundary and intensification areas within existing developments. Development of a composite land use plan that clearly defines the assumptions for this project will allow for informed stakeholder engagement resulting in overall buy-in of the proposed plan and reduce pressure from external stakeholders and the development community.

Reference: Land Use Plan

2.1 Project Boundary

The original study area boundaries have been combined into a single study area as per the 6181 - Water and Wastewater Serviceability Study - East, City Center and West Technical Memo provided on July 20, 2023. Confirmation from the City was required for the existing developed land along with identification of lands currently approved for development that should be considered.

Review of background information, discussion at various project meetings and in-depth discussion with the large City of Regina stakeholder group at Workshop 1 resulted in the Project Boundary shown on the attached Future Land Use Map.

The rationale for the Project Boundary incorporates the following boundaries and built infrastructure:

1. Regina Bypass
2. Joint Planning Area (from Regina's Official Community Plan, 2013)
3. City Limits (from OCP, 2013)
4. Future Long-Term Growth Area (~500K from OCP, 2013)
5. Original Project Boundary (from RFP)

Broad consensus was achieved at the conclusion of Workshop 1 that the Project Boundary was appropriate for the purposes of this project.

2.2 Land Use Plan

The Future Land Use Map identifies existing developed land and future land uses for land between the existing developed land and the study area boundary. Future land uses were broken down into general categories including residential, commercial, and industrial. The future land uses are based on a combination of existing City policy documents and our understanding of future development.

In addition to future land uses on currently undeveloped lands, intensification areas were identified to maintain consistency with the OCP and Housing Accelerator Fund application commitments.

In Workshop 2 the project team and stakeholder group reviewed the project boundary and land use results from Workshop 1. The focus of Workshop 2 was discussion of intensification strategies, identification of intensification areas, and assignment of intensification densities to those areas. The resulting intensification consensus is shown on the Future Land Use Map.

Refer to Table 1 below for a summary of the future land uses.

Reference: Land Use Plan

Table 1: Summary of Future Land Uses*

Land Use Type	Area (Ha)	Density	Equivalent Residential Population
Residential	6,277	50 ppl/ha	313,850
Commercial	675	65 ppl/ha	43,875
Industrial	4,991	25 ppl/ha	124,775
Intensification – Medium	1,591	65 ppl/ha	103,415
Intensification – High	936	235 ppl/ha	219,960

* Adapted from Water Design Standard, September 2023 and Wastewater Design Standard, May 2022

The Equivalent Residential Population column in Table 1 above shows the ultimate population at "full build out" for each of the land use types. These populations are required as flow generating inputs for the water and wastewater modeling and should not be thought of as population targets, but as maximum population thresholds for modeling purposes.

For the two intensification types, the Equivalent Residential Populations do not account for the actual current land uses, only a maximum threshold for modeling purposes for the ultimate population at "full build out". They are not a likely population in the short or medium term, and they are not a projected population increase for the intensification areas.

The purpose of assigning land use types and population densities to the study area is to provide appropriate water and wastewater demand assumptions for the analysis of the Water and Wastewater Serviceability Study – East, City Center and West. The proposed land uses are not to be considered as assigned land uses per official City of Regina standards or policies. It is understood that future land uses may change over time through reviews of the OCP Growth Plan as more detailed plans for neighbourhoods/employments areas are developed.

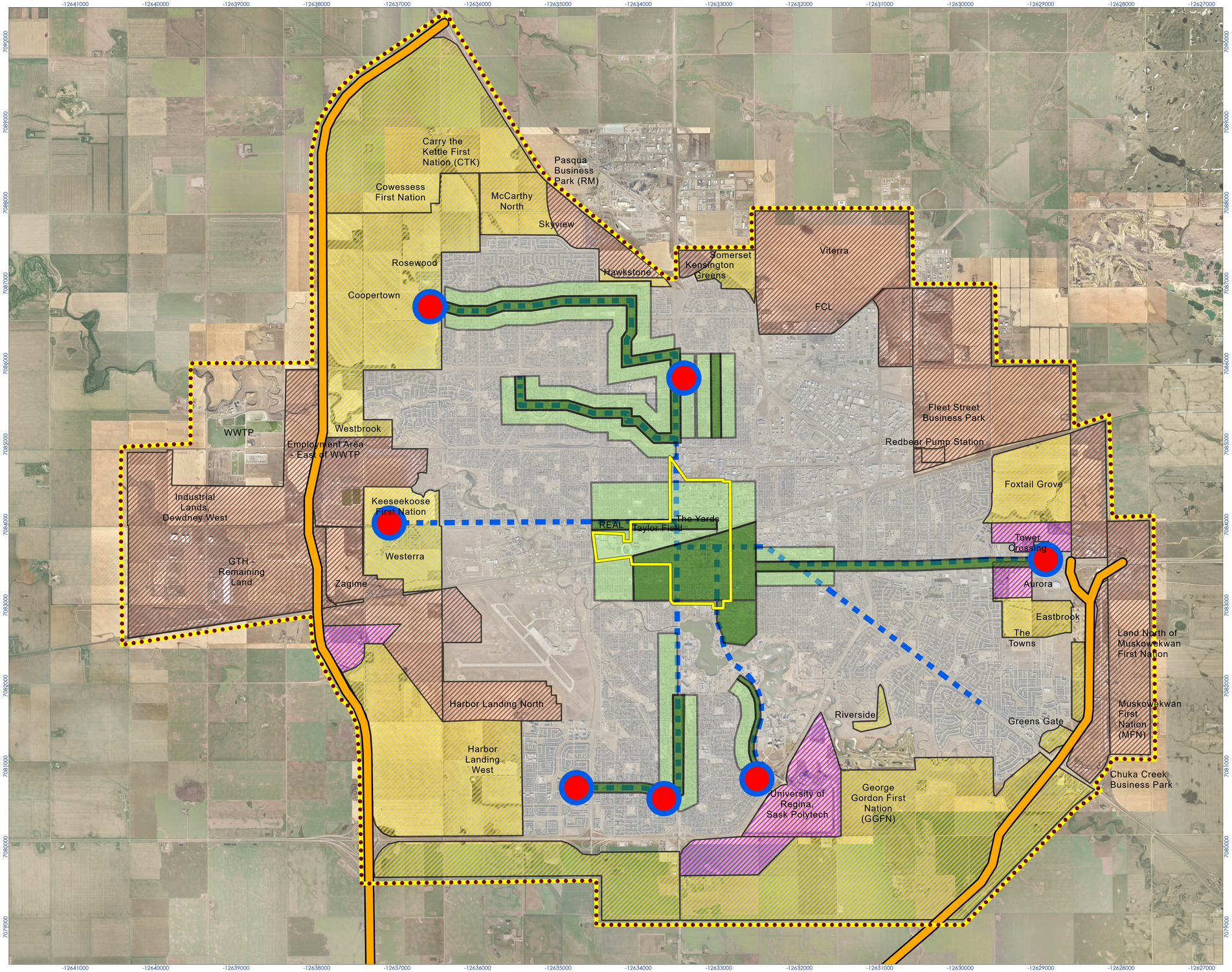
With the project boundary, future land uses and intensification strategy defined, the project team can proceed with the water and wastewater modeling required to move towards city-wide servicing strategies.

Respectfully,

STONE & ARROW CONSULTING LP

Jeff Blyth P.Eng.
Senior Associate, Water
Phone: 306-201-9368
jeff.blyth@stantec.com

Attachment: Future Land Use Map



STONE & ARROW CONSULTING LP

LEGEND

- PROJECT BOUNDARY
- CITY CENTRE
- BYPASS
- EXPRESS ROUTE
- URBAN CENTRE
- EXISTING DEVELOPED LAND (11943 ha)

INTENSIFICATION AREAS

- 65 ca/ha (1591 ha)
- 235 ca/ha (936 ha)

FUTURE LAND USE

- COMMERCIAL (675 ha)
- INDUSTRIAL (4991 ha)
- RESIDENTIAL (6277 ha)

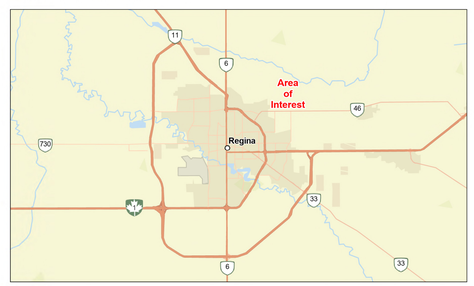
N

0 925 1,850 metres

(At original document size of 22x34)
1:34,960,006

Notes

1. Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
2. Data Sources:
3. Background: World Street Map: Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
World Imagery: City of Regina, Maxar



Project Location
Regina,
Saskatchewan

Prepared by LB on 2024-01-18

Client/Project

Intensification Areas REVA

City of Regina
Water and Waste Water Serviceability

Figure No.

Title

FUTURE LAND USE MAP

C:\Users\bnott\Desktop\AM\City of Regina\2023-4972_CoR_Citywide\2023-4972_CoR_Citywide.aprx Revised: 2024-03-14 By: bnott

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Appendix C Design Criteria

STONE & ARROW CONSULTING LP

Memo

To:	Stacey Kaminski, P.Eng. City of Regina	From:	Jeff Blyth, P.Eng. Stone & Arrow Consulting LP
Project/File:	Water and Wastewater Serviceability Study – East, City Center and West 111260018	Date:	March 14, 2024

Reference: Water and Wastewater Serviceability Study – East, City Center and West Design Criteria

1 Objective

The purpose of this memo is to summarize the design standards that will be used for the Water and Wastewater Serviceability Study – East, City Center and West.

2 Design Criteria

2.1 Design Population

The design population for all future developments will use the Design Population Table identified in the City of Regina (City) Water Design Standards, September 2023 and Wastewater Design Standards, May 2022. In addition to the population tables, two categories of intensification were identified, discussed, and confirmed with City of Regina stakeholders at Workshop 2. The intensification design populations are intended to represent future population densities within existing areas consistent with the City's intensification goals.

1. Intensification – Medium
    - Consistent with "Commercial, Mixed" zoning at a population density of 65 persons/hectare.
2. Intensification – High
    - Consistent with "High Rise Residential" zoning at a population density of 235 persons/hectare.

2.2 Water

The water distribution network will be assessed using the COR-20170517-WMP-Ext_SystemReview.wtg WaterCAD model.

The analysis of the water distribution network will use the City's Water Design Standards, September 2023 unless otherwise noted.

2.2.1 DESIGN DEMAND

- The City Water Master Plan Final Report (February 2019, AECOM) indicates that the Average Day Demand of 390 litres per capita per day (Lpcd) accounts for all water use in the system. The report further identifies a value of 265 Lpcd for residential land use based on water consumptions records at the time. Although the report does not explicitly outline water consumption values for non-residential land uses, these can be found within the provided WaterCAD Model.
- The following water consumption values will be applied as fixed demands to remain consistent with the existing WaterCAD model:
    - Residential - 265 Lpcd
    - Commercial, industrial, institutional - 175 Lpcd

2.2.2 DETAILED DESIGN

- Recommendations will be consistent with the City of Regina's Water Design Standards, September 2023.
- It is assumed that the City of Regina's Water Design Standards, September 2023 will apply to all areas within the model, including areas outside of the City limits.

2.3 Wastewater

The wastewater collection system will be assessed using the North_Study_Wastewater_Final_20230330.icmt InfoWorks ICM model. The model was provided in version 10. We will work in the version provided and not update it to the current version. All final deliverables will be provided in version 10.

The analysis of the wastewater collection system will use the City's Wastewater Design Standards, May 2022 unless otherwise noted.

The wastewater collection system is to be designed to convey a design peak flow rate equal to the sum of the peak dry weather flow and inflow/infiltration.

2.3.1 ESTIMATED WASTEWATER FLOWS

- Average daily wastewater flow used for designing residential and light and medium industrial areas will be 225 Lpcd. All other areas will be 454 Lpcd.
- A high-level review of major lift station operating capacities will be completed to identify discrepancies within the model. Any major discrepancies will be addressed.

2.3.2 DETAILED DESIGN

- Recommendations will be consistent with the City of Regina's Wastewater Design Standards, May 2022.
- High-level serviceability-focused system control recommendations will be provided to support future development.
- Review and provision of an alternate solution to the City's Wastewater Design Standards, May 2022 for direct connection to a 300 mm sewer main will be included under a separate memo.

3 Closure

This technical memorandum was prepared for the City of Regina to confirm the design criteria for water and wastewater servicing for the Water and Wastewater Serviceability Study – East, City Center and West.

Please do not hesitate to contact the undersigned with questions about this memo or if you have trouble getting access to the shared file locations.

Respectfully,

STONE AND ARROW CONSULTING LP

Jeff Blyth P.Eng.
Senior Associate, Water
Phone: 306-201-9368
jeff.blyth@stantec.com

Appendix D Opportunities and Constraints

STONE & ARROW
CONSULTING LP

Memo

To:	Stacey Kaminsky, P.Eng. City of Regina	From:	Jeff Blyth, P.Eng. Stone & Arrow Consulting LP
Project/File:	111260018	Date:	June 27, 2024

Reference: Water and Wastewater Serviceability Study
Opportunities and Constraints

1 Objective

The objective of this memo is to identity high-level and systemic opportunities and constraints for future development of the City of Regina's water distribution and wastewater collection infrastructure. These considerations will guide the detailed modelling and analysis of both systems as the project moves forward. This will ensure that the project team remains focused on the primary objective of identifying a water and wastewater infrastructure strategy that accommodates significant intensification within the current City footprint along with typical suburban growth on the outskirts.

2 Understanding

The City is shifting from servicing planned areas to providing servicing in advance of development. The City of Regina (City) commissioned Stone & Arrow Consulting LP (Stone & Arrow) to complete a water and wastewater serviceability to support that shift in development servicing approach. This memo is the fourth preliminary technical memo helping to address background information and to clearly define the project scope before commencing bulk of the analysis. The previously submitted memos are listed below:

- Background Information Review and Gaps Analysis; March 14, 2024
- Design Criteria; March 14, 2024
- Land Use Plan; March 14, 2024

Following two half-day workshops with City stakeholders, the Land Use Plan established the project boundary and the planned land use for areas to be developed including the areas targeted for intensification.

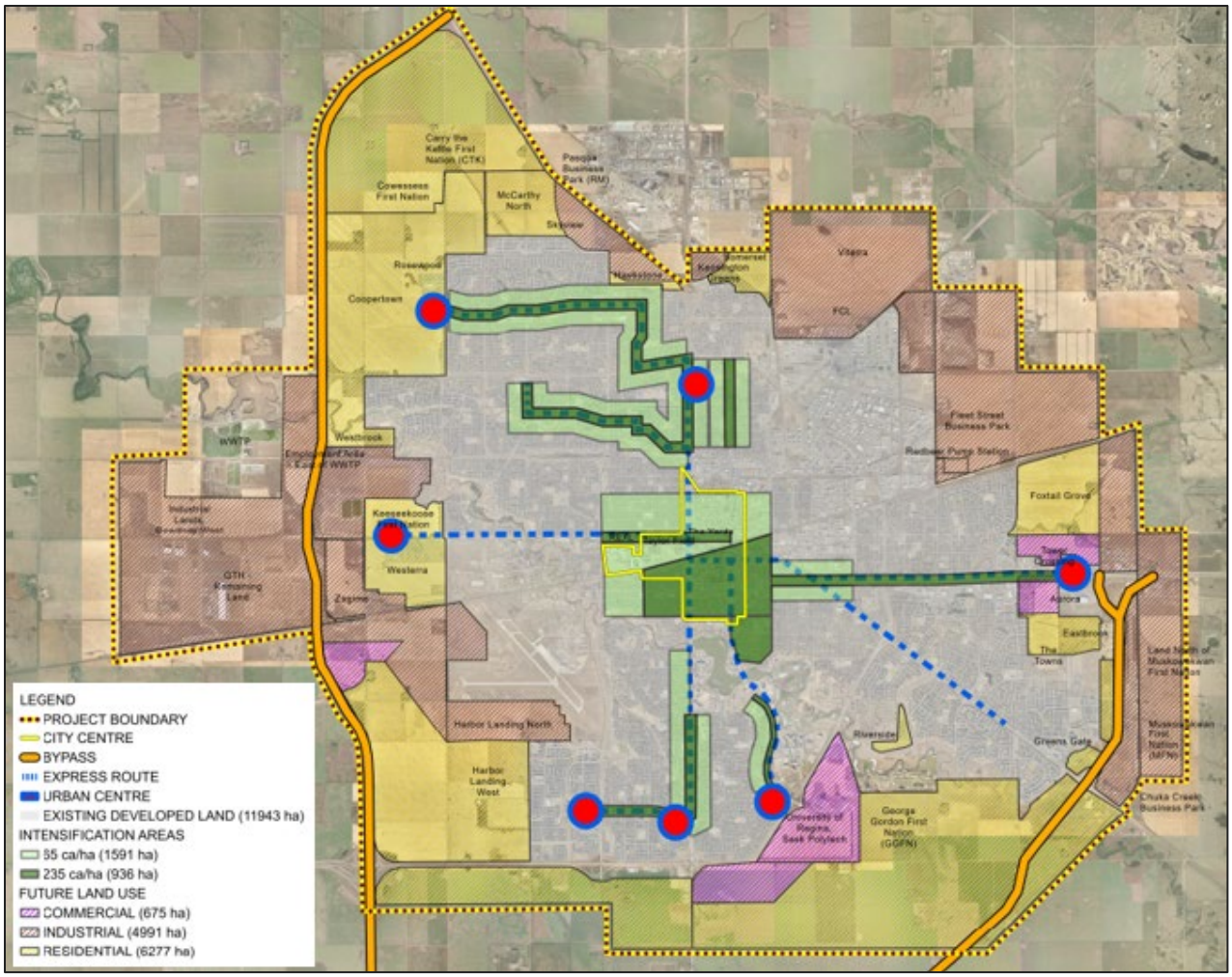


Figure 2.1-1: Land Use Plan

These land uses were assigned population densities from the City's standards and from discussions in stakeholder workshops. Both the boundaries and population densities were discussed at length with the City stakeholders and consideration was given to both the likelihood and to what extent growth may occur. One key objective in establishing the population densities was that the approach taken shall adhere to existing policy documents, where possible. It is also important to note that it was understood that growth and especially intensification may not occur to the extent shown but that it was important that servicing should not prohibit the growth. The population densities were then used to generate the water and wastewater demands required for system analysis.

3 Water Distribution

3.1 Equivalent Population and Water Demands

The Land Use Plan was used to develop a potential ultimate City water demand based on the proposed population densities as shown in the table below. An estimated average day water demand for each land use was established by applying a per capita water demand specific for each land use type. The City Water Master Plan Final Report (February 2019, AECOM) indicates that the Average Day Demand of 390 litres per capita per day (Lpcd) accounts for all water use in the system. The report further identifies a value of 265 Lpcd for residential land use based on water consumption records at the time. Although the report does not explicitly outline water consumption values for non-residential land uses, these can be found within the provided WaterCAD Model. These demands are included in the provided WaterCAD model, COR-FINAL-WMP.wtg, dated; October 23, 2023.

The table below summarizes the total combined and equivalent population and average day demand for each land use based on the design criteria memo. Again, it is important to note that the equivalent populations not be construed as an expected population, but an accumulation of potential populations across the City. Furthermore the equivalent populations are based on values currently being used by the City and that this project was not to consider future changes to demographics, typical water consumption trends, climate change or other changes that may further change the values used to determine average daily water demands.

Land Use Type	Area (Ha)	Density (ppl/ha)	Demand (L/c/d)	Equivalent Population	Average Day Demand (ML/d)
Existing Population			390	226,000	88
Residential	6,277	50	265	314,000	83
Industrial	4,991	25	175	125,000*	21
Commercial	675	65	175	39,500*	7
Intensification – Medium	1,591	65	265	103,000	27
Intensification – High	936	235	265	220,000	58
Adjustment			265	(97,000)**	(26)
Total				**767,000**	**264**

Table 3.1-1: Equivalent Population and Demands

*Equivalent population used for water supply
**The intensification within the existing areas will not replace the existing population already residing in those areas. The existing demands require adjustment to reduce duplication of the demands.

The existing populations shown in the table were recorded in the 2021 census. The non-residential equivalent populations for the industrial and commercial areas were calculated based on estimated densities and demand per capita to determine the total required average day demand for each future land use.

The institutional water demands are included with the commercial demands. This is to ensure that the Equivalent Populations and Demands table is aligned with the approved land use figure noted above. These demands were calculated by establishing the equivalent population of 50 persons per hectare for the area of the University of Regina, and adding it to the equivalent population for commercial land to ensure the WaterCAD model accounts for all water to the system.

3.2 Water Storage and Pumping Capacity

The future average day demand (ADD) of 260 ML/d is estimated to be approximately three times the existing ADD of 88.3 ML/d. With this magnitude of water demand increase, portions of the existing City infrastructure will be deficient. For instance, the City's water storage reservoirs and pumping stations will require expansion or upgrades to meet future needs.

Water storage should typically be in the order of two times the future estimated ADD. Therefore, based on an estimated future ADD of 260 ML/d, the future reservoir storage would be in the order of 520 ML.

The City's water pumping facilities should have a combined pumping capacity capable of meeting the future peak hour demands. According to the City's Development Standard, the peak hour demand can be estimated as 2.9 times ADD. As such, the future pumping capacity shall be capable of a minimum combined pumping rate of 765 ML/d. As the existing pump station capacities are 675 ML/d, the pumping capacity within the system will need to be upgraded to meet the demand identified in this study.

The reservoir storage and pumping capacity of the existing system will require upgrades and expansion to meet the future system needs as summarized below.

Scenario	Usable Reservoir Storage	Pumping Capacity
Existing System (including Redbear Pump Station and Reservoirs currently under construction)	245 ML	675 ML/d
Future System	520 ML	765 ML/d

Table 3.2-1: Water Storage and Pumping Capacity

3.3 Existing Water Supply and Distribution Network

The City of Regina receives its water supply from the Buffalo Pound Water Treatment Plant (BPWTP) through two parallel pipelines. The first supply pipeline, with a diameter of 900 mm was installed in the 1950s. The second pipeline, installed in stages between 1990 and 2003, has a larger diameter of 1050 mm. The potable water is pumped over 60 km to the City of Regina, where the City's water storage and distribution system stores and distributes potable water to the City's consumers.

The City's water distribution system consists of two pressure zones (the Primary and the North Pressure Zone), five existing water storage reservoirs and three pumping stations. Two additional reservoirs and one pumping station are under construction in the City's northeast and will be called the Redbear Reservoirs and Pumping Station.

3.3.1 RESERVOIR STORAGE, SUPPLY AND TRANSFER

The primary reservoirs for the distribution system are the Pasqua, Northwest, and the future Redbear Reservoirs. These reservoirs are and will be used to meet daily demand fluctuations. The Albert Street, Tor Hill and 4th Avenue Reservoirs are secondary reservoirs as they are used only during peak water demands. The Northwest and Pasqua Reservoirs are filled from the BPWTP supply pipelines. These reservoirs were built in the 1970s and are considered to be in good condition. The North Pumping Station transfers water from these two reservoirs to the Albert Street Reservoir and the Farrell Pumping Station through a dedicated transfer pipeline. A secondary supply system with a dedicated transfer pipeline exists between the Tor Hill Reservoir, 4th Avenue Reservoir and the Farrell Pumping Station. The Tor Hill Reservoir is filled from the distribution system while the 4th Avenue Reservoir is filled via the Tor Hill Reservoir.

The Redbear Reservoirs will be filled from the Northwest and Pasqua Reservoirs via transfer by the North Pumping Station and a dedicated supply pipeline which is currently being constructed in 2024.

The Albert Street Reservoir is located in the Sherwood Industrial Park north of Highway No. 11. It was constructed in the 1930s for the purpose of well water storage from a well system in the northern aquifer located north of the city. The northern aquifer wells have not been used for many decades due to relatively poor water quality of the aquifer. The Albert Street Reservoir is currently part of the City's potable water storage system. It is filled from a single pipeline from the North Pumping Station and supplies the Farrell Pumping Station for downtown supply during peak demands.

The Tor Hill Reservoir is located northeast of the city near the Tor Hill Golf Course. In the past, the city supplemented the treated water supply from BPWTP with groundwater obtained from the Boggy Creek well field located northeast of the City; however, since twinning of the BPWTP supply line, the City no longer uses groundwater as a daily source of potable water. The wells are maintained for emergency purposes only. Since wells are no longer used, the Tor Hill Reservoir is not ideally located for existing operations. The Tor Hill Reservoir is currently used to supply the 4th Avenue Reservoir by gravity during periods of peak demand.

The 4th Avenue Reservoir is located near the intersection of Ross Avenue and Toronto Street near the City centre. It is our understanding that the 4th Avenue Reservoir leaks and recent rehabilitation of the reservoir was not completely successful in eliminating reservoir leakage. The 4th Avenue Reservoir supplies the Farrell Pumping Station but due to the distance from the Farrell Pumping Station and lack of elevation difference, the lower volume of the 4th Avenue Reservoir is not useable.

A summary of the City's reservoirs, the reservoir supply source, storage capacity, and year of construction and upgrade are summarized below:

Reservoir	Supply Source	Estimated Storage Capacity / Usable Capacity (ML)	Year of Construction and Upgrade
Pasqua	BPWTP supply	22.7 / 20.1	1970
Northwest	BPWTP supply	45.4 / 38.2	1979
Albert Street	North Pump Station Transfer	45.4 / 43.9	1930s
Tor Hill	City Loop (Distribution)	22.7 / 21.6	1919 and 1992
4th Avenue	North Pump Station Transfer, Albert St Reservoir and Tor Hill	45.4 / 36.5	1947, 1993 and 2016
Redbear A and B	North Pump Station Transfer	42.5 / 42.5 42.5 / 42.5	2024 and 2025

Table 3.3-1: Reservoir storage, supply and transfer

3.3.2 WATER DISTRIBUTION SYSTEM AND PUMPING STATIONS

The City's distribution system consists of the primary pressure zone and the north pressure zone.

The Primary Pressure Zone is currently serviced by the North Pumping Station and the Farrell Pumping Station. The North Pumping Station is the City's primary pumping station and operates 24 hours per day. A large diameter trunk main called the "City Loop" (500 mm to 1050 mm in diameter) originates at the North Pumping Station and encircles the City mostly along the Ring Road and Lewvan Drive. The inner portion of the City Loop or the downtown area is serviced by the Farrell Pumping Station which operates only during the daytime hours when demands are higher.

The southeast portion of the Primary Pressure Zone has seen significant development over the last decade. With the increased water demand in the southeast, this area has experienced deficient pressures compared to other areas of the City. To improve water service to the City's southeast, an Eastern Pressure Solution project is currently underway which includes construction of the Redbear Reservoirs and Pumping Station in the City's northeast and a dedicated supply pipeline from the North Pumping Station to the Redbear site. Once complete, the Redbear Pumping Station will service the Primary Pressure Zone and will improve pressures in the City's east.

The North Pressure Zone is currently serviced by the North Zone Pumping Station located on the northwest corner of Pasqua Street and 9th Avenue North. The North Zone Pumping Station is fed by gravity from the Northwest Reservoir.

The Redbear Pump Station is located near the boundary of the Primary and North Pressure Zones and as such, the Redbear Pump Station will also have the ability to distribute to the North Pressure Zone as development in the City's northeast progresses.

The Farrell Pumping Station is located near the corner of Dewdney Avenue and Broad Street. The station is fed by the Albert Street Reservoir and the 4th Avenue Reservoir and it can also be supplied by the North Pumping Station. The station is currently used to supplement the North Pumping Station specifically providing service to the City's downtown during daytime hours when water demands are higher. The Farrell Pumping Station is aging and in need of replacement.

A summary of the City's water pumping stations, the primary reservoirs they pump from, the pressure zone they distribute to, their pumping capacity, and year of construction and upgrades are summarized below.

Pumping Station	Primary / Secondary Supply	Pressure Zone	Pumping Capacity (ML/d)	Year of Construction and (Upgrade)
North Pumping Station	Pasqua and Northwest Reservoir	Primary Zone	333	1963
North Zone Pumping Station	Northwest Reservoir	North Zone	35	2015
Farrell Pumping Station	North Pump Station, Albert Street Reservoir and 4th Avenue Reservoir	Primary Zone	138	1961
Redbear	Redbear Reservoirs A and B	Primary zone plus (future secondary stn for the North Zone)	169	2025

Table 3.3-2: Water distribution and pumping stations

3.3.3 WATER INFRASTRUCTURE SUMMARY

The following figure illustrates the existing supply and distribution system for the City of Regina.

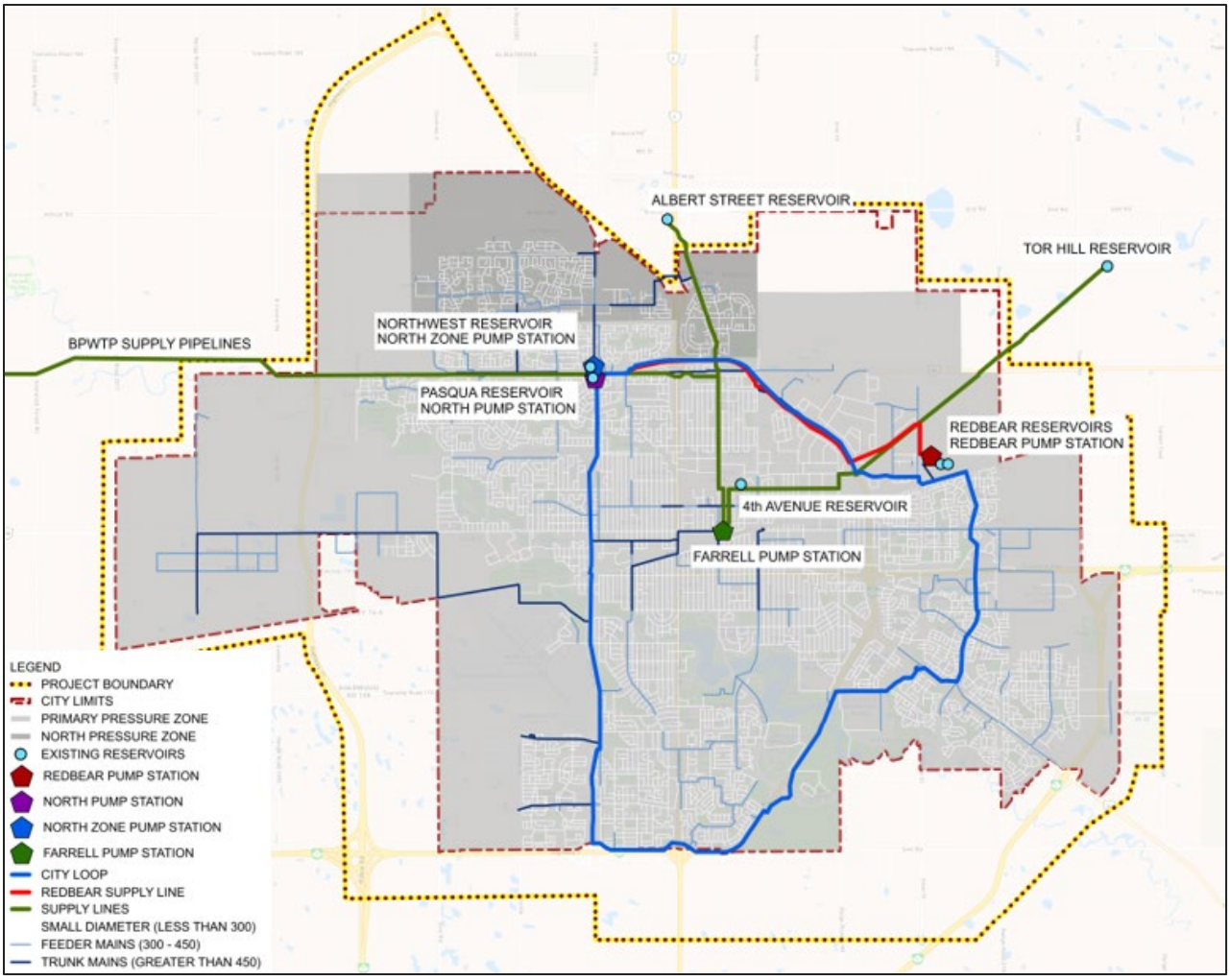


Figure 3.3-1: Existing Water Supply and Distribution Network

The following is noted from the figure:

- Once Redbear is complete, the City will operate four pump stations and seven storage reservoirs.
- The City has two pressure zones i.e., Primary Pressure Zone and the North Pressure Zone.
- The Primary Pressure Zone includes a large diameter trunk called the City Loop which is fed from the North Pump Station and will be fed by the Redbear Pump Station.
- The Farrell Pump Station services the downtown and is connected to the Albert Street Reservoir, Tor Hill Reservoir, and 4th Avenue Reservoir via the City's dedicated supply pipeline.

3.4 Constraints

Several constraints within the existing water distribution network were identified whilst reviewing the serviceability of the City. These are summarized below:

3.4.1 EXISTING INFRASTRUCTURE CONSTRAINTS

To service the future proposed developments and an ultimate population as identified in this study the existing water system reservoirs will need to be expanded and / or upgraded and additional pumping facilities may need to be constructed. Considering that development and growth in population of this magnitude will take multiple decades, the water system facilities will have aged and may need replacement. As such there are a number of constraints in the water system that will hinder water system upgrade and expansion. These constraints are shown on the figure below and described later in this section.

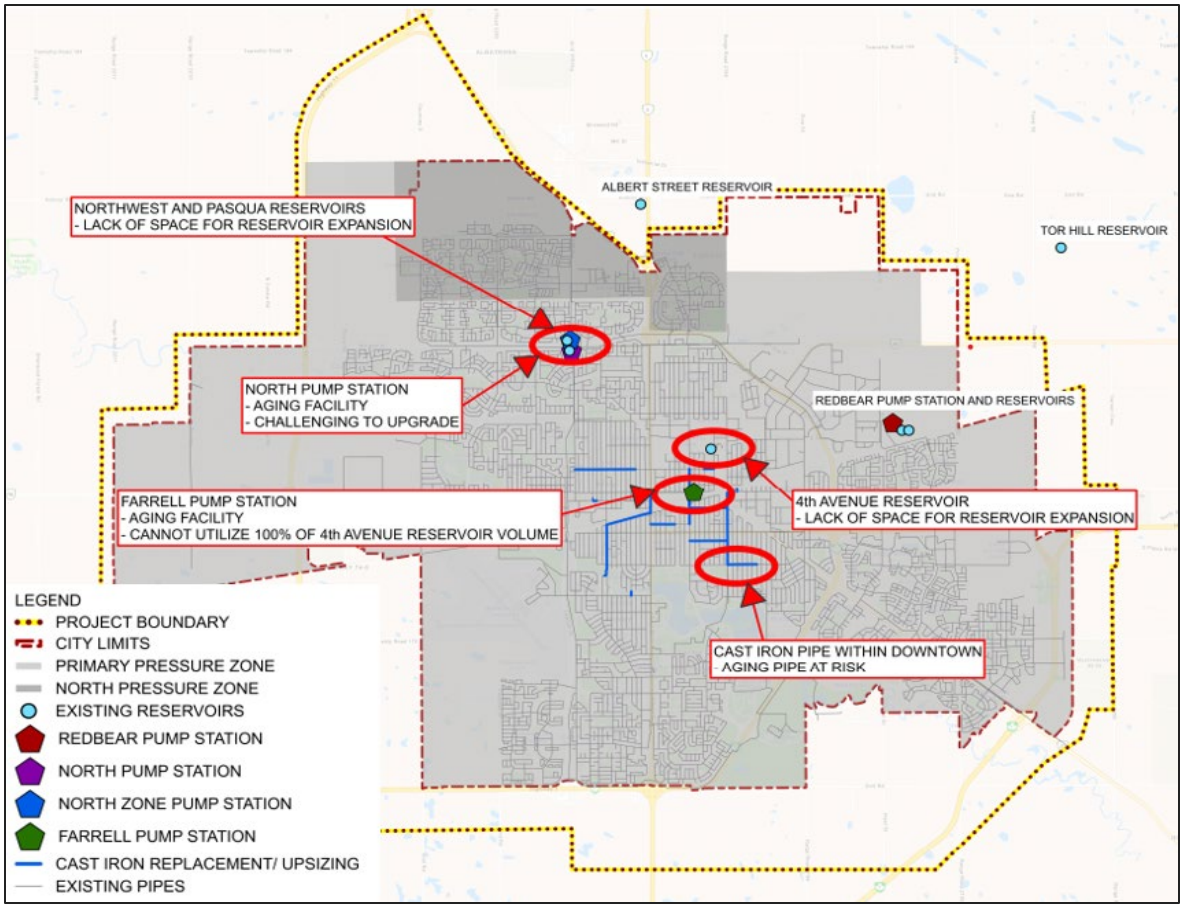


Figure 3.4-1: Existing Water System Constraints

3.4.1.1 Spatial Constraint for Infrastructure Expansion

- The increase in population and water demand will require construction of additional water storage reservoirs. The lack of open space to accommodate the construction of a new reservoir next to the existing reservoirs at the Northwest, Pasqua, and 4th Avenue Reservoir locations is illustrated below.

Figure 3.4-3: Northwest and Pasqua Reservoir

Figure 3.4-2: 4th Avenue Reservoir

- The North Pump Station, constructed in 1963, is aging and lacks available internal space for additional pump sets making upgrades challenging. Although the North Pump Station has many years of serviceable life remaining, over the design horizon of this study, the station will likely need upgrade or replacement prior to the ultimate City development.

3.4.1.2 Aging Infrastructure Constraint

- The Farrel Pump Station, constructed during 1961, is aging and needs replacement. Also, due to its distance from the 4th Avenue Reservoir the pump station is not capable of fully utilizing the reservoir's capacity. This is due to head loss incurred over the distance between the Farrell Station and the 4th Avenue Reservoir. If Farrell is not replaced, the storage at the 4th Avenue Reservoir and possibly Albert Street and Tor Hill Reservoirs may become unusable.

- The 4th Avenue Reservoir was constructed in 1947 and has undergone some upgrades and repairs over time. The reservoir is leaking at an unknown rate.

- The Tor Hill and Albert Street Reservoirs were constructed in 1919 and 1931 respectively for the purpose of well water supply to the City. Since well water is only an emergency source, the reservoirs have provided supply to the Farrell Pumping Station for peak demands. If the future

operating philosophy eliminates the use of a downtown pump station the future use of the Albert Street and Tor Hill Reservoirs may be in question.

- The City's distribution system includes some large diameter cast iron trunk mains. These trunk mains frequently break especially with any increase in pressure. Over recent years, the City has been replacing the existing cast iron pipe

3.4.2 TOPOGRAPHY

The City of Regina exhibits higher elevations in the northeast, which gradually descend southwest towards Wascana Creek. This elevated terrain poses challenges for water distribution as water pressure drops in higher elevations. At higher elevations there may be a need for a dedicated pump station and additional pressure zone.

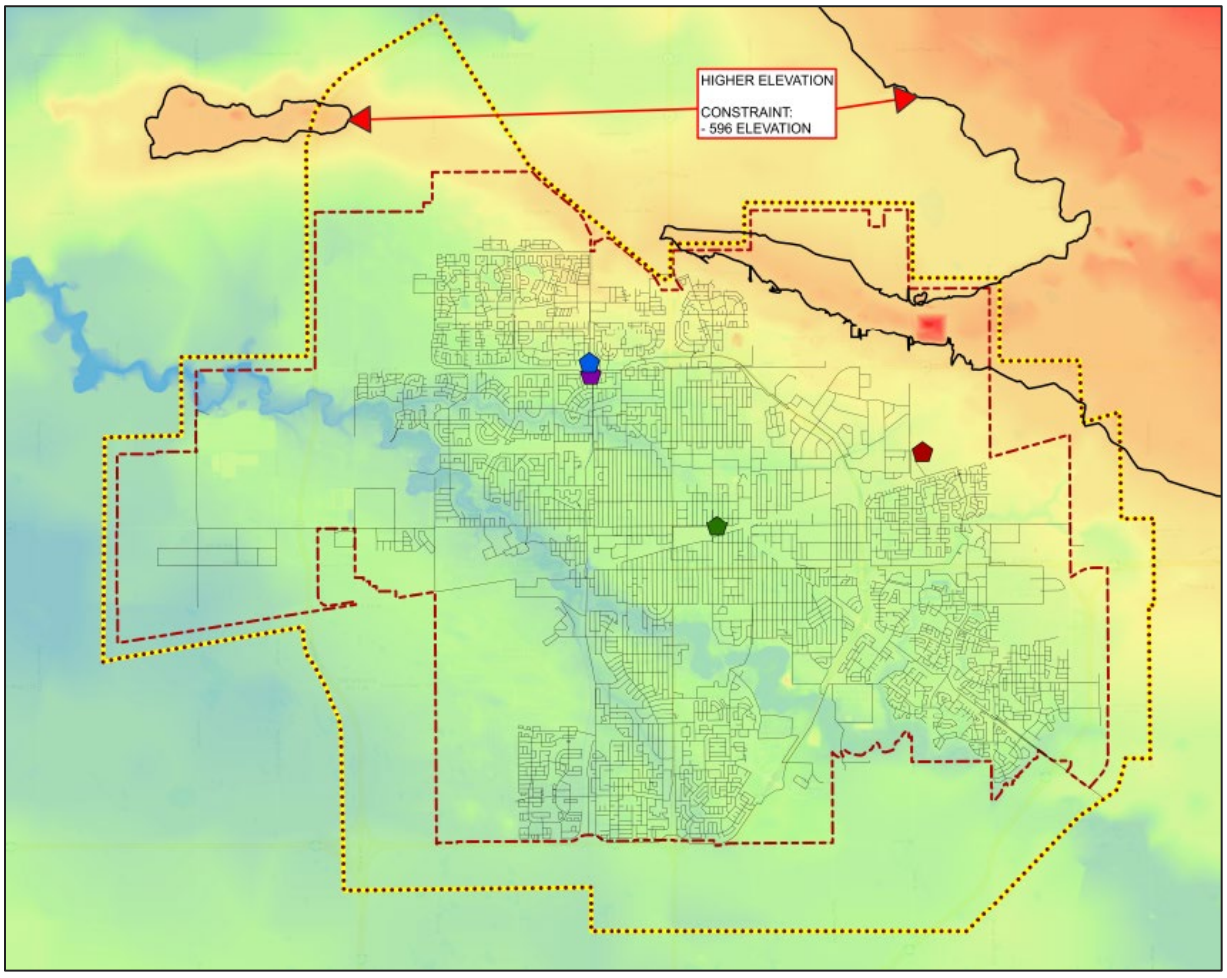


Figure 3.4-4: Elevation Constraints

The elevation figure identifies the following constraint:

- The higher elevation in the east and northeast will require additional pumping effort to supply at minimum pressures. We have identified that development higher than 596 m above sea level will required higher pumping to overcome the elevation.

3.5 Opportunities

To service the future development as identified in this study, several water system opportunities have been identified which will allow for increase of the water storage volume and pumping capacity as well as expansion and improvement of the water distribution network to accommodate increased water demand.

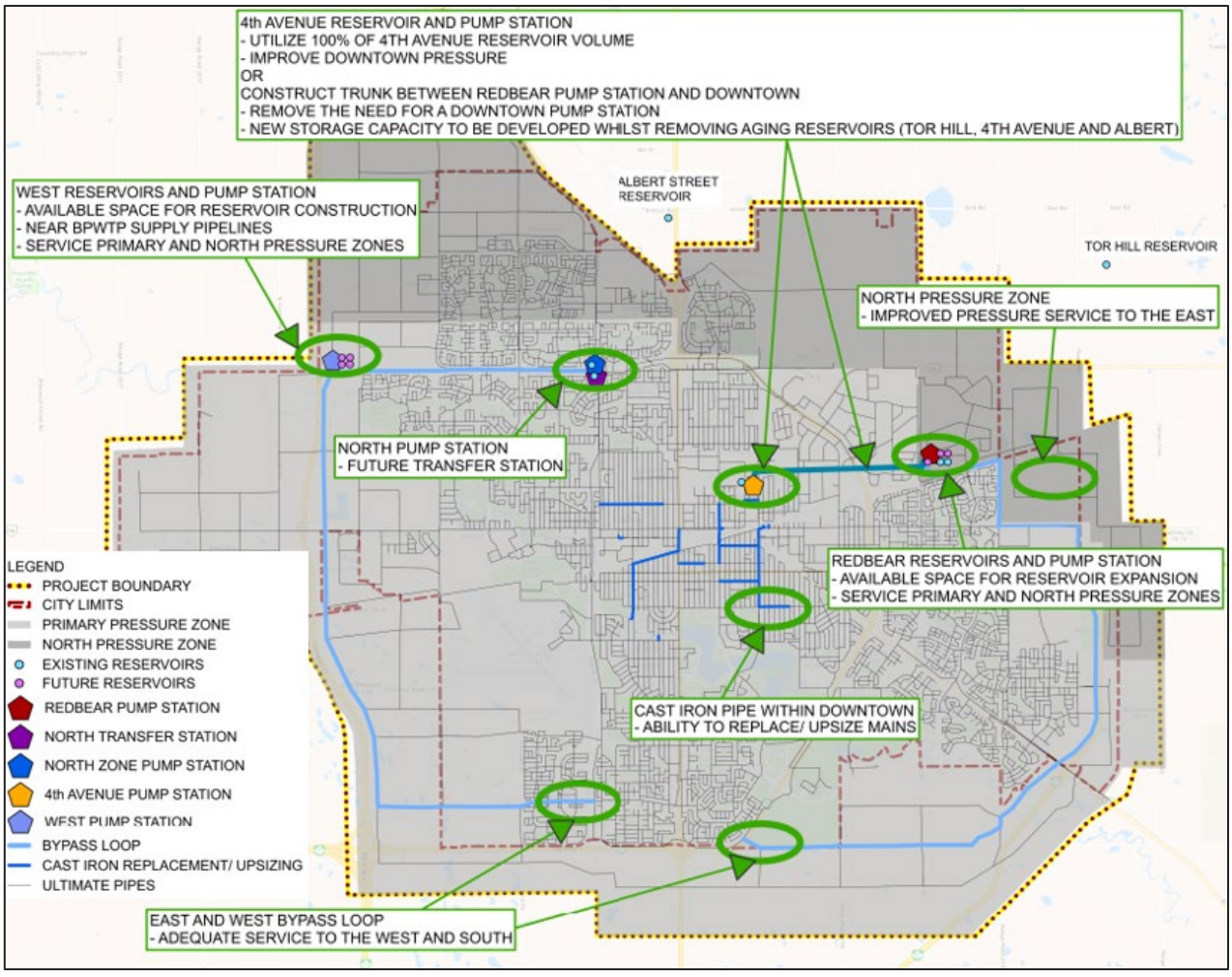


Figure 3.5-1: Ultimate Water Opportunities

The water system opportunities available to the City to achieve the growth identified in this study are summarized below in the following subsections.

3.5.1 STORAGE CAPACITY EXPANSION

Increased reservoir storage capacity will be required for population growth exceeding approximately 500,000 persons. Although there is space at the Redbear site for additional reservoirs, water must be transferred from the North Pump Station to Redbear Reservoir which results in an additional power consumption and cost. Developing future reservoir storage in the City's west, near the Buffalo Pound water supply pipelines is beneficial as transfer pumping will be reduced.

The Redbear Pump Station site is designed to accommodate an addition of three future reservoirs which is advantageous for City growth.

If the 4th Avenue, Tor Hill and / or Albert Street Reservoirs are abandoned because of age and or change in water distribution system operating philosophy, this volume of storage would need to be replaced in another location.

3.5.2 PUMPING CAPACITY DEVELOPMENT

There will be a need to increase the overall pumping station capacity due to a projected increase in peak hour demand to 765 ML/d. The pumping capacity will need to increase from 655 ML/d to 765 ML/d.

A pump station on the west side of the City near the Bypass will promote improved pressure along the City's west allowing for future development along the Bypass within the Primary Pressure Zone. A West Pump Station located near the boundary between the Primary and North Pressure zone would allow for the pump station to also service the North Zone using dedicated pumps.

With recent upgrades, the North Pumping Station will have many years of service life remaining. However, when upgrades or pumping expansion is required, the City may consider using a West Pump Station as the primary station and converting the North Pump Station to a transfer station to transfer stored water to the Redbear Reservoirs and other Reservoirs that exist at that time.

3.5.3 DOWNTOWN PUMPING SYSTEM

The Farrell Pumping facility is near the end of its serviceable life and the City had recently started plans to design a replacement pump station near the 4th Avenue Reservoir. The City has recently commented that the 4th Avenue Reservoir leaks and requires periodic repair. As such, the City is questioning if a downtown pump station is needed with the current construction of the Redbear Pump Station.

A large diameter trunk main from Redbear to Downtown will provide similar downtown pressure to that provided of a downtown pump station which provides the opportunity to eliminate a downtown pump station. However, removing the downtown pump station will eliminate the value of the 4th Avenue Reservoir. As the Tor Hill and Albert Street Reservoirs also feed downtown to the Farrell Pumping Station and 4th Avenue Reservoirs, they too may be deemed wasted storage unless their supply is directed to the Redbear Facility. Ultimately, the City may want to consider abandoning the 4th Avenue, Albert Street and Tor Hill Reservoirs in the future and then adding future 110 ML of water storage volume at the Redbear site and out west near 9th Avenue North and the Bypass.

If the Tor Hill and Albert Street Reservoirs are abandoned; their supply pipelines to downtown could be either relined or pipe burst to serve as trunk mains to the downtown core promoting the opportunity to remove a downtown pumping station.

This all being said, there is also the opportunity to maintain a downtown pumping station near the 4th Avenue Reservoir. In fact, the 4th Avenue Reservoir could be demolished and replaced with a smaller reservoir with an adjacent pump station. Under this scenario, the Tor Hill and Albert Street Reservoirs and supply systems could remain in operation as long as possible and trunk mains from Redbear would not be required.

A downtown solution will require a separate business case study to determine the life cycle cost analysis and benefit due to the magnitude of infrastructure that will be removed from the system and be replaced at new strategic positions.

3.5.4 NORTH PRESSURE ZONE EXPANSION

Improved pressures can be obtained east by extending the reach of the North Pressure Zone along the northeast and east side to a location between Victoria Avenue and Arcola Avenue. The Redbear Pump Station would be the main source of pressure in this area.

3.5.5 NEW DISTRIBUTION TRUNK MAINS

The existing cast iron mains in the City are being phased out. This provides an opportunity to upsize these mains to accommodate future demands especially in the intensification areas.

With proposed development encroaching towards the Bypass away from the current City Loop, water pressure begins to reduce. The development of a large diameter Bypass Loop connected to the Western Pump Station in the west and the Redbear Pump Station in the east, and interconnected to the City Loop will provide a robust distribution system.

3.5.6 TOPOGRAPHY

The City of Regina exhibits higher elevations in the northeast, which gradually descend southwest towards Wascana Creek. This elevated terrain poses challenges for water distribution as water pressure drops in higher elevations. At higher elevations, there may be a need for a dedicated pump station and additional pressure zone.

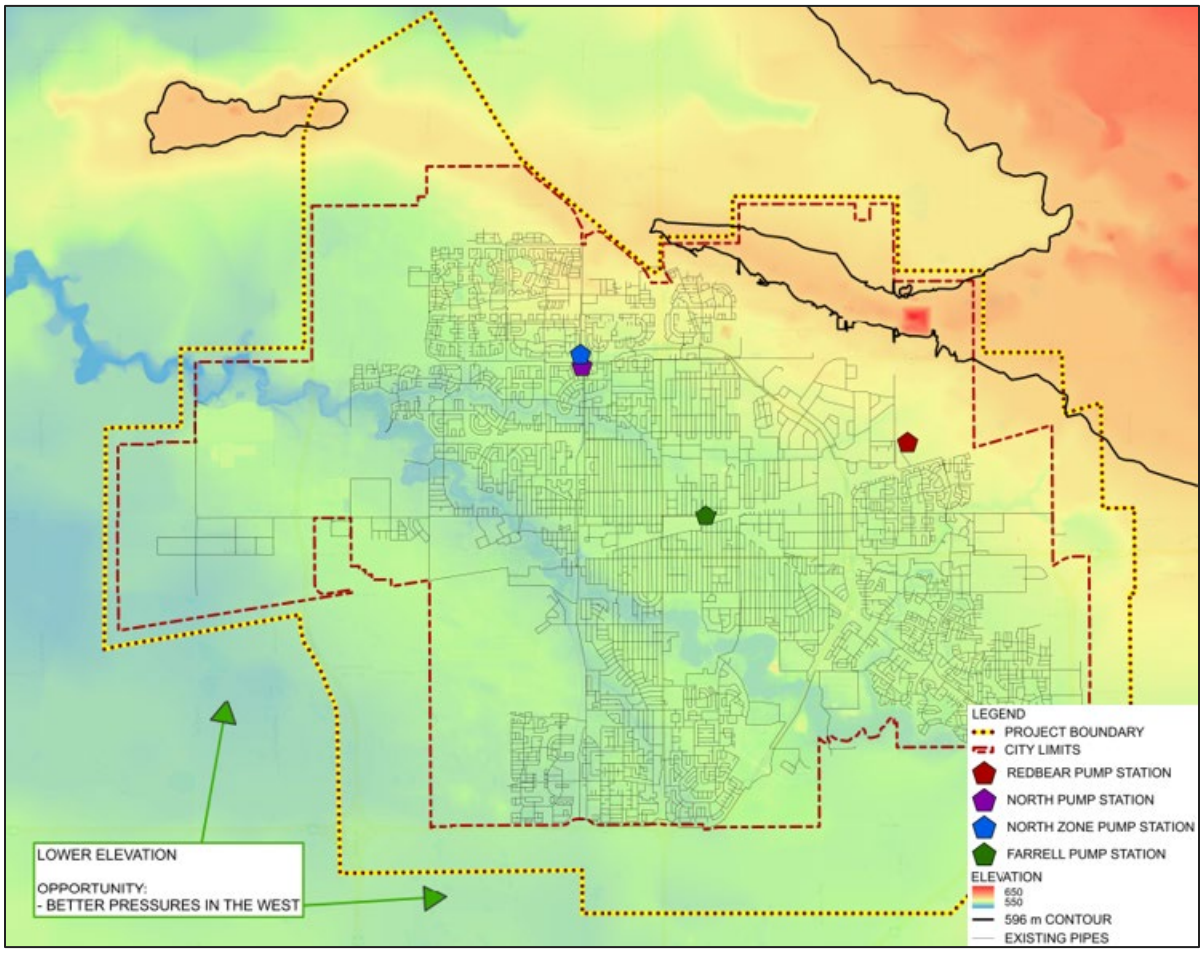


Figure 3.5-2: Topography Opportunities

The contour figure identifies the following opportunities for water service:

- The lower elevation in the southwest is more suitable for development due to less pumping effort required to supply these areas with minimum pressure.
- The placement of future reservoirs at higher elevations in the northeast of the City offers several advantages for the system but it is important to recognize that additional pumping will be required. Water will have to be pumped from the proposed reservoir position to the distribution network due to the higher elevation not providing sufficient pressure which will allow for gravity feed into the system.

4 Wastewater Collection

Although Stone & Arrow's original work plan projected to have wastewater modeling start following submission of the four preliminary memos, some early modeling tasks commenced and support the work on opportunities and constraints presented here.

Using the background information provided by the City of Regina, a high-level review of opportunities and constraints of the existing system was completed to guide modeling. The major themes of the review are included in this memo.

The model was adjusted to reflect the additional demand from intensification and new suburban development. A preliminary, conceptual pipe network for the future areas was added to the model and connected to the existing system according to a conventional infrastructure development strategy of tying into the closest previously existing pipe. Some initial model runs were completed assessing system performance for three scenarios:

1. Existing
2. Intensification
3. Intensification + Future Areas

These model runs confirmed the themes identified from the high-level technical review.

4.1 Existing System

Regina's existing wastewater collection, conveyance and treatment system effectively defines the constraints and opportunities for future growth and development. The following figure shows a conceptual representation of the system.

Reference: Opportunities and Constraints

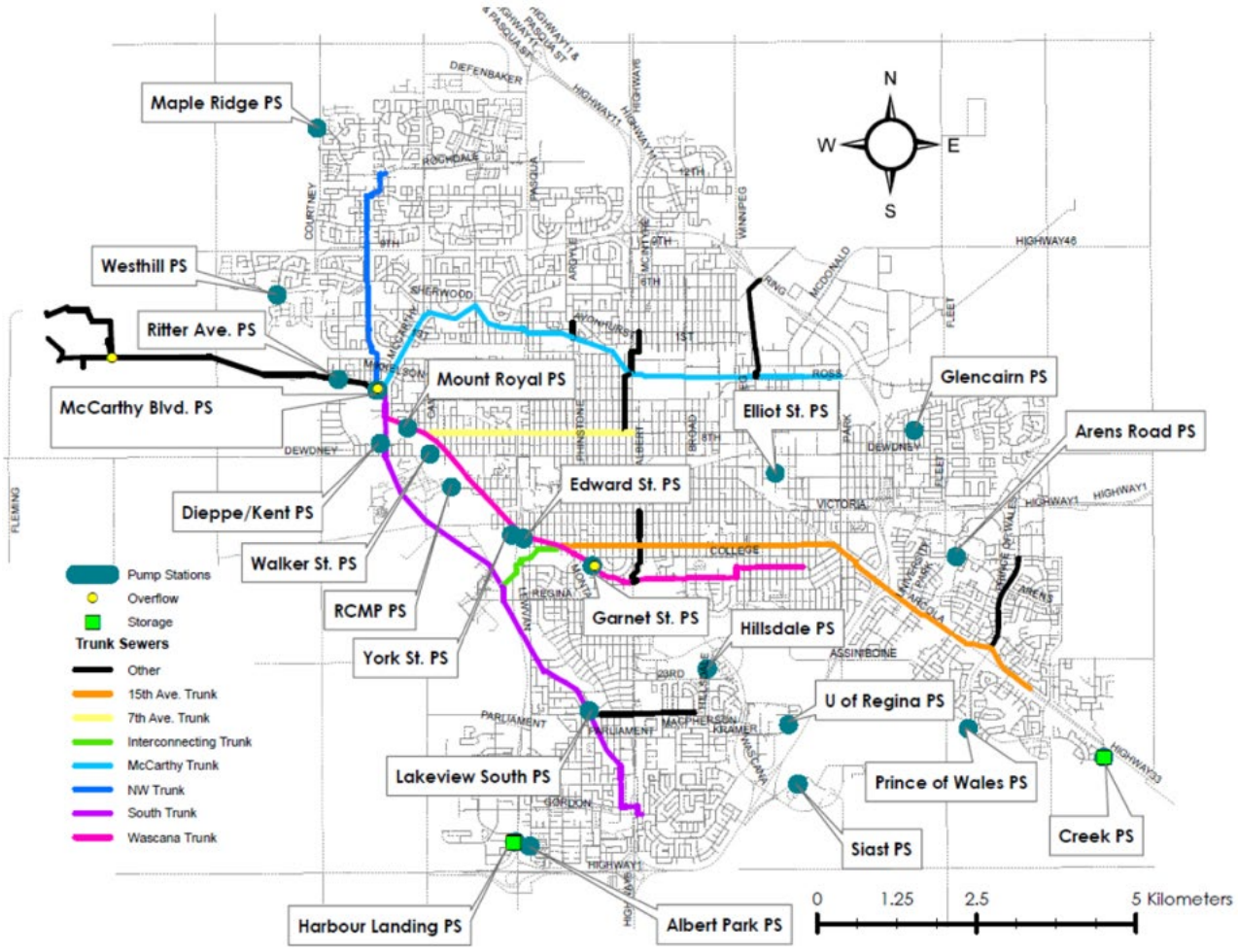


Figure 4.1-1: Existing Wastewater Collection System

Wastewater is collected at its source in homes, businesses, institutional and industrial facilities. It is then directed through a network of sewers of increasing size to the McCarthy Boulevard Pump Station (MBPS). The sewer network also includes various local lift stations supporting system function. The MBPS pumps the wastewater through three large forcemains to the Wastewater Treatment Plant (WWTP) where the water is treated to meet regulatory requirements and released into Wascana Creek. System flow is roughly east to west with the WWTP located west of the existing city, just outside the Regina Bypass.

Regina's wastewater system functions well for typical dry-weather conditions but is stressed during large wet-weather events. Very rare wet-weather events can overload the system to the point where basement flooding and releases to the environment occur. The City's master planning and system efforts have historically been focused on reducing the incidence of such releases.

4.2 Constraints

Infrastructure development in Regina has progressed over a long period of time with each new component designed according to the needs of the moment and near future at that moment. This has resulted in a system that relies heavily on older infrastructure that is often stressed beyond its intended capacity when current demands, including recent regulatory compliance requirements, are applied to it.

The existing system configuration, physical characteristics and geographical location present constraints that must be overcome or managed to facilitate new development. The following subsections present the major constraints.

4.2.1 IMPACT OF WET WEATHER FLOW

In sharp contrast to other types of liquid conveyance systems (e.g. the water distribution system), modern sewer systems are largely designed to accommodate substances that designers would prefer never to enter them. The largest fraction of wastewater flowing in our collection system during high-peak events (i.e. relatively rare rainfall or snowmelt events) is not the wastewater flowing from toilets, sinks, and industrial systems, but inflow and infiltration (I&I).

I&I refers to all the extraneous flows that make their way into the sewers in addition to wastewater. Typical sources of I&I are listed here:

- Groundwater that seeps into sewers through pipe joints and maintenance holes
- Stormwater and runoff
- Weeping tile flows connected to wastewater sewers
- Cross-connections between stormwater and wastewater sewer systems
- Combined sewers (not a big issue in Regina)

Modern municipal design standards, including Regina's Wastewater Design Standards, account for this and all new sewers are required to be designed to accommodate wet weather flow. The result of this is a sewer system that normally functions far below its capacity (typical dry-weather flow) and quite rarely is overwhelmed (large wet-weather event). The large and rare wet-weather events are the events that can lead to releases to the environment.

These factors together mean that intensification will have a much smaller impact on the wastewater collection system than new greenfield development.

The following graph shows the dry-weather and wet-weather flow for the "Existing", "Intensification", and "Intensification + Future Areas" scenarios in the wastewater model in the large-diameter pipe immediately upstream of MBPS. This analysis uses the 1:25 24-hr wet weather event coinciding with the AM dry weather peak to give us a reasonable "worst-case" scenario to evaluate system response.

Reference: Opportunities and Constraints

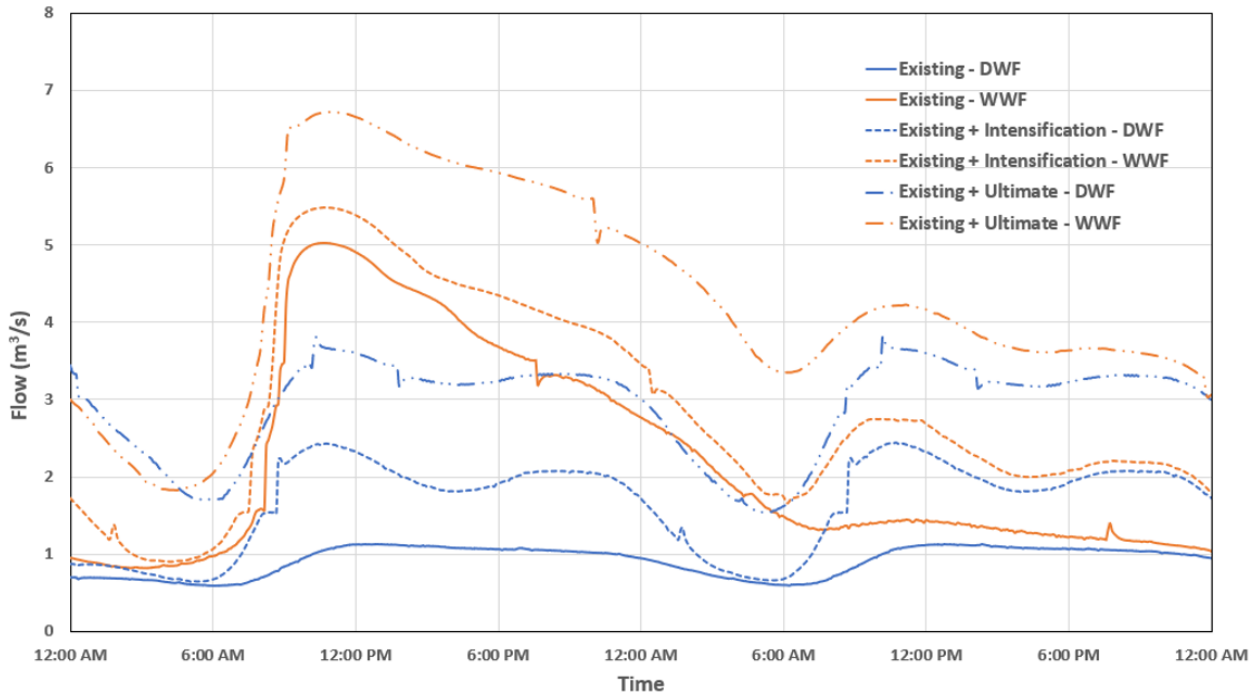


Figure 4.2-1: Flow vs. Time for 1:25 Wet Weather Event

As you can see, wet-weather flow is the large majority of the total flow and appropriately dictates the sizing of the sewers.

4.2.2 UNDERPERFORMING TRUNKS

The following figure shows the wastewater trunks identified as performing below an appropriate level of service in the most recent Master Plan. During typical dry-weather flow the system performs well and can accommodate the demand.

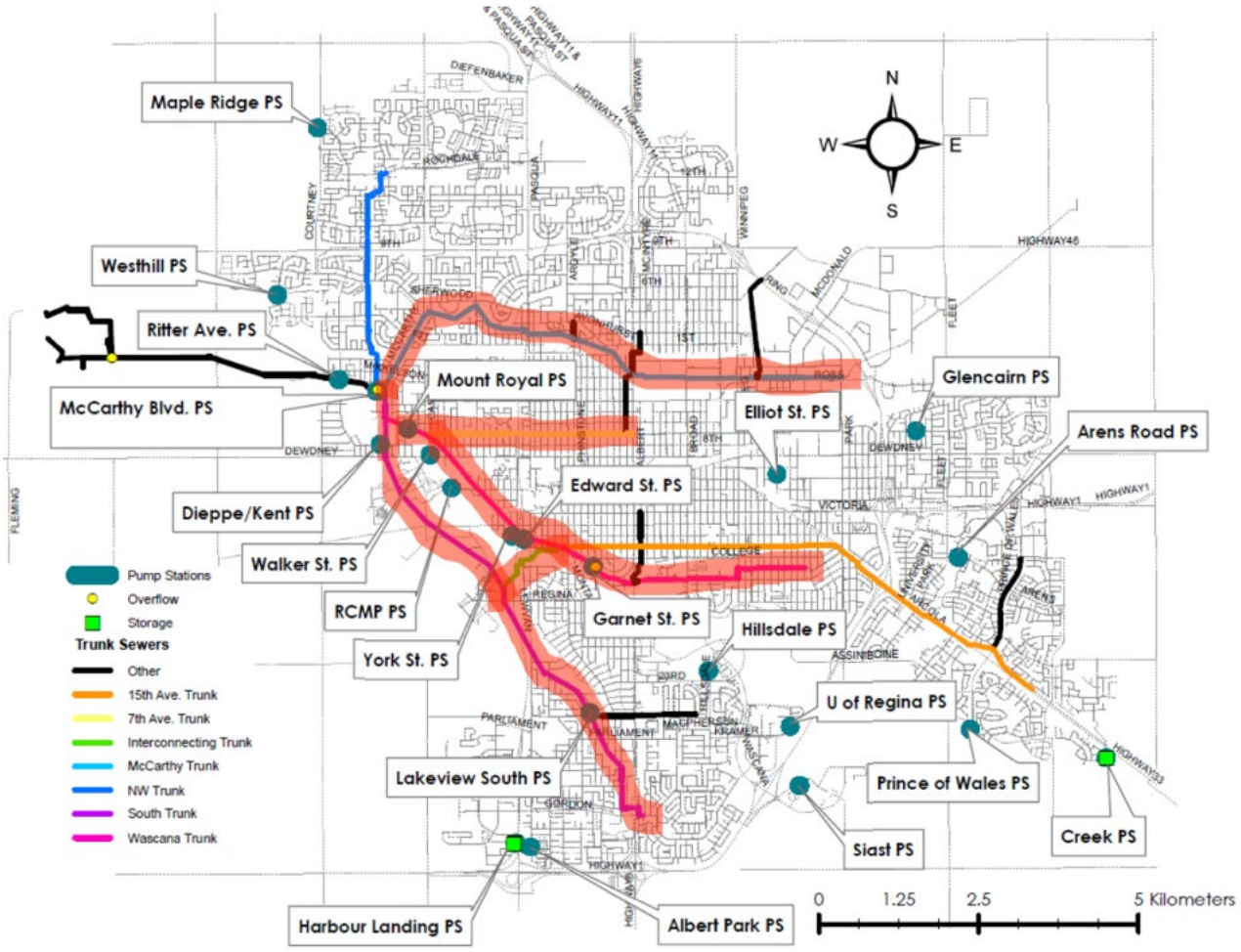


Figure 4.2-2: Underperforming Major Wastewater Trunks

However, wet-weather events cause significant problem along and upstream of the South, Interconnecting, Wascana, McCarthy and 7th Avenue Trunks. These issues would need to be addressed prior to allowing major development in the contributing catchments of these trunks. The previous Master Plan makes recommendations accordingly.

4.2.3 SYSTEM BOTTLENECKS

System bottlenecks impose significant constraints on future development. Any time a significant number of network branches direct flow through single point, system performance is at risk. There are a variety of relatively minor local bottlenecks, but two major bottlenecks shown in the following figure impact current and future serviceability options:

1. McCarthy Boulevard Pump Station (small red ellipse)
2. Regina Wastewater Treatment Plant (large red ellipse)

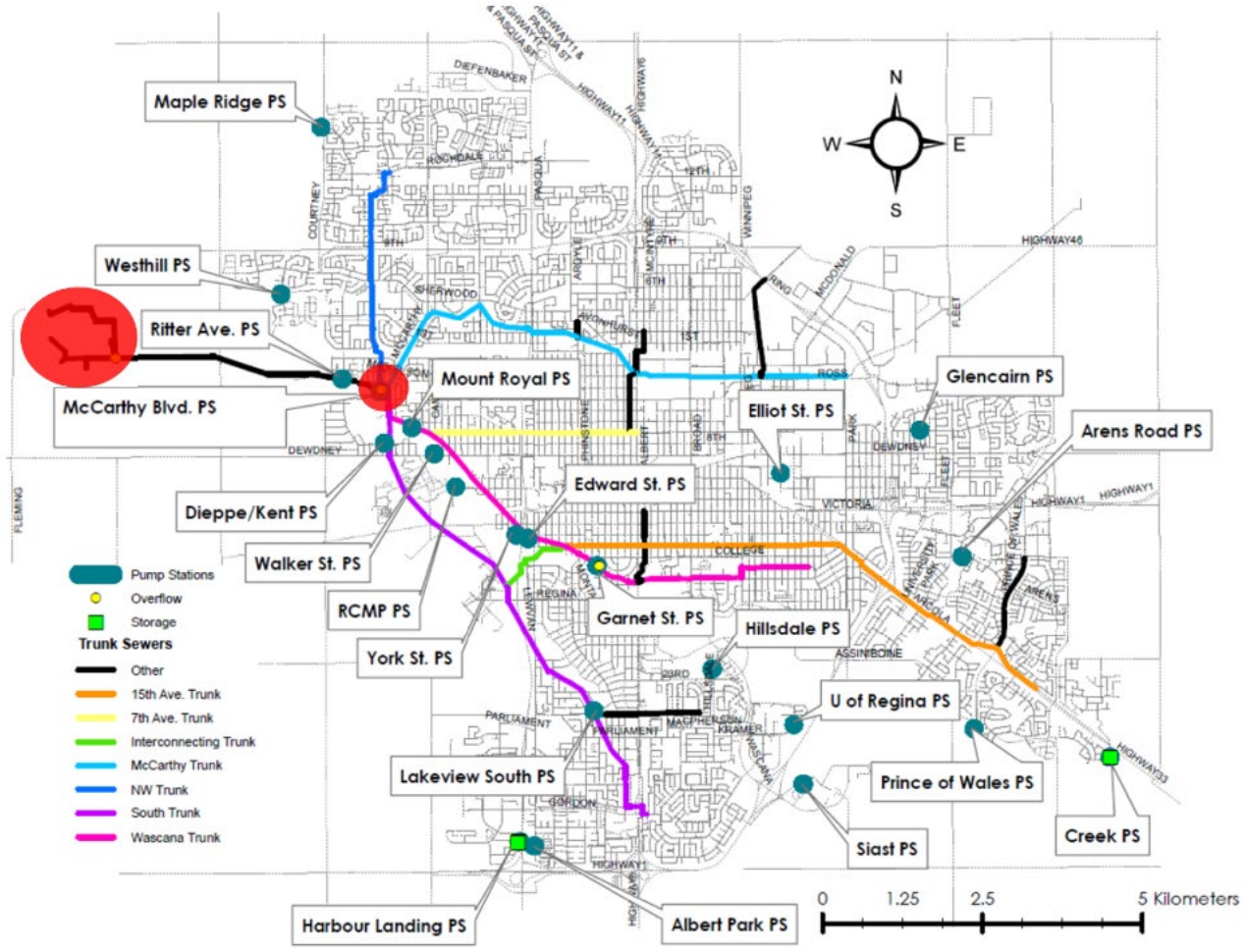


Figure 4.2-3: Major Bottlenecks

Except for a few minor exceptions all wastewater collected in the sewer system flows to the MBPS and must be pumped from there to the WWTP quickly and efficiently enough to avoid upstream backup, basement flooding, and releases to the environment. Even though the MBPS and forcemains have been recently improved, they currently must perform very close to capacity during large wet-weather events.

The existing WWTP is the only wastewater treatment facility available to City of Regina and must be the final destination for all wastewater. The WWTP has significant storage capacity and is not space constrained. Therefore, modifications at the WWTP could accommodate different approaches to wastewater collection and treatment.

4.2.4 TOPOGRAPHY

The City of Regina is topographically flat and relatively sparsely populated. The topography is shown in the figure below.

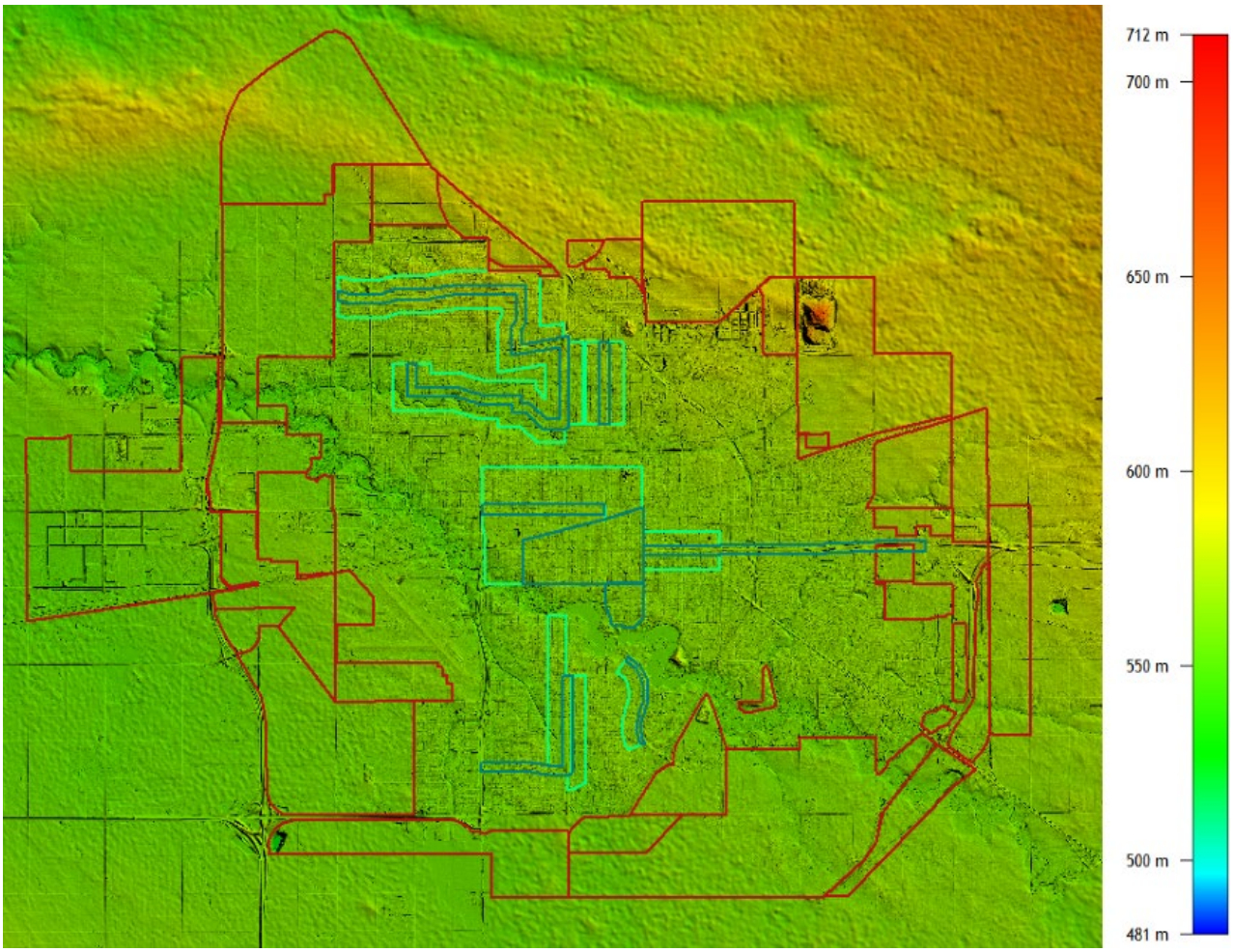


Figure 4.2-4 Topography in Regina Area

With the MBPS and WWTP located on the west side of the City and given that the topography falls from higher to lower as one moves from northeast to southwest, developing gravity sewers that flow counter to that or long distances from the eventual destination is challenging. Underground infrastructure becomes costly when the required excavations are deep or when trenchless technology is required.

With these factors in mind, it is clearly more cost effective to develop closer to the WWTP if possible and to work with the Northeast-to-Southwest topographic profile.

4.3 Opportunities

Five main high-level strategic opportunities were identified to help guide the remainder of the modeling and analysis for this project.

4.3.1 IMPLEMENT MASTER PLAN RECOMMENDATIONS

The existing system is deficient in ways that are well understood and should be improved. Previous master plans have made appropriate recommendations to address the deficiencies. The City has begun implementing some of those recommendations with tenders for the South Trunk Upgrade project currently being evaluated. This project is a major step forward for the City's wastewater system. Stone & Arrow will ensure that our work in the existing City footprint remains consistent with the recommendations of the most recent master plan.

Reducing I&I can have significant positive impacts for both stormwater and wastewater systems. The previous master plan also recommended that the City implement a formal Extraneous Flow Reduction Program. Given the outsized influence that I&I has on the performance of the wastewater system, significant progress on this front would be beneficial. Unless there is clear direction from the City, alternative I&I assumptions will not be incorporated into project analysis.

4.3.2 INTENSIFICATION

Intensification as considered in the Land Use Plan is an important opportunity. The underlying reason for this is that adding population density without adding new development area does not significantly increase wet-weather flow. With negligible increases to wet-weather flow, system performance is not negatively impacted. Adding new greenfield development has a much greater impact on the system performance because it significantly increases wet-weather flow.

From a wastewater system perspective, intensification development can commence immediately. Our analysis will prioritize this opportunity accordingly.

4.3.3 WORK WITHIN PHYSICAL CONSTRAINTS

It may seem simplistic, but gravity sewers are the backbone of the wastewater collection system and water flows downhill. Making the physical constraints work to our advantage helps us deliver better performing solutions with reasonable costs for construction and operation. Our analysis will prioritize solutions that minimize the length and depth of buried infrastructure.

4.3.4 SYNERGY WITH WATER DISTRIBUTION

The water system has topographical and source (Buffalo Pound WTP to the west) constraints that are similar to the wastewater system's topographical and destination (WWTP to the west) constraints. The west and southwest areas of the city are attractive from a servicing perspective for both systems. Our analysis

will prioritize this opportunity and any others where it is clear that there are potential cost and construction efficiencies.

4.3.5 REDUCE IMPACT OF BOTTLENECKS

The combined challenges of the MBPS bottleneck and the long distances sewers must traverse to convey wastewater from the east side of the city to the WWTP make it important to consider avoiding the MBPS with new wastewater demand whenever possible.

New developments (and potentially some existing areas) could convey new flows directly to WWTP bypassing the MBPS. This would lead to a prioritization of new developments on the west side of the City. This strategy would require evaluation of the storage and treatment regime at the WWTP but given the potential long-term cost efficiency this is worth consideration.

4.4 East-Side WWTP

Over the past 15-20 years various stakeholders have proposed the idea of a 2nd WWTP on the east side of the city as a good solution to the wastewater system constraints that limit development in that area. The most recent master plan evaluated an East-Side WWTP as one of 20 sets of system improvements to address system Level of Service for the 300K and 500K population thresholds. The advantages and disadvantages of this strategy as identified in the master plan are shown below.

Strategy	Advantages	Disadvantages
Second Wastewater Treatment Plant	• Potential to pick up wastewater from 500K developments in the Southeast.	• High capital costs. • Ability to get buy in from all stakeholders and to implement solution within a reasonable schedule. • Redirection of existing services in east end. • A new WWTP would need to be combined with other solutions to deal with service level in the southwest portion of the City.

Figure 4.4-1: Advantages and Disadvantages of Second WWTP

When this strategy was evaluated and compared to the other 19 improvement strategies it ranked 20th out of 20 strategies that were considered. The case for this strategy has probably significantly worsened since the master plan deemed it inadvisable. The technical, environmental, socio-cultural and economic conditions upon which the strategies were evaluated have not changed significantly in a direction that would make this worth investigating further.

5 Closure

The opportunities and constraints included in this memo will guide the continued modeling and analysis of the water and wastewater systems as we progress toward an overall serviceability strategy that meets the project requirements.

Respectfully,

STONE & ARROW CONSULTING LP

Jeff Blyth P.Eng.
Associate, Water
Phone: 306-201-9368
jeff.blyth@stantec.co
m

Attachment: None

Appendix E Second WWTP Assessment

STONE & ARROW CONSULTING LP

Memo

To:	Stacey Kaminsky, A.Sc.T. City of Regina Regina, SK	From:	Curtis Wiebe, P.Eng. Stone & Arrow Consulting LP Regina, SK
Project/File:	111260018	Date:	September 6, 2024

Reference: Water and Wastewater Serviceability Study
Second Wastewater Treatment Plant Assessment

The objective of this technical memo is to provide additional technical information to support the conclusion in the Wastewater Masterplan that an East WWTP is not a preferred solution to the wastewater servicing challenges for developing on the east side of the City.

Background

Due to capacity constraints within the existing wastewater collection system, a new approach to wastewater servicing in East Regina is required to allow growth to continue without negatively impacting current residents or limiting future development options in the east of the City. One possible solution that has been proposed at various times to solve these problems is the design and construction of a new wastewater treatment plant (WWTP) east of the City.

The most recent Wastewater Master Plan completed by the City of Regina (Stantec, 2019) included an evaluation of a “long list” of improvements within a framework that included four categories of criteria: Technical, Socio-Cultural, Natural Environment and Economic. The long list included 20 improvement alternatives which included the East WWTP. After evaluation based on the criteria listed, the East WWTP was ranked 20 out of 20 or least desirable of the 20 improvement alternatives. Accordingly, it was not included on the short list or investigated further within the scope of that project.

Current System Configuration

The City’s wastewater is collected in a branched network of sewers, trunks, and lift stations that flow to the McCarthy Boulevard Pump Station (MBPS) on the west side of the City (with minor exceptions for the GTH and Westerra). The MBPS pumps the City’s wastewater through three large forcemains to the WWTP west of Regina. This branched configuration and terminal bottleneck at the MBPS dictates current system performance and future improvement possibilities.

East WWTP Concept

A variety of practical considerations and assumptions would dictate the configuration of a second WWTP on the east side of the City. For the high-level discussion in this document, the following is assumed to allow for a comparison with the long-term solution proposed in the Water and Wastewater Serviceability Report:

- Modern, state-of-the-art biological-mechanical WWTP

- Treatment capacity of greater than 50 megalitres per day (ML/day); City's current WWTP capacity is 197 ML/day
- Requires major interceptor trunk sewer project through the existing City to re-route sufficient wastewater to "feed" the new WWTP
- Close to developable land in East Regina and potential future customers for wastewater treatment (Balgonie, White City, Emerald Park, Pilot Butte, etc.)
- Close to acceptable discharge location for treated effluent
- Minimum distance from existing or future development of 300 metres; current development is within this distance from Regina Bypass
- Operated by City of Regina

The following assessment is based on these assumptions.

Location Challenges

Challenges related to locating a new WWTP east of Regina include:

- The topography in Regina is higher in the east-northeast and lower in the west-southwest. It is less cost-effective to design wastewater collection systems that flow in the opposite direction of the topography.
- A new East WWTP would need to be located close to existing and new developments, and close to an appropriate discharge location. This would likely require it to be located close to Wascana Creek, upstream of the City of Regina. Discharging to Boggy Creek would be more technically challenging, but possible.
- Land for the East WWTP would have to be procured along with land for the large sewers required to connect the new WWTP to the existing wastewater collection network.
- A WWTP is not a desired neighbour for most land uses – could depress development demand and property values creating a "dead zone" which might otherwise have premium value.
- A new WWTP requires a 300-metre buffer zone – consuming developable land with no benefit.

Discharge Challenges

There are two local natural channels that could potentially accommodate outlets for a new WWTP: Wascana Creek and Boggy Creek.

- Wascana Creek has steady but low flow and is dammed in Regina to create Wascana Lake (originally for railway water supply), the focal point (along with Saskatchewan's legislature) of

Wascana Centre. Wascana Creek flows through Regina from southeast to northwest, eventually draining into the Qu'Appelle River west of Lumsden.

- Boggy Creek has low seasonal flow and flows roughly southeast to northwest, passing north of Regina. Boggy Creek was dammed to create the Condie Reservoir (also originally for railway water supply). Condie Reservoir is now surrounded by the Condie Nature Refuge, a provincial recreation site. Boggy Creek flows into the Qu'Appelle River northeast of Lumsden.

Challenges related to discharging to either water body include:

- Hydraulic issues – a new WWTP would significantly alter the flow regime of either creek causing maintenance and management issues.
- Winter ice issues – a new WWTP would change ice formation and buildup patterns causing maintenance and management issues.
- Optics of discharging wastewater treatment effluent upstream of First Nations, nature refuge, recreational sites, Qu'Appelle River, and the City of Regina and the core of its recreational facilities (Wascana Centre) are problematic.
    - Regulatory scrutiny would be significant to ensure such project was appropriate.
    - Stakeholder communication and engagement would be very challenging to ensure public acceptance.
- Provincial (Water Security Agency, Ministry of Environment) and federal (Fisheries and Oceans Canada) regulatory bodies would need to be engaged and approve the project; this is a potentially lengthy process (years not months).

These problems exist whether Wascana Creek or Boggy Creek is selected as a discharge location. The stakeholder optics might be more challenging if Wascana Creek was chosen. The environmental and regulatory barriers might be more difficult if Boggy Creek was chosen. There are not clear or practical ways to mitigate many of these problems regardless of the location selected.

Required Interceptor Trunk

To get a large portion of the City's wastewater routed to an East WWTP an interceptor trunk would have to be planned, designed, and built in conjunction with the East WWTP. For a new WWTP to be commissioned properly and function according to design, a large portion of the City's wastewater would need to be available to the new WWTP on "Day 1". For this to happen, an interceptor trunk system would need to be designed and constructed ***before*** the new WWTP was commissioned.

To capture and re-direct enough wastewater to make a new WWTP viable, the interceptor trunk would have the following characteristics:

- Large diameter – approximately 2 metres in diameter

Reference: Opportunities and Constraints

- Very complex design and construction due to size and routing through City
    - Possibly along Ring Road from Winnipeg Street or McDonald Street to Arcola Avenue or Wascana Parkway
- Long construction schedule due to complexity
- Disruptive construction
    - Will disrupt transportation in multiple years
    - Will disrupt wastewater collection as new connections are made

Coordination between the interceptor trunk project and East WWTP is crucial. There would need to be somewhere for wastewater to go as soon as the new connections are made. There needs to be sufficient wastewater for a new WWTP to function properly. This is a very complex planning and design problem and service interruptions to existing neighbourhoods may be difficult to avoid.

Capital Cost

Using some recent Stantec projects as background and some very high-level assumptions of the cost-to-capacity relationship it is reasonable to assume that a new East WWTP with a capacity of approximately 50 ML/day would cost somewhere around $250M. The interceptor trunk required to make appropriate use of the new WWTP could easily cost as much or more than the WWTP itself resulting in a cost of up to $500M. This does not include costs associated with land procurement which will be significant.

It is important to note that the large majority of this cost would need to be funded “up-front” without generating benefit or related revenue for the City of Regina for the duration of construction (3 to 5 years).

It’s also important to note that construction of an East WWTP and interceptor trunk will not displace the need for previously identified improvements within the existing City. Those improvements (with some adjustments) will still need to be completed in addition to a new interceptor trunk and East WWTP.

Operating Cost and Complexity

Currently the City of Regina has an agreement with EPCOR to operate the current WWTP. This operating agreement started as part of the last major upgrade at the existing WWTP. One key advantage of this agreement is the cost certainty it gives the City with respect to operations of the WWTP.

If the City decided to build a second WWTP, decisions about the funding and operations would have to be made in the beginning. Business cases around different options would have to be generated. Some options that could be considered include the following:

Add new WWTP to existing agreement with EPCOR

This would be efficient administratively and there should be a way to realize the operational efficiencies of having the same vendor provide operating services for two sites. However, it would be difficult to have a

truly competitive bidding process if EPCOR was pre-selected for this. A lack of competition often leads to higher costs.

Undertake new P3 competition

A new public-private partnership (P3) competition resulting in another design-build-finance-operate-maintain (DBFOM) agreement similar to the one the City of Regina currently has with EPCOR could be undertaken. This would again give the City cost certainty with respect to operations, but with EPCOR as an incumbent at the existing WWTP it would be challenging to structure a fair competition with other vendors. Also, excluding EPCOR would be problematic with respect to fairness and also would prevent capitalizing on the operational efficiencies of having a common operator for both City of Regina WWTPs.

Conventional DBB operated by City

The City could undertake a conventional design-bid-build (DBB) project, procure a design consultant and tender the construction to a qualified contractor. This approach would require the City to allocate appropriate internal resources to the design and construction phases of the project, build an operations staff for the new WWTP following construction, and secure funding for a major infrastructure investment.

This could be problematic given the specialization of the skills required for WWTP operations personnel and the presence of another large WWTP in the community. The City could find itself competing with EPCOR (and itself by proxy) for operations staff. Also, if there were significantly different operating costs between the two facilities, one or the other would be open to criticism along with the City itself.

This option might be seen as contrary to the City's current operations approach given the current EPCOR agreement.

Comparison with South Bypass Recommendation

The Water and Wastewater Serviceability Study recommended that a South Bypass be constructed to service the lands west, southwest, south and southeast of the existing City footprint. This approach bypasses the MBPS and would not negatively impact level of service in the existing City. Similar solutions have been proposed as part of other wastewater and development studies and have not been undertaken by the City due to the scale, scope, and cost.

A new East WWTP is inferior to the South Bypass as a solution to wastewater infrastructure in East Regina in the following ways:

- More expensive
- More regulatory resistance and complexity
- More challenging stakeholder engagement
- More problematic environmental issues
- More difficult planning and staging

  - South Bypass can add development incrementally along its length as construction progresses
  - East WWTP and interceptor trunk have to be largely constructed before any benefit to residents or new development can proceed
- More complicated operations scenario

Conclusion

It is clear that major wastewater infrastructure improvements are required to remove the barriers to growth and development currently present in East Regina. A new WWTP is not a cost effective or practical short- or long-term solution to removing those barriers.

It is recommended that the City investigate, design, and construct the South Bypass to help development move forward in East Regina.

Respectfully,

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Appendix F Detailed Cost Breakdown (OPC)

Appendix F Detailed Cost Breakdown (OPC)

F.1 Water

Table F1: Downtown Intensification Opinion of Probable Cost (Figure 5-1)				
4th Avenue Pump Station and Reservoir				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
30 ML reservoir	each	$500,000	30	$15,000,000
4th Avenue Pump Station	each	$15,000,000	1	$ 5,000,000
			Appurtenances (10% of cost)	$ 3,000,000
			Sub-Total	$33,000,000
			Engineering (15%)	$4,950,000
			Contingency (50%)	$16,500,000
			Subtotal for 4th Avenue Pump Station and Reservoir	$54,500,000
Replacement of Cast Iron Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Existing main	each	$1,500	20	$30,000
Pipe renewal through trenchless technology				
for 400 mm diameter pipe	m	$2,800	822	$2,302,000
for 600 mm diameter pipe	m	$3,000	724	$2,172,000
for 750 mm diameter pipe	m	$3,800	1050	$3,990,000
for 900 mm diameter pipe	m	$4,200	324	$1,361,000
			Appurtenances (30% of cost)	$2,957,000
			Sub-Total	$12,810,000
			Engineering (15%)	$1,921,500
			Contingency (50%)	$6,405,000
			Subtotal for Replacement of Cast Iron Mains	$21,100,000

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Large Diameter Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Urban Restoration	m	$500	2049	$1,025,000
Excavation and backfill with 750 mm diameter pipe	m	$2,100	1029	$2,161,000
Excavation and backfill with 900 mm diameter pipe	m	$2,500	907	$2,268,000
Excavation and backfill with 1050 mm diameter pipe	m	$3,200	113	$362,000
Appurtenances (30% of cost)				$1,745,000
Sub-Total				$7,560,000
Engineering (15%)				$1,134,000
Contingency (50%)				$3,780,000
Subtotal for Large Diameter Trunk Mains				$12,500,000
Downtown System Improvements: Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Existing main	each	$1,500	7717	$11,576,000
Urban Restoration	m	$500	7787	$ 3,894,000
Excavation and backfill with 400 mm diameter pipe	m	$1,250	7717	$9,646,000
Excavation and backfill with 600 mm diameter pipe	m	$1,800	70	$126,000
Appurtenances (30% of cost)				$2,932,000
Sub-Total				$12,700,000
Engineering (15%)				$1,905,000
Contingency (50%)				$6,350,000
Subtotal for Downtown System Improvements: Feeder Mains				$21,000,000
Victoria Avenue System Improvement Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Existing main	each	$1500	250	$375,000
Urban Restoration	m	$500	6600	$3,300,000
Excavation and backfill with 400 mm diameter pipe	m	$1250	6600	$8,250,000
Appurtenances (30% of cost)				$2,475,000
Sub-Total				$14,400,000
Engineering (15%)				$2,160,000
Contingency (50%)				$7,200,000
Subtotal for Victoria Avenue System Improvement Feeder Mains				$23,800,000

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Table F2: North of Downtown Intensification Opinion of Probable Cost (Figure 5-2)				
North Intensification Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Urban Restoration	m	$500	915	$458,000
Connection to Existing main	each	$1,500	240	$360,000
Excavation and backfill with 600 mm diameter pipe	m	$1,800	915	$1,647,000
			Appurtenances (30% of cost)	$494,000
			Sub-Total	$2,960,000
			Engineering (15%)	$440,000
			Contingency (50%)	$1,480,000
			Subtotal for North Intensification Trunk Mains	$4,900,000
North Intensification Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Urban Restoration	m	$500	12314	$6,157,000
Connection to Existing main	each	$1,500	300	$450,000
Excavation and backfill with 400 mm diameter pipe	m	$1,250	12314	$15,393,000
			Appurtenances (30% of cost)	$4,620,000
			Sub-Total	$26,620,000
			Engineering (15%)	$3,990,000
			Contingency (50%)	$2,000,000
			Subtotal for North Intensification Feeder Mains	$32,600,000

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Table F3: South of Downtown Intensification Opinion of Probable Cost (Figure 5-3)				
South Intensification Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Urban Restoration	m	$500	1127	$564,000
Connection to Existing main	each	$1,500	200	$300,000
Excavation and backfill with 600 mm diameter pipe	m	$1,800	1127	$2,029,000
			Appurtenances (30% of cost)	$610,000
			Sub-Total	$3,500,000
			Engineering (15%)	$530,000
			Contingency (50%)	$1,750,000
			Subtotal for South Intensification Trunk Mains	$5,800,000
South Intensification Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Urban Restoration	m	$500	5521	$2,761,000
Connection to Existing main	each	$1,500	300	$ 450,000
Excavation and backfill with 400 mm diameter pipe	m	$1,250	5521	$6,901,000
			Appurtenances (30% of cost)	$2,070,000
			Sub-Total	$12,180,000
			Engineering (15%)	$1,830,000
			Contingency (50%)	$6,090,000
			Subtotal for South Intensification Feeder Mains	$20,100,000

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Table F4: East Upgrades Opinion of Probable Cost (Figure 5-4)				
East Bypass Loop				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Redbear pump station	each	$500,000	1	$500,000
Greenfield excavation and backfill with 1200 mm watermain	m	$3,800	1801	$6,844,000
Greenfield excavation and backfill with 1050 mm Watermain	m	$3,000	3024	$9,072,000
Greenfield excavation and backfill with 900 mm Watermain	m	$2,500	5237	$13,093,000
			Appurtenances (30% of cost)	$8,850,000
			Sub-Total	$38,360,000
			Engineering (15%)	$5,750,000
			Contingency (50%)	$19,180,000
			Subtotal for East Bypass Loop	$63,300,000
North Pressure Zone Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Redbear pump station	each	$500,000	1	$500,000
Greenfield excavation and backfill with 750 mm watermain	m	$2,100	37	$78,000
Greenfield excavation and backfill with 600 mm watermain	m	$1,800	5571	$10,028,000
			Appurtenances (30% of cost)	$3,182,000
			Sub-Total	$13,790,000
			Engineering (15%)	$2,070,000
			Contingency (50%)	$6,900,000
			Subtotal for North Pressure Zone Trunk Mains	$22,800,000
Redbear Reservoir Expansion				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Redbear pump station	each	$500,000	1	$500,000
150 ML reservoir	each	$500,000	150	$75,000,000
			Appurtenances (10% of cost)	$7,550,000
			Sub-Total	$83,100,000
			Engineering (15%)	$12,470,000
			Contingency (50%)	$41,550,000
			Subtotal for Redbear Reservoir Expansion	$137,100,000

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Primary Pressure Zone Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to large diameter trunk	each	$100,000	1	$100,000
Greenfield excavation and backfill with 400 mm feeder main	m	$1,250	6954	$8,693,000
Appurtenances (10% of cost)				$869,000
Sub-Total				$9,700,000
Engineering (15%)				$1,460,000
Contingency (50%)				$4,850,000
Subtotal for Primary Pressure Zone Feeder Mains				$16,000,000

North Pressure Zone Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to large diameter trunk	each	$100,000	1	$100,000
Greenfield excavation and backfill with 400 mm feeder main	m	$1,250	7077	$8,846,000
Appurtenances (10% of cost)				$885,000
Sub-Total				$9,830,000
Engineering (15%)				$1,470,000
Contingency (50%)				$4,920,000
Subtotal for North Pressure Zone Feeder Mains				$16,200,000

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Table F5: Southeast Upgrades Opinion of Probable Cost (Figure 5-5)				
Bypass Loop				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Arcola bypass loop	each	$300,000	1	$300,000
Connection to City loop	each	$500,000	1	$500,000
Greenfield excavation and backfill with 600 mm watermain	m	$1,800	5382	$9,688,000
Greenfield excavation and backfill with 750 mm Watermain	m	$2,100	1826	$3,835,000
			Appurtenances (30% of cost)	$4,300,000
			Sub-Total	$18,620,000
			Engineering (15%)	$2,790,000
			Contingency (50%)	$9,310,000
			Subtotal for Bypass Loop	$30,700,000
Southeast Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Bypass loop	each	$150,000	2	$300,000
Greenfield excavation and backfill with 600 mm feeder main	m	$1,800	790	$1,422,000
			Appurtenances (30% of cost)	$430,000
			Sub-Total	$2,152,000
			Engineering (15%)	$320,000
			Contingency (50%)	$1,080,000
			Subtotal for Southeast Trunk Mains	$3,600,000
Southeast Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to large diameter trunk	each	$ 100,000	3	$300,000
Greenfield excavation and backfill with 400 mm feeder main	m	$1,250	4267	$5,334,000
			Appurtenances (30% of cost)	$1,600,000
			Sub-Total	$7,230,000
			Engineering (15%)	$1,080,000
			Contingency (50%)	$3,620,000
			Subtotal for Southeast Feeder Mains	$11,900,000

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Table F6: Southwest Upgrades Opinion of Probable Cost (Figure 5-6)				
West Bypass Loop				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to GTH trunks	each	$300,000	1	$300,000
Connection to Harbour Landing	each	$150,000	2	$300,000
Greenfield excavation and backfill with 600 mm watermain	m	$1,800	2892	$5,206,000
Greenfield excavation and backfill with 750 mm Watermain	m	$2,100	1415	$2,972,000
Greenfield excavation and backfill with 900 mm Watermain	m	$2,500	2875	$7,188,000
			Appurtenances (30% of cost)	$4,610,000
			Sub-Total	$20,580,000
			Engineering (15%)	$3,090,000
			Contingency (50%)	$10,290,000
			Subtotal for Bypass Loop	$34,000,000
Southwest Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to Harbour Landing and Bypass loop	each	$300,000	2	$ 600,000
Greenfield excavation and backfill with 600 mm feeder main	m	$1,800	4114	$7,405,000
Greenfield excavation and backfill with 750 mm feeder main	m	$2,100	2424	$5,090,000
			Appurtenances (30% of cost)	$1,530,000
			Sub-Total	$14,630,000
			Engineering (15%)	$2,190,000
			Contingency (50%)	$7,320,000
			Subtotal for Southwest Trunk Mains	$ 24,100,000
Southwest Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to large diameter trunk	each	$100,000	3	$300,000
Greenfield excavation and backfill with 400 mm feeder main	m	$1,250	7618	$9,523,000
			Appurtenances (30% of cost)	$2,860,000
			Sub-Total	$12,680,000
			Engineering (15%)	$1,900,000
			Contingency (50%)	$ 6,340,000
			Subtotal for Southwest Feeder Mains	$20,900,000

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Table F7: West Upgrades Opinion of Probable Cost (Figure 5-7)				
West Pump Station and Reservoirs				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
150 ML reservoir	each	$500,000	150	$75,000,000
Pump station	LS	$84,000,000	1	$84,000,000
			Appurtenances (10% of cost)	$15,900,000
			Sub-Total	$174,900,000
			Engineering (15%)	$26,240,000
			Contingency (50%)	$87,450,000
			Subtotal for West Pump Station and Reservoirs	$288,600,000
West Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to main in GTH	each	$150,000	2	$300,000
Greenfield excavation and backfill with 600 mm feeder main	m	$1,800	150	$270,000
			Appurtenances (30% of cost)	$80,000
			Sub-Total	$650,000
			Engineering (15%)	$100,000
			Contingency (50%)	$330,000
			Subtotal for West Trunk Mains	$1,100,000
West Bypass Loop				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to bypass loop	each	$300,000	1	$300,000
Connection to West pump station	each	$500,000	1	$500,000
Greenfield excavation and backfill with 1050 mm Watermain	m	$3,000	1541	$4,623,000
Greenfield excavation and backfill with 1200 mm Watermain	m	$3,800	3240	$12,312,000
Appurtenances (30% of cost)				$5,080,000
Sub-Total				$22,820,000
			Engineering (15%)	$3,420,000
			Contingency (50%)	$11,410,000
			Subtotal for West Bypass Loop	$37,700,000

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West Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to large diameter trunk	each	$100,000	3	$300,000
Greenfield excavation and backfill with 400 mm feeder main	m	$1,250	8485	$10,606,000
			Appurtenances (30% of cost)	$3,180,000
			Sub-Total	$14,090,000
			Engineering (15%)	$2,110,000
			Contingency (50%)	$7,050,000
			Subtotal for West Feeder Mains	$23,300,000
9th Avenue North Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to North Pump Station	each	$500,000	1	$500,000
Connection to West Bypass Loop	each	$300,000	1	$300,000
Urban Restoration	m	$500	5445	$2,723,000
Excavation and backfill with 1050 mm Watermain	m	$3,000	4326	$12,978,000
Excavation and backfill with 1200 mm Watermain	m	$3,800	1119	$4,252,000
			Appurtenances (30% of cost)	$5,170,000
			Sub-Total	$25,920,000
			Engineering (15%)	$3,890,000
			Contingency (50%)	$12,960,000
			Subtotal for 9th Avenue North Trunk Mains	$42,800,000

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Table F8: Northwest Upgrades Opinion of Probable Cost (Figure 5-8)				
North Loop				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to City	each	$150,000	1	$150,000
Connection to West pump station	each	$500,000	1	$500,000
Greenfield excavation and backfill with 600 mm watermain	m	$1,800	5927	$10,669,000
Greenfield excavation and backfill with 750 mm Watermain	m	$2,100	2808	$5,897,000
Greenfield excavation and backfill with 900 mm Watermain	m	$2,500	1773	$4,433,000
			Appurtenances (30% of cost)	$6,300,000
			Sub-Total	$ 27,950,000
			Engineering (15%)	$4,190,000
			Contingency (50%)	$13,980,000
			Subtotal for North Loop	$46,100,000
Northwest Trunk Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to North Loop and existing City trunk	each	$150,000	2	$300,000
Greenfield excavation and backfill with 600 mm feeder main	m	$1,800	2426	$4,367,000
			Appurtenances (30% of cost)	$1,310,000
			Sub-Total	$5,980,000
			Engineering (15%)	$900,000
			Contingency (50%)	$2,990,000
			Subtotal for Northwest Trunk Mains	$9,900,000
Northwest Feeder Mains				
Description	**Unit**	**Unit Price**	**Quantity**	**Extension**
Connection to large diameter trunk	each	$100,000	3	$300,000
Greenfield excavation and backfill with 400 mm feeder main	m	$1,250	16569	$20,711,000
			Appurtenances (30% of cost)	$6,210,000
			Sub-Total	$27,220,000
			Engineering (15%)	$4,080,000
			Contingency (50%)	$13,610,000
			Subtotal for Northwest Feeder Mains	$44,900,000

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F.2 Wastewater

Opinion of Probable Cost - Option 1 - McCarthy Trunk Upgrades				
Description	Unit	Unit Price	Quantity	Extension
Pipe (surface restoration)				
300mm - 675mm	m	$3,000	1,203	$3,609,000
750mm - 1050mm	m	$3,500	3,318	$11,613,000
1200mm - 1500mm	m	$4,000	5,181	$20,724,000
1650mm - 2100mm	m	$4,500	2,133	$9,598,500
Appurtenances				$2,400,000
Offline Storage at MBPS (16,000 m3 storage and 0.3 m3/s pumping)	each	$44,000,000	1	$44,000,000
Subtotal				$92,000,000
Engineering (15%)				$13,800,000
Contingency (50%)				$46,000,000
Total				**$152,000,000**

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Opinion of Probable Cost - Option 2 - 7th Avenue Trunk Upgrades				
Description	Unit	Unit Price	Quantity	Extension
Pipe (surface restoration)				
300mm - 675mm	m	$3,000		$0
750mm - 1050mm	m	$3,500	3,229	$11,301,500
1200mm - 1500mm	m	$4,000	10,274	$41,096,000
1650mm - 2100mm	m	$4,500	0	$0
Appurtenances				$2,600,000
Offline Storage at MBPS (21,400 m3 storage and 0.3 m3/s pumping)	each	$46,000,000	1	$46,000,000
Subtotal				$104,000,000
Engineering (15%)				$15,600,000
Contingency (50%)				$52,000,000
Total				**$172,000,000**

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Opinion of Probable Cost - North Bypass Greenfield Infrastructure				
Description	Unit	Unit Price	Quantity	Extension
Pipe (incl. forcemains)				
300mm - 675mm	m	$2,000	8,768	$17,536,000
750mm - 1050mm	m	$2,500	4,101	$10,252,500
1200mm - 1500mm	m	$3,000	3,536	$10,608,000
1650mm - 2100mm	m	$3,500	0	$0
Appurtenances				$3,700,000
Pump Stations				
Coopertown (2.44 m3/s)	each	$58,000,000	1	$58,000,000
Subtotal				$101,000,000
Engineering (15%)				$15,150,000
Contingency (50%)				$50,500,000
Total				**$167,000,000**

Stantec

Opinion of Probable Cost - South Bypass Greenfield Infrastructure

Description	Unit	Unit Price	Quantity	Extension
Pipe (incl. forcemains)				
300mm - 675mm	m	$2,000	19,630	$39,260,000
750mm - 1050mm	m	$2,500	8,051	$20,127,500
1200mm - 1500mm	m	$3,000	4,922	$14,766,000
1650mm - 2100mm	m	$3,500	7,727	$27,044,500
Appurtenances				$8,900,000
Pump Stations				
Harbor Landing West (3.2 m3/s)	each	$76,000,000	1	$76,000,000
Southwest of Harbor Landing West (2.0 m3/s)	each	$47,000,000	1	$47,000,000
South of MFN (1.2 m3/s)	each	$29,000,000	1	$29,000,000
Subtotal				$263,000,000
Engineering (15%)				$39,450,000
Contingency (50%)				$131,500,000
Total				**$434,000,000**

Stantec

Opinion of Probable Cost - MBPS North Greenfield Infrastructure				
Description	Unit	Unit Price	Quantity	Extension
Pipe (surface restoration)				
300mm - 675mm	m	$3,000	1,100	$3,300,000
750mm - 1050mm	m	$3,500	937	$3,279,500
1200mm - 1500mm	m	$4,000	2,200	$8,800,000
1650mm - 2100mm	m	$4,500	0	$0
Pipe (incl. forcemains)				
300mm - 675mm	m	$2,000	4,408	$8,816,000
750mm - 1050mm	m	$2,500	0	$0
1200mm - 1500mm	m	$3,000	0	$0
1650mm - 2100mm	m	$3,500	0	$0
Appurtenances				$2,300,000
Subtotal				$27,000,000
Engineering (15%)				$4,050,000
Contingency (50%)				$13,500,000
Total				**$45,000,000**

Stantec

Opinion of Probable Cost - MBPS Northeast Greenfield Infrastructure				
Description	Unit	Unit Price	Quantity	Extension
Pipe (surface restoration)				
300mm - 675mm	m	$3,000		$0
750mm - 1050mm	m	$3,500		$0
1200mm - 1500mm	m	$4,000		$0
1650mm - 2100mm	m	$4,500	0	$0
Pipe (incl. forcemains)				
300mm - 675mm	m	$2,000	8,201	$16,402,000
750mm - 1050mm	m	$2,500	1,007	$2,517,500
1200mm - 1500mm	m	$3,000	0	$0
1650mm - 2100mm	m	$3,500	0	$0
Appurtenances				$2,400,000
Subtotal				$22,000,000
Engineering (15%)				$3,300,000
Contingency (50%)				$11,000,000
Total				**$37,000,000**

Stantec

Opinion of Probable Cost - MBPS East Greenfield Infrastructure				
Description	Unit	Unit Price	Quantity	Extension
Pipe (surface restoration)				
300mm - 675mm	m	$3,000		$0
750mm - 1050mm	m	$3,500		$0
1200mm - 1500mm	m	$4,000	845	$3,380,000
1650mm - 2100mm	m	$4,500		$0
Pipe (incl. forcemains)				
300mm - 675mm	m	$2,000		$0
750mm - 1050mm	m	$2,500		$0
1200mm - 1500mm	m	$3,000		$0
1650mm - 2100mm	m	$3,500	0	$0
Appurtenances				$300,000
Subtotal				$4,000,000
Engineering (15%)				$600,000
Contingency (50%)				$2,000,000
Total				**$7,000,000**

STONE & ARROW CONSULTING LP

Memo

To:	Stacey Kaminsky, P.Tech. City of Regina	From:	Jeff Blyth, P.Eng. Stone & Arrow Consulting LP
Project/File:	111260018	Date:	May 9, 2025

Reference: Water and Wastewater Serviceability – Validation Memo

1 Objective

As part of the Water and Wastewater Serviceability Project, a high-level validation of the water and wastewater models was completed. The validation was based on updated hydrant test data for the water model and flow monitoring and rainfall data for the wastewater model. The objective of this technical memo is to summarize the validation process and results.

2 Water Distribution

The current WaterCAD model was validated against hydrant test data provided by the City of Regina. Sample hydrants were selected in each of the four City quadrants, and hydrant test results were compared against the model results. In general, the hydrant test results and model were found to be in good conformance with less than 34 kPa (5 psi) difference found in the samples assessed. Some variance is expected as elevations will differ between the field and model, as will demand. The model validation results indicate that the WaterCAD model is appropriate for the purposes of completing the Serviceability Study.

While undertaking the model validation, Stone & Arrow has identified locations that the City may wish to investigate further. These are areas where the model results appear more plausible than the hydrant test results, and likely warrant additional review or re-testing.

- Harbour Landing – Southwest Quadrant
    - Headloss during fire flow was unexpectedly high in the Harbour Landing area. Interim development conditions may explain some results, however, it appears likely that there may have been additional sources of headloss, such as closed or partially closed valves. It is recommended that the City conduct additional testing in this area to identify if this condition is still occurring. Valves should be confirmed to be fully open including connection to the 1050 mm and 900 mm water transmission main. This is not considered to be a shortfall of the WaterCAD model, but more likely a localized issue within the existing distribution system.
- North Pressure Zone – Northwest Quadrant
    - Additional testing is recommended in the north pressure zone, which is supplied by the North Zone Pump Station. Only two hydrant test reports were identified within this service area and both

hydrant reports indicate higher than anticipated headloss. Based on location, these hydrant tests may have occurred during interim development conditions and are no longer sufficient for validation. As such, there were insufficient hydrant test results to adequately validate the north pressure zone. Based on good conformance within the primary pressure zone, it is likely that the model is equally suitable for use within the north pressure zone.

As outlined above, the WaterCAD model is considered to be appropriate for the purposes of completing the Serviceability Study.

3 Wastewater Collection

The monitoring stations P1 to P8 were used for the verification purpose. These monitors were installed on major sanitary trunks in the wastewater collection system. The locations of these monitors are shown in Figure 3-1 and coordinates are presented in Table 3-1. The monitors P1 to P7 were used in the calibration exercise completed by Stantec (Stantec, 2014).

Table 3-1 ***Location of Flow Monitors***

Flow Monitor	Trunk	Coordinates	
P1	Wascana Trunk	50.4373	-104.62021
P2	15th Avenue Trunk	50.44245	-104.63257
P3	7th Avenue Trunk	50.45838	-104.65905
P4	Wascana Trunk	50.45811	-104.66283
P5	South Trunk	50.45972	-104.67268
P6	NW Trunk	50.47301	-104.67627
P7	McCarthy Blvd Trunk	50.47126	-104.66724
P8	Interconnection Trunk	50.44197	-104.6391

Figure 3-1 ***Flow Monitor Locations***

The City of Regina wastewater model was calibrated by Stantec in 2014. The wet weather flow (WWF) model was calibrated against four rainfall events from 2013 and was validated against one rainfall event from 2012. The dry weather flow (DWF) model was also calibrated and validated using 2012-2013 data.

As part of the validation efforts for this project, Stone and Arrow used two rainfall events (May 27-28, 2023 and June 1-2, 2023) to verify the WWF and one event (May 23-24, 2023) of monitored data to verify the DWF. The recorded depths of these two rainfalls are 31.6 mm and 45.2 mm, respectively. The monitors recorded flow rates at 5-minute intervals. The rain gauge data provided by the City of Regina at Toronto Street station (528422.699E, 5590500.624N) was applied in the modeling exercise. This station was selected since it is geographically located approximately at the center of the City. Refer to Appendix D for the rainfall date.

The model performance was assessed against three indicators – alignment of peak flows, difference in peak flow rate, and 48-hour flow volume. Upon review, the DWF and WWF model results appear to

generally follow the monitored data. Some variance is expected as the comparison is based on rainfall data in one location which is not a perfect representation of the rainfall from across the City. However, the timing of the modelled peaks generally aligns with the monitored peaks as shown in the figures in Appendix A. Additionally, the peak flow rates and 48-hour flow volumes are within 25% for peak flows and 20% for flow volumes in most cases which aligns with the Integrated Urban Drainage Modeling Guide, 2011. The model validation results indicate that the wastewater model is appropriate for the purposes of completing the Serviceability Study.

While undertaking the model validation, Stone & Arrow identified one location that the City may wish to investigate further. This is an area where the monitored and modelled results do not align and likely warrant additional review or re-testing.

It was observed that the model considerably overestimates both peak DWF and WWF volumes at P4 and underestimates at DWF at P8. This may be due to the incorrect setting of the weir at the interconnection trunk that controls flow distribution between the interconnection trunk and the Wascana trunk. This does not impact the results of the Serviceability Study as this weir was proposed to be removed for the ultimate scenario to direct more flows to the twinned south trunk and therefore, options presented in the serviceability study will not be affected by the weir settings. In addition, options presented in the serviceability study were based on peak wet weather flows since peak wet weather flows were larger in magnitude compared to the peak dry weather flows.

4 Closure

Based on the above validation efforts, the water and wastewater models are suitable for use in the Water and Wastewater Serviceability Study. It is recommended that the City validate the models once new major infrastructure such as the Red Bear Pump Station and South Trunk Upgrades are commissioned.

Respectfully,

STONE & ARROW CONSULTING LP

Jeff Blyth P.Eng.
Associate, Water
Phone: 306-201-9368
jeff.blyth@stantec.com

Appendix A Flow Rate Comparison Figures

Reference: Validation Memo

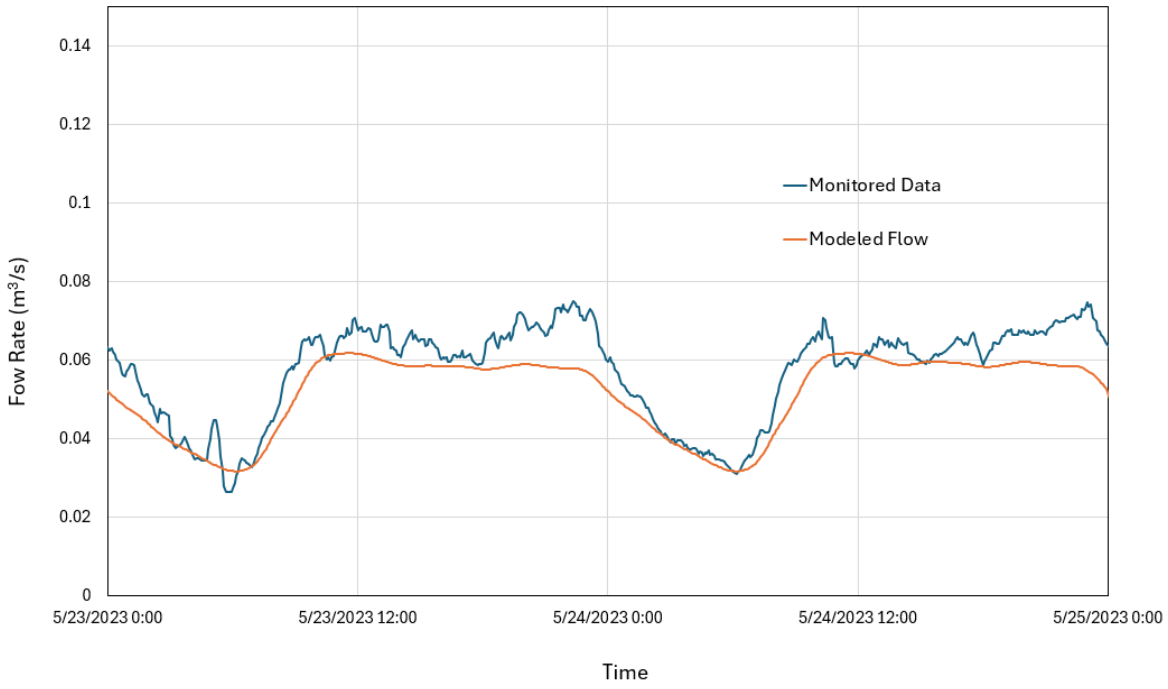


Figure A-1: DWF Comparison at P1 Station using May 23-24, 2023 Monitored Data

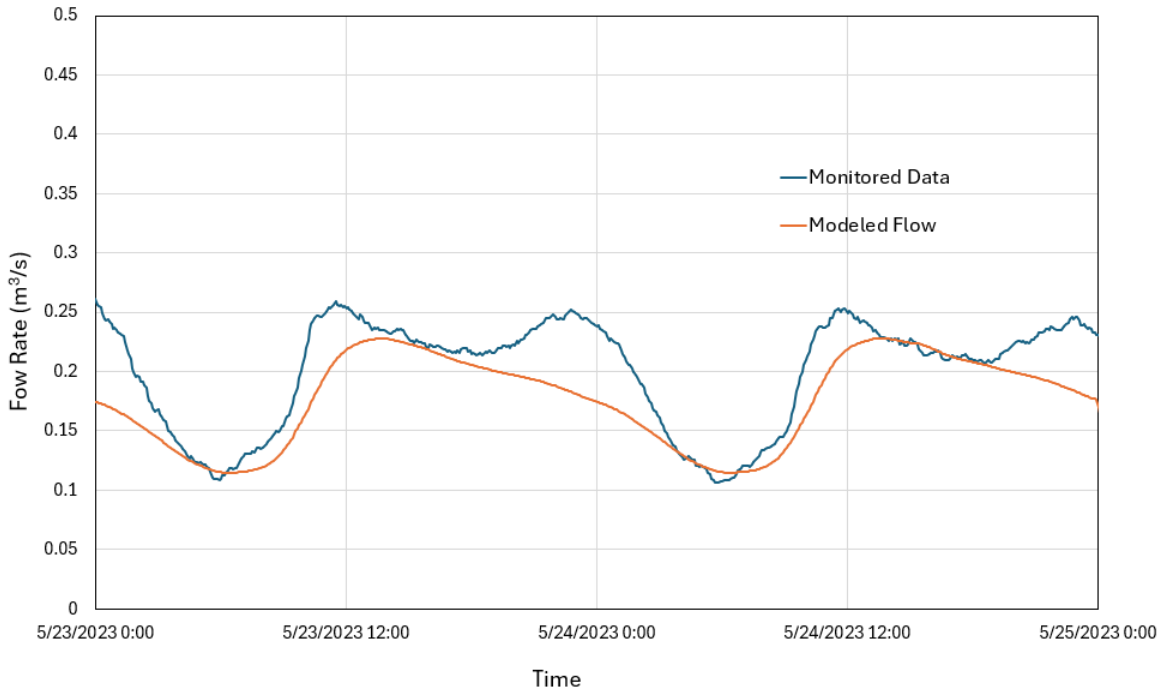


Figure A-2: DWF Comparison at P2 Station using May 23-24, 2023 Monitored Data

Reference: Validation Memo

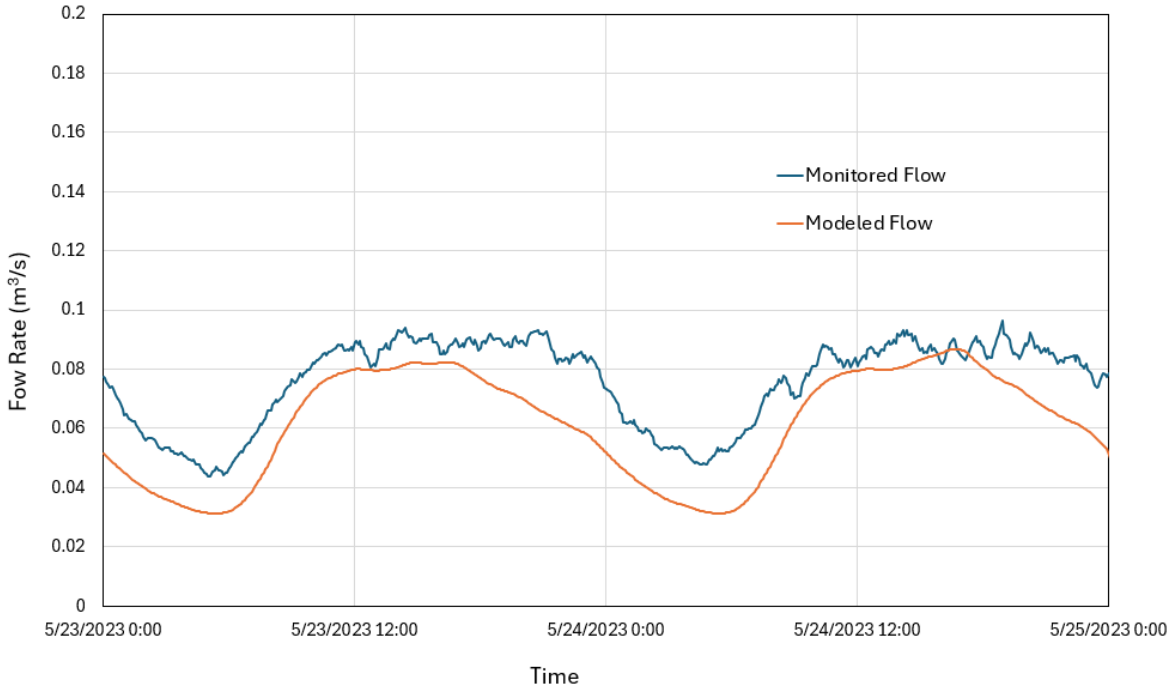


Figure A-3: DWF Comparison at P3 Station using May 23-24, 2023 Monitored Data

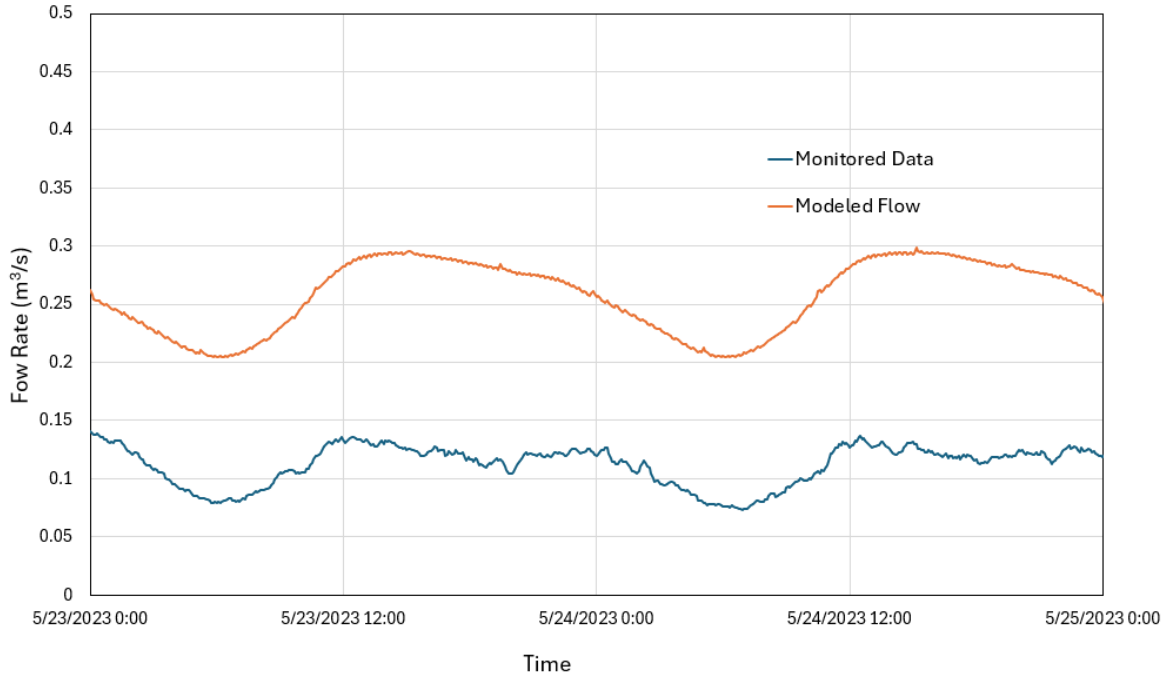


Figure A-4: DWF Comparison at P4 Station using May 23-24, 2023 Monitored Data

Reference: Validation Memo

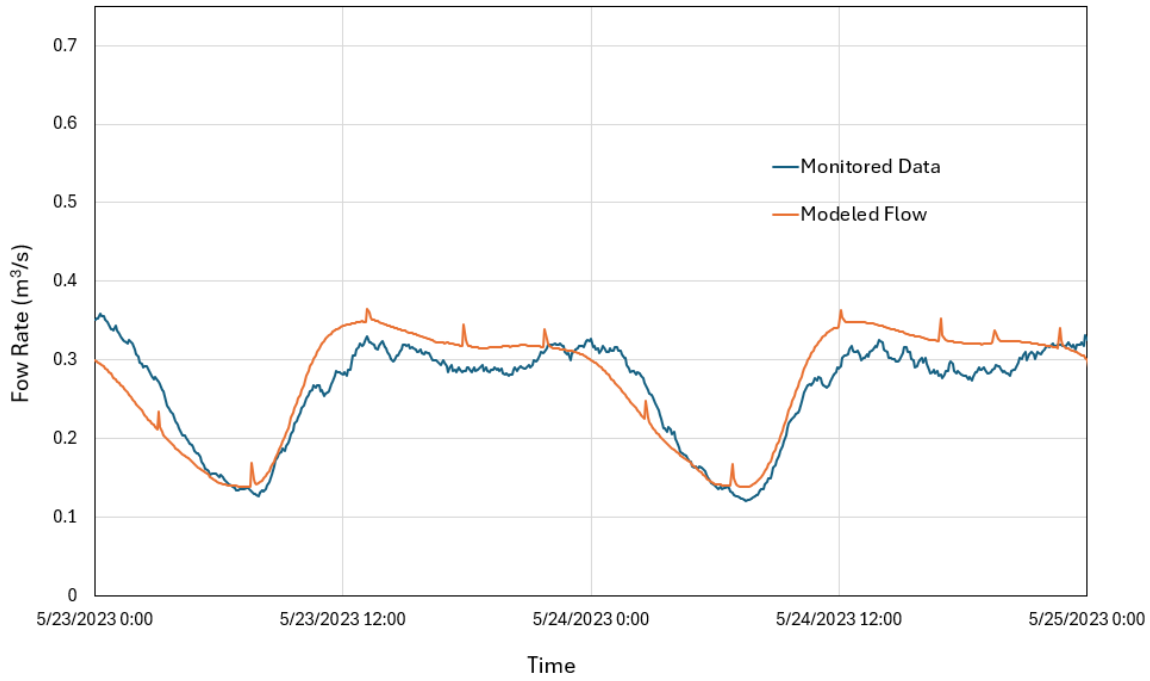


Figure A-5: DWF Comparison at P5 Station using May 23-24, 2023 Monitored Data

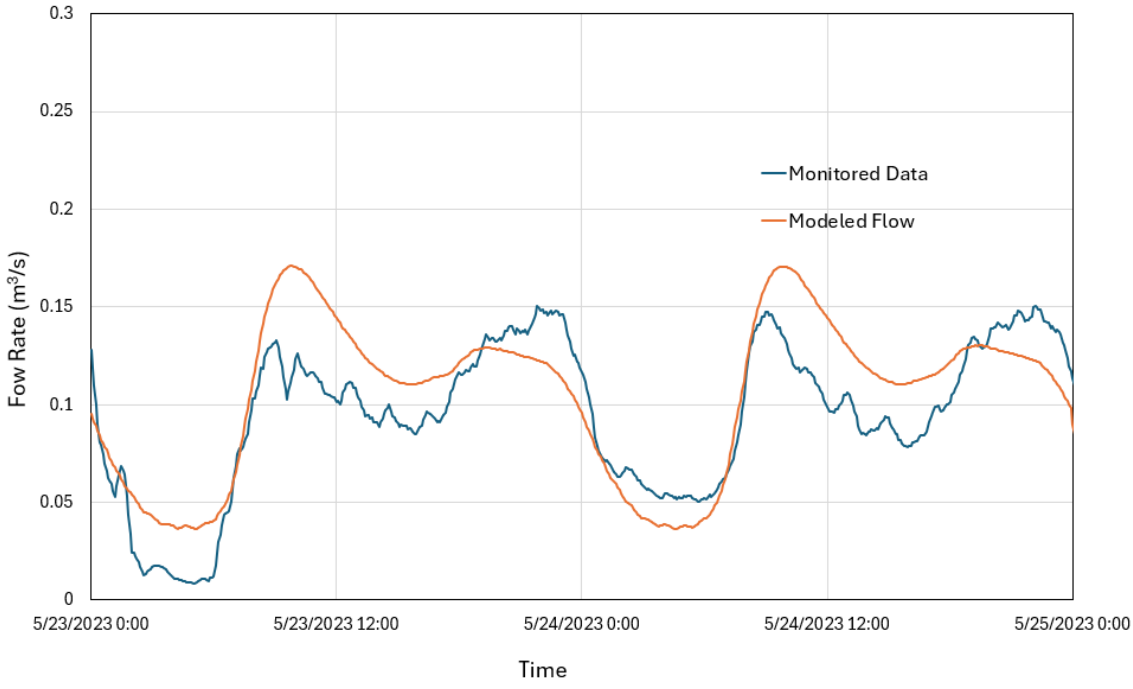


Figure A-6: DWF Comparison at P6 Station using May 23-24, 2023 Monitored Data

Reference: Validation Memo

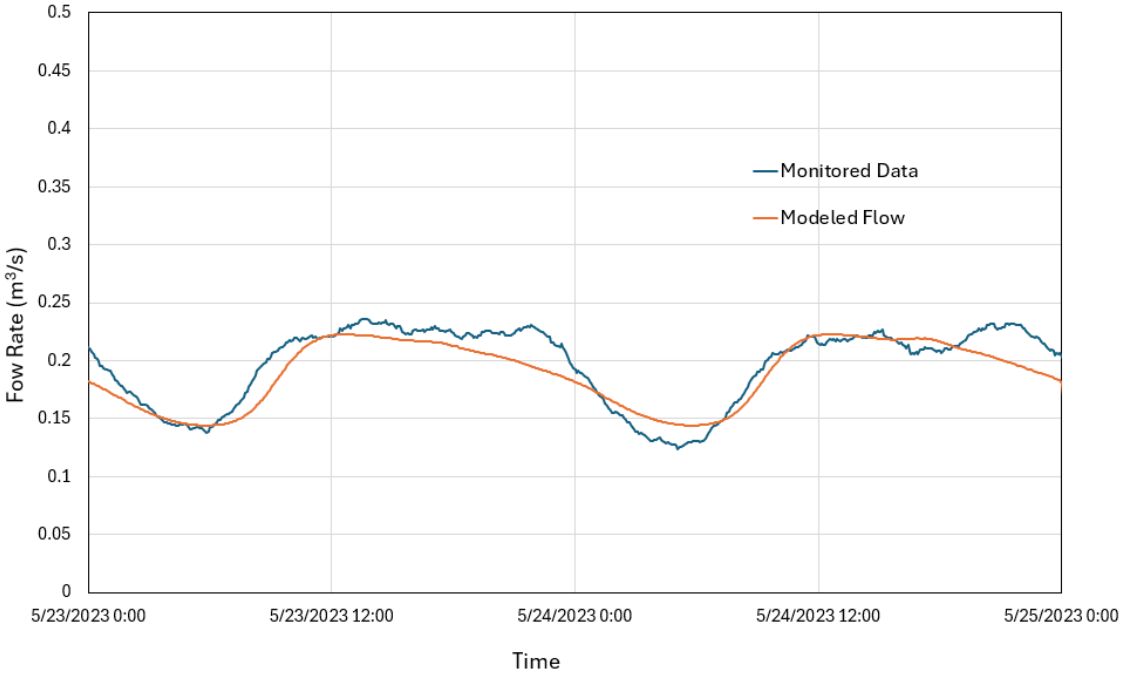


Figure A-7: DWF Comparison at P7 Station using May 23-24, 2023 Monitored Data

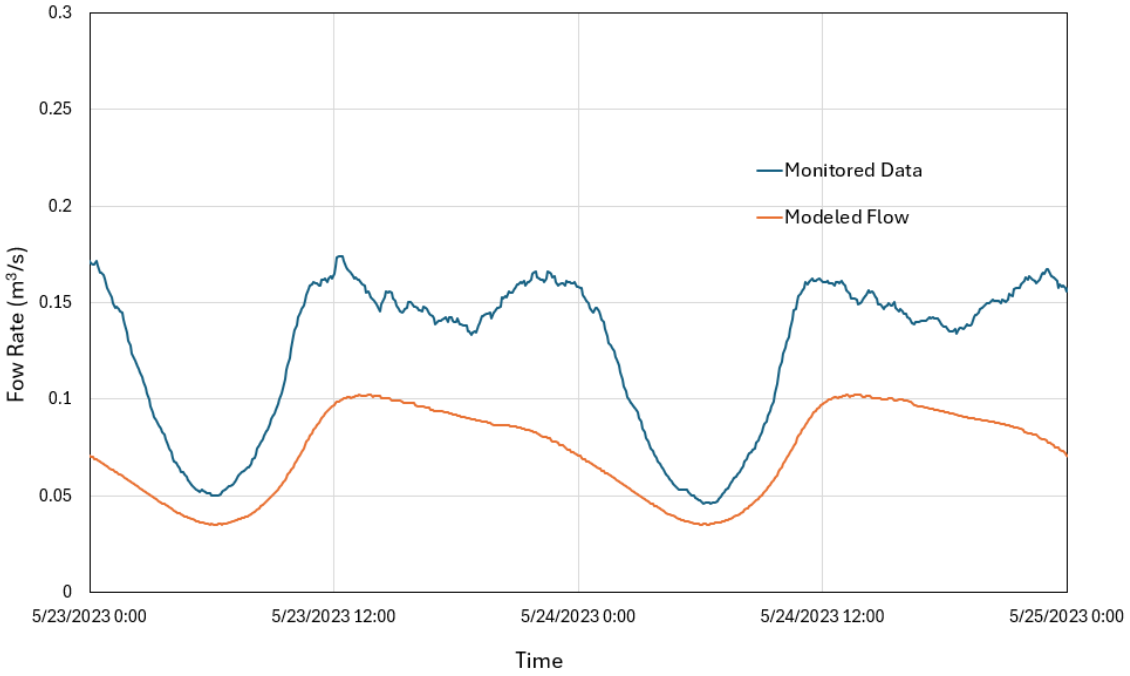


Figure A-8: DWF Comparison at P8 Station using May 23-24, 2023 Monitored Data

Reference: Validation Memo

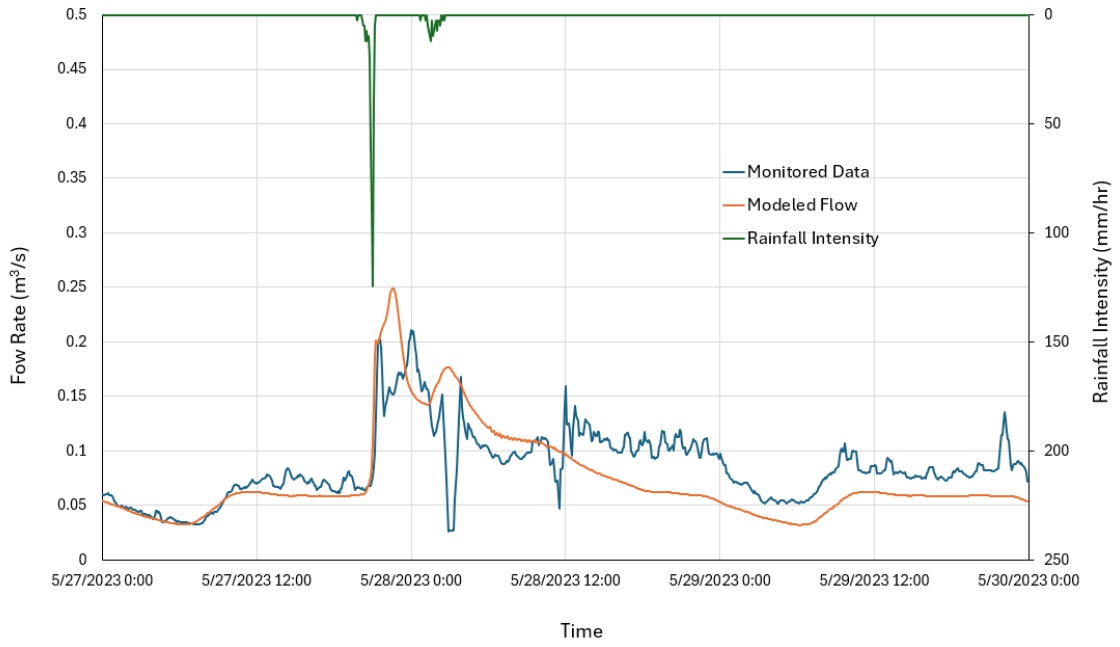


Figure A-9: WWF Comparison at P1 Station for May 27-28, 2023 Rainfall Event

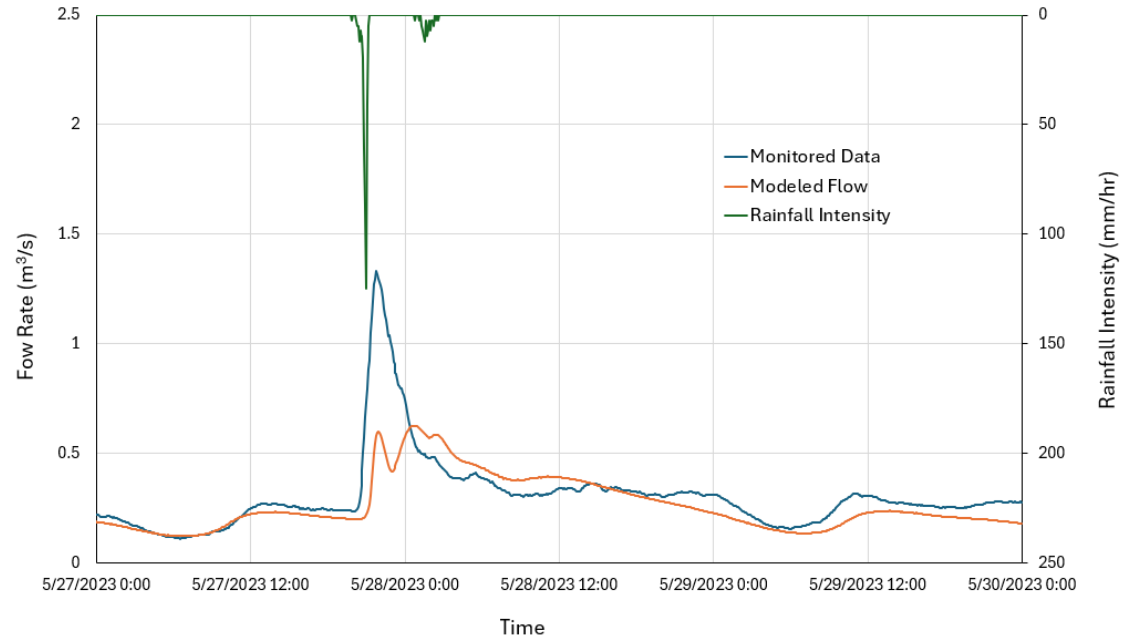


Figure A-10: WWF Comparison at P2 Station for May 27-28, 2023 Rainfall Event

Reference: Validation Memo

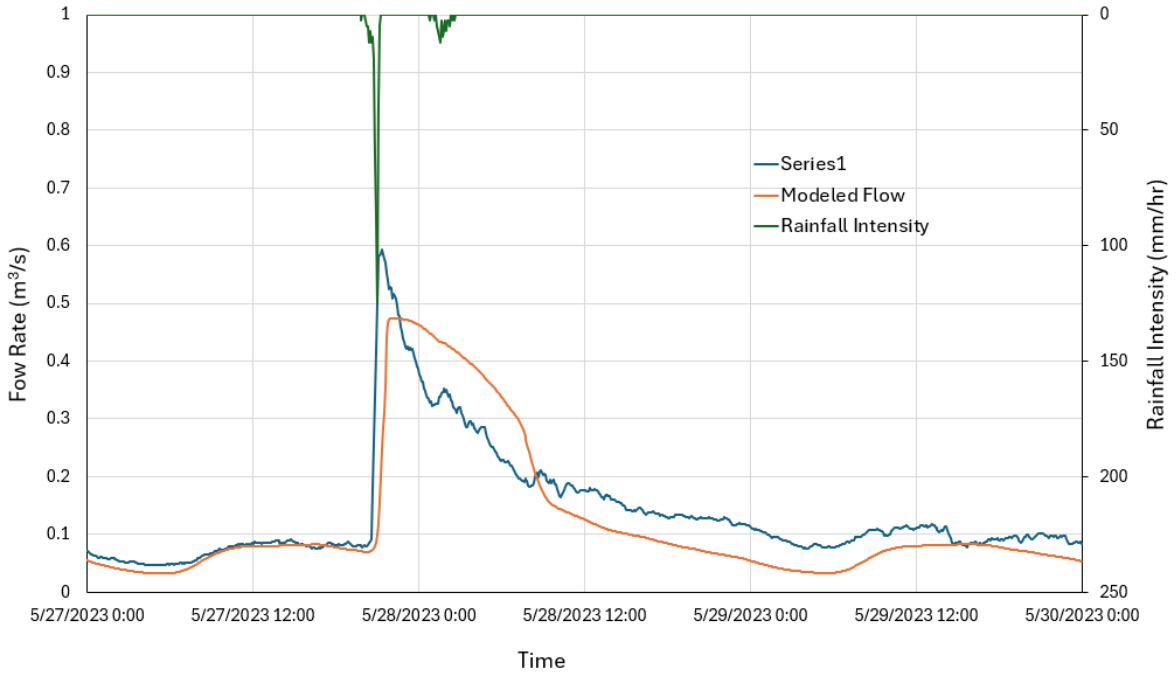


Figure A-11 WWF Comparison at P3 Station for May 27-28, 2023 Rainfall Event

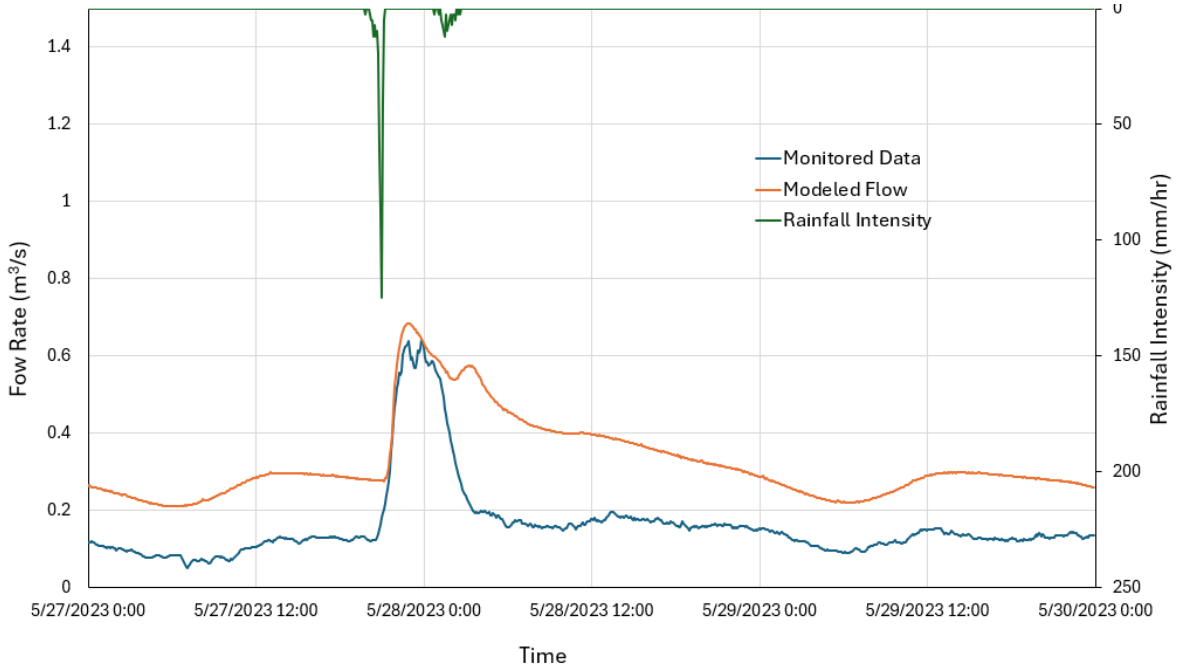


Figure A-12 WWF Comparison at P4 Station for May 27-28, 2023 Rainfall Event

Reference: Validation Memo

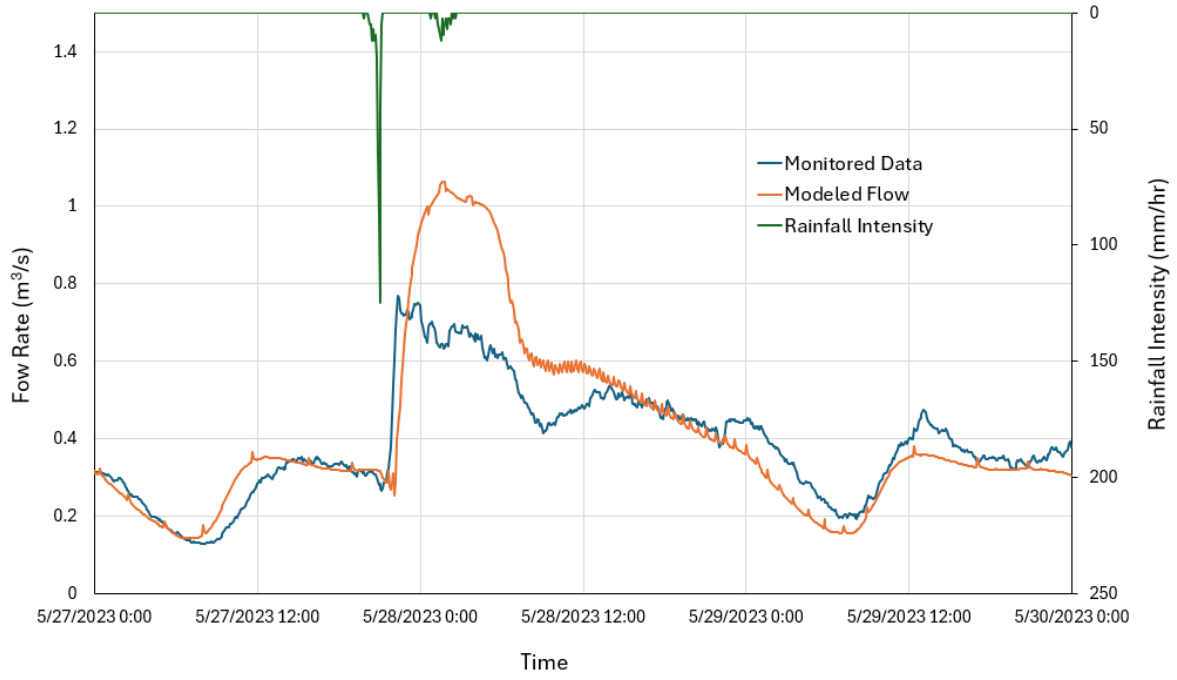


Figure A-13 WWF Comparison at P5 Station for May 27-28, 2023 Rainfall Event

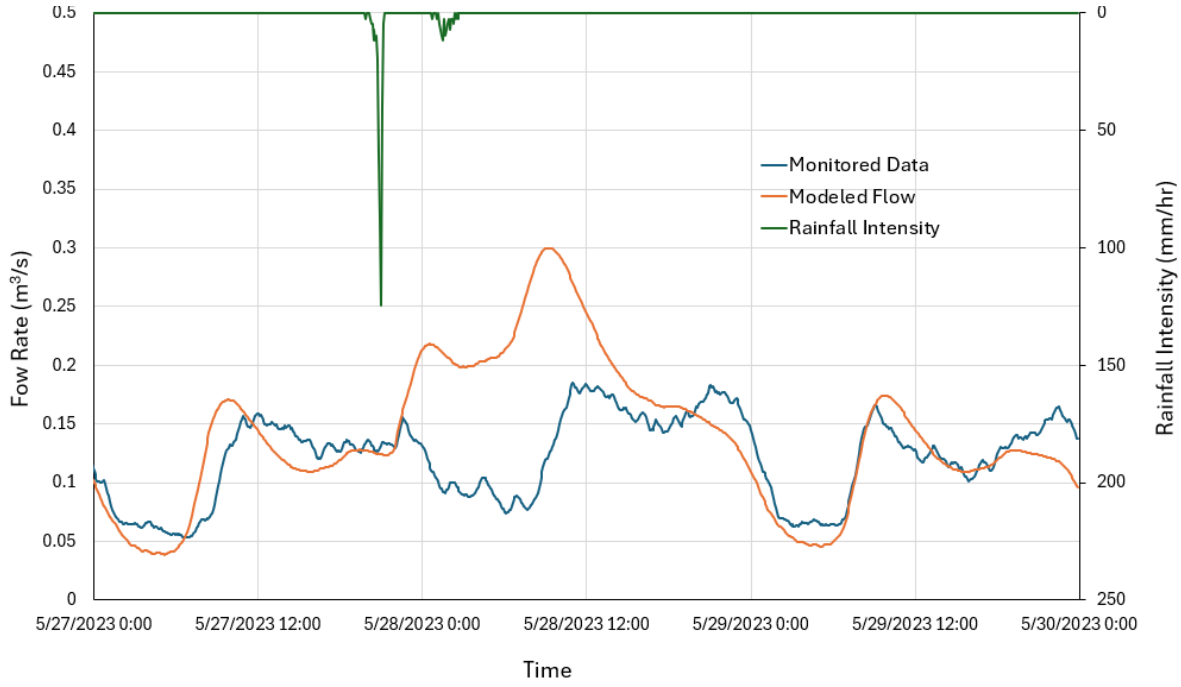


Figure A-14 WWF Comparison at P6 Station for May 27-28, 2023 Rainfall Event

Reference: Validation Memo

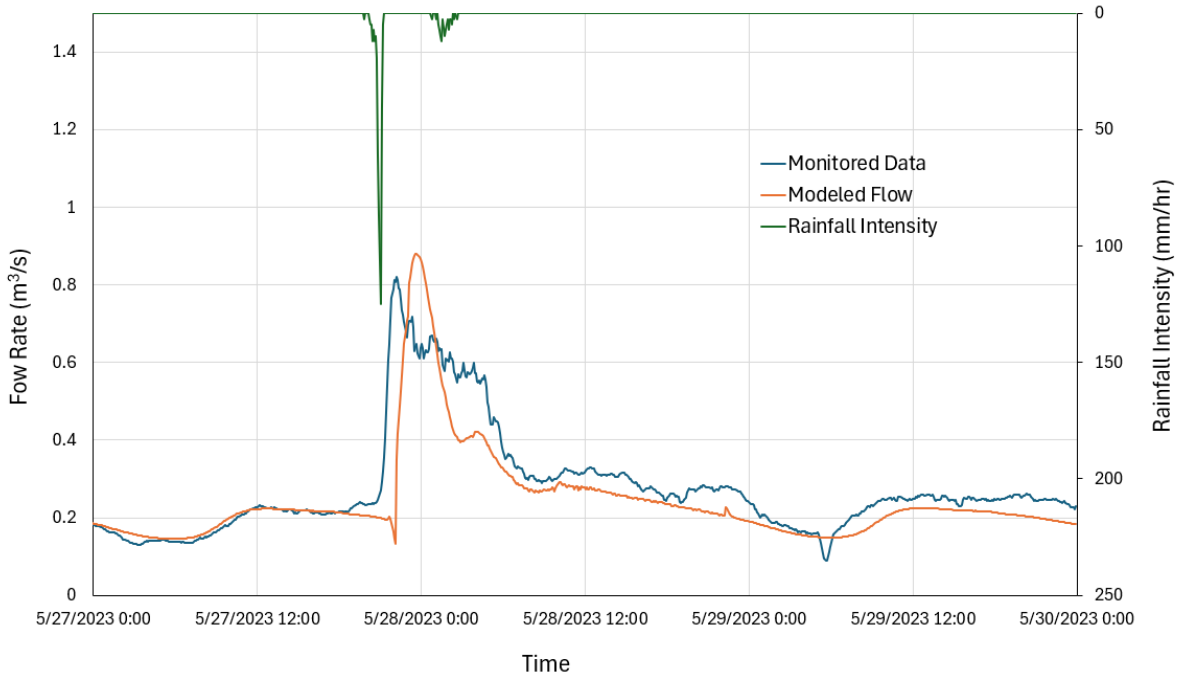


Figure A-15 WWF Comparison at P7 Station for May 27-28, 2023 Rainfall Event

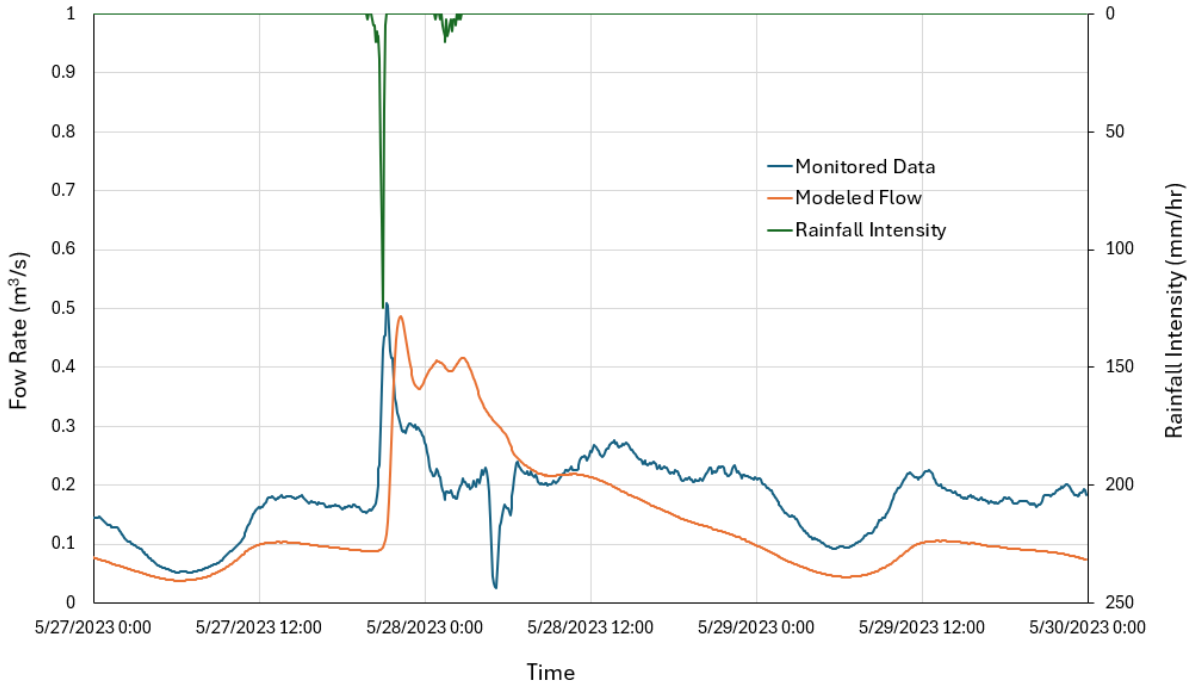


Figure A-16 WWF Comparison at P8 Station for May 27-28, 2023 Rainfall Event

Reference: Validation Memo

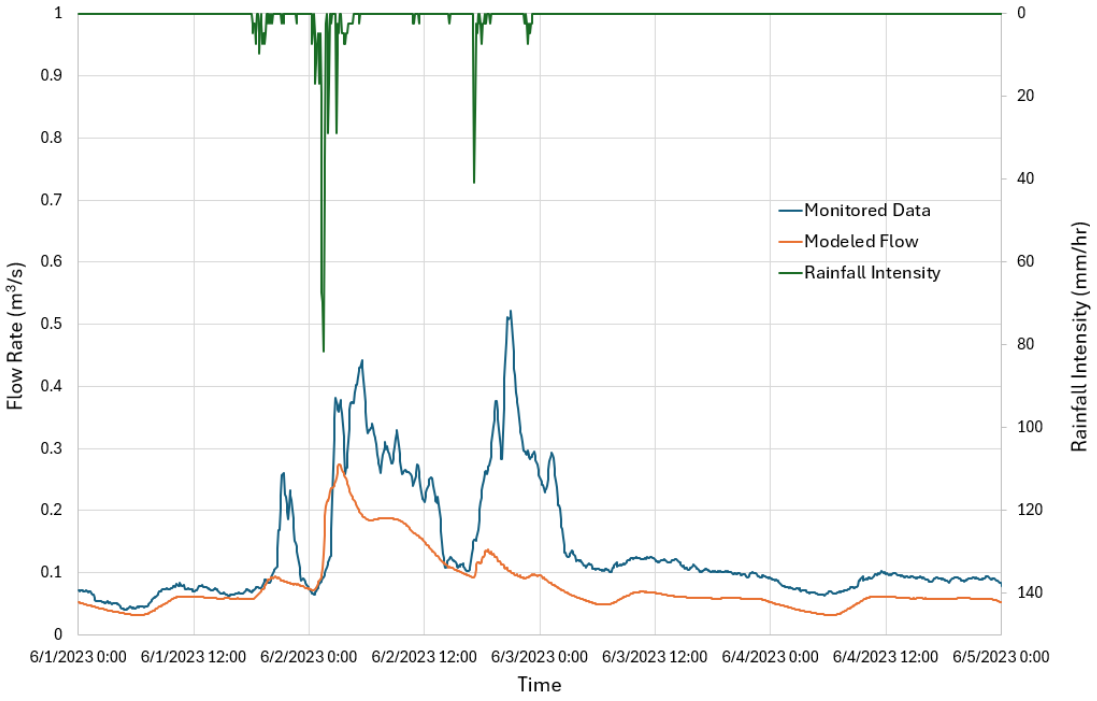


Figure A-17 WWF Comparison at P1 Station for June 1-2, 2023 Rainfall Event

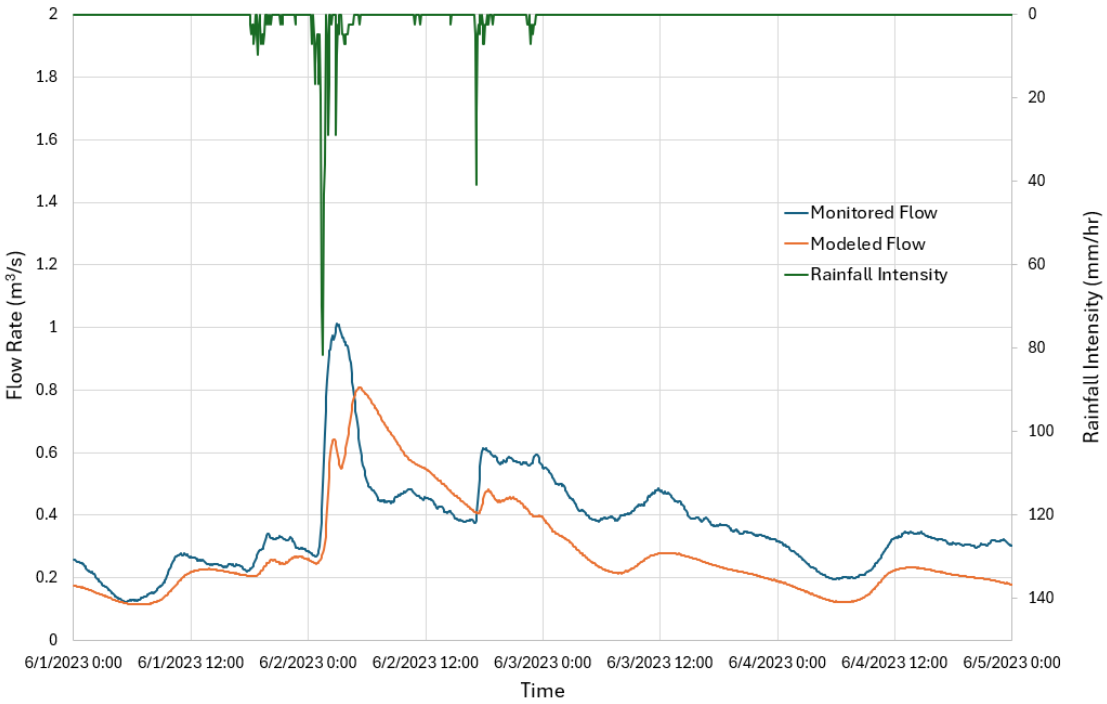


Figure A-18 WWF Comparison at P2 Station for June 1-2, 2023 Rainfall Event

Reference: Validation Memo

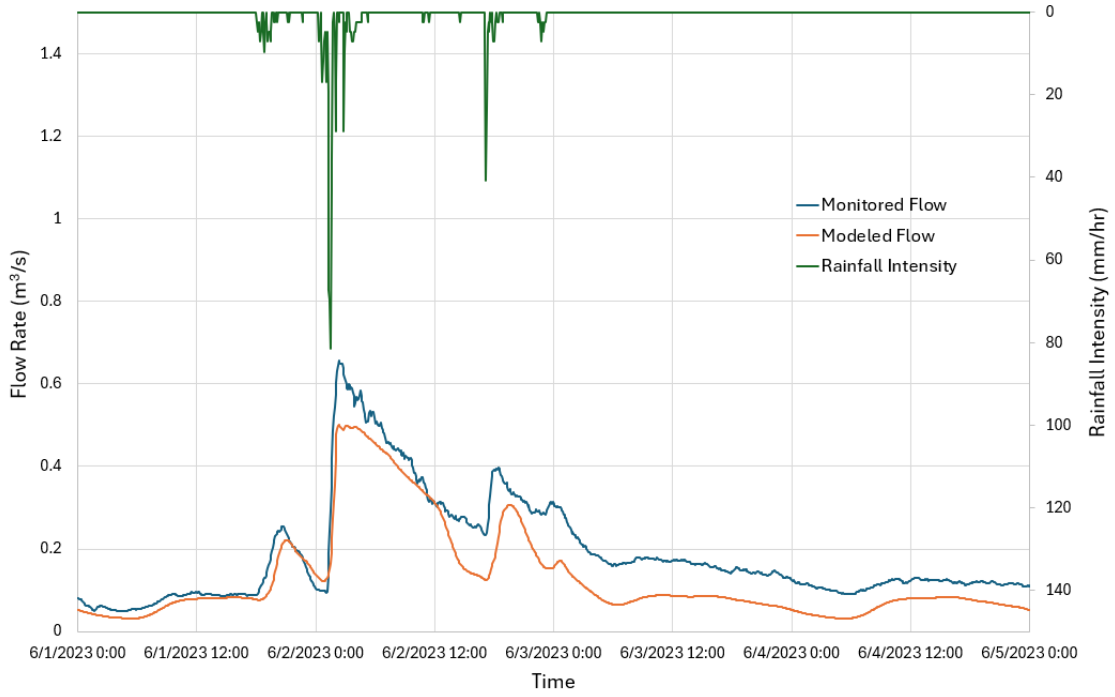


Figure A-19 WWF Comparison at P3 Station for June 1-2, 2023 Rainfall Event

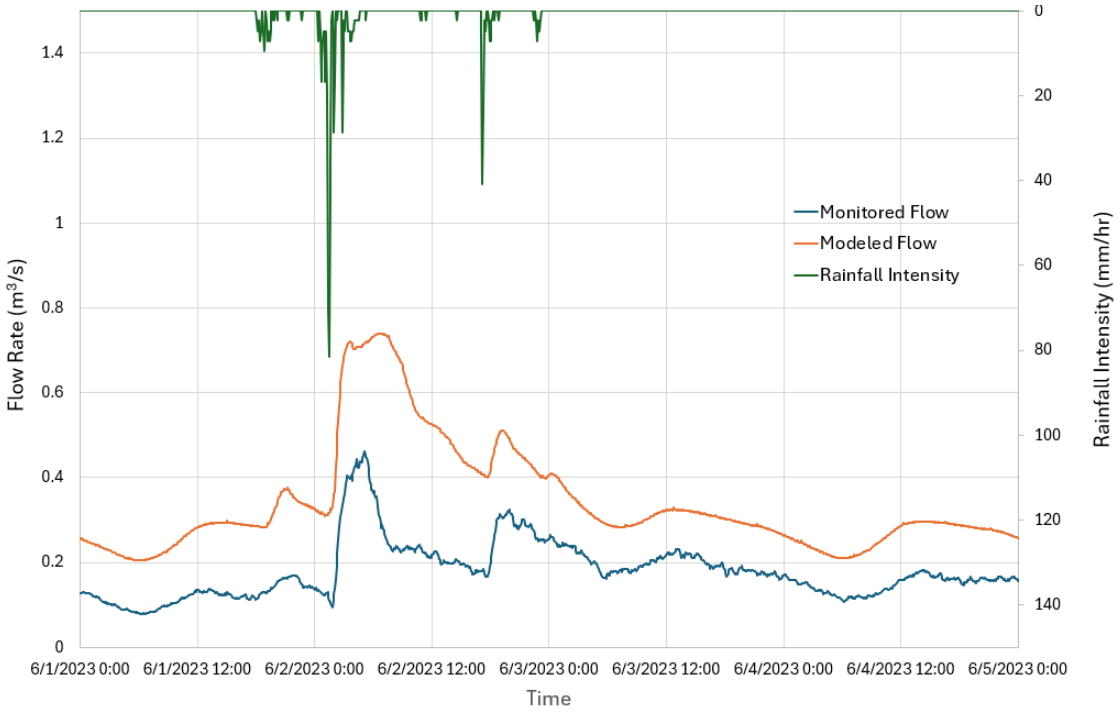


Figure A-20 WWF Comparison at P4 Station for June 1-2, 2023 Rainfall Event

Reference: Validation Memo

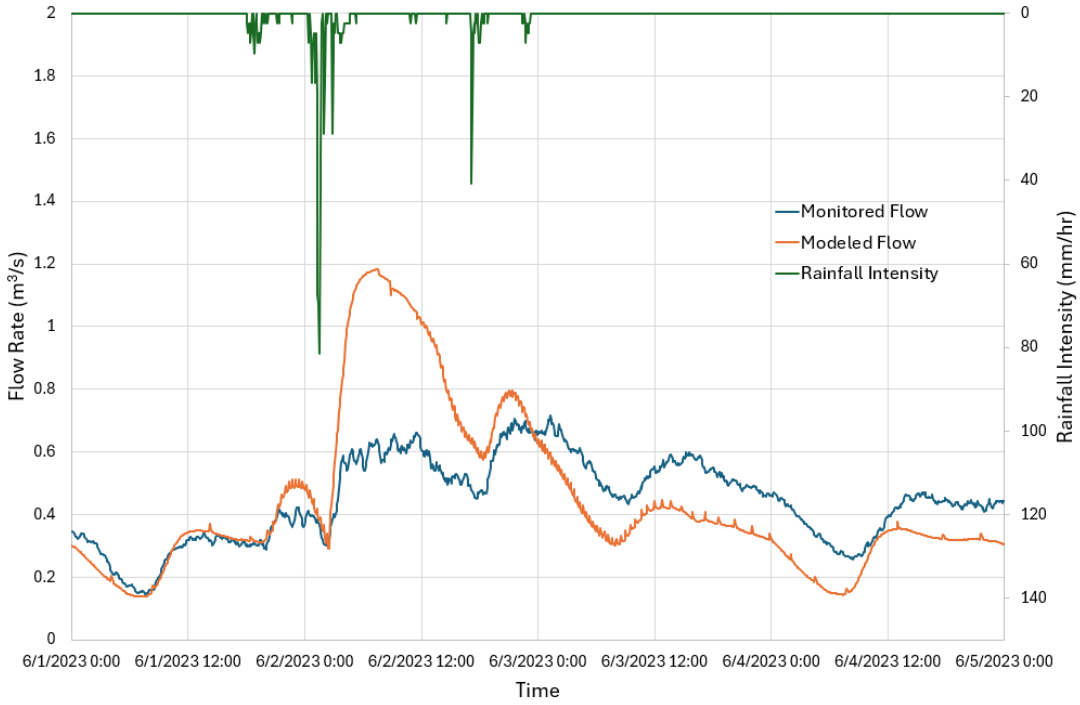


Figure A-21 WWF Comparison at P5 Station for June 1-2, 2023 Rainfall Event

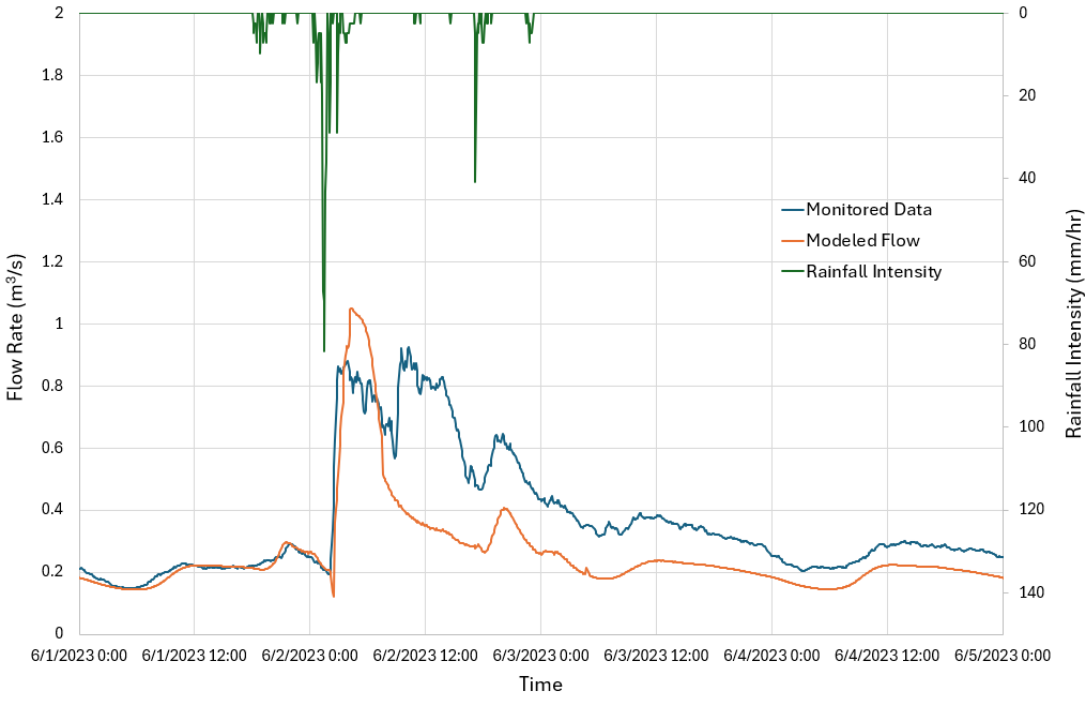


Figure A-22 WWF Comparison at P7 Station for June 1-2, 2023 Rainfall Event

Reference: Validation Memo

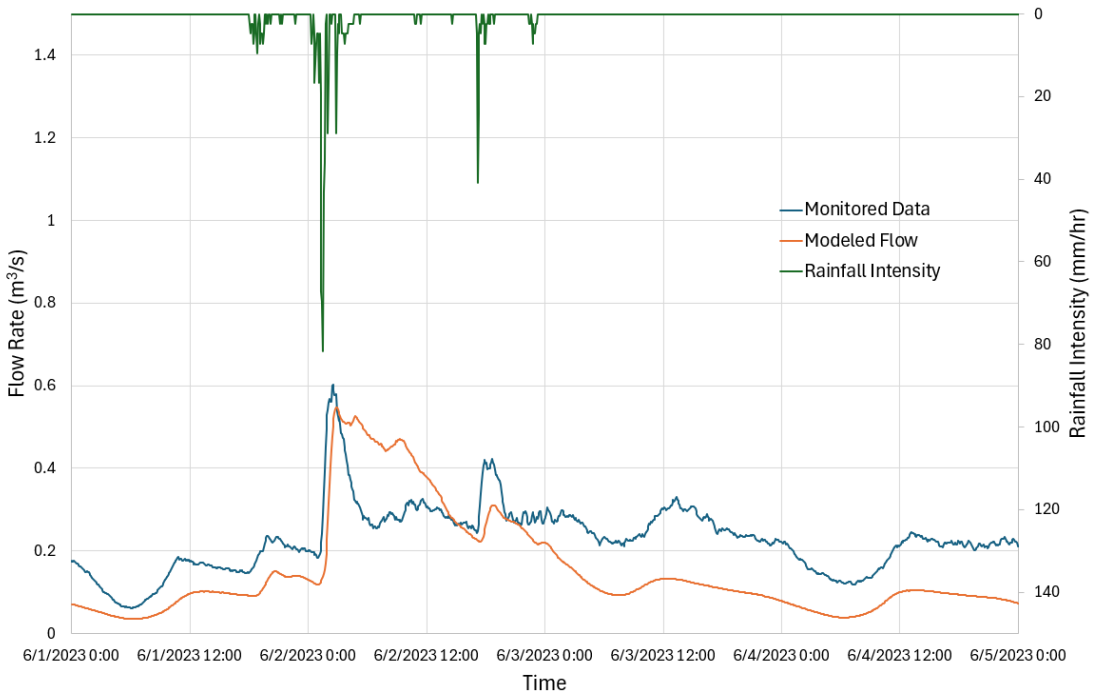
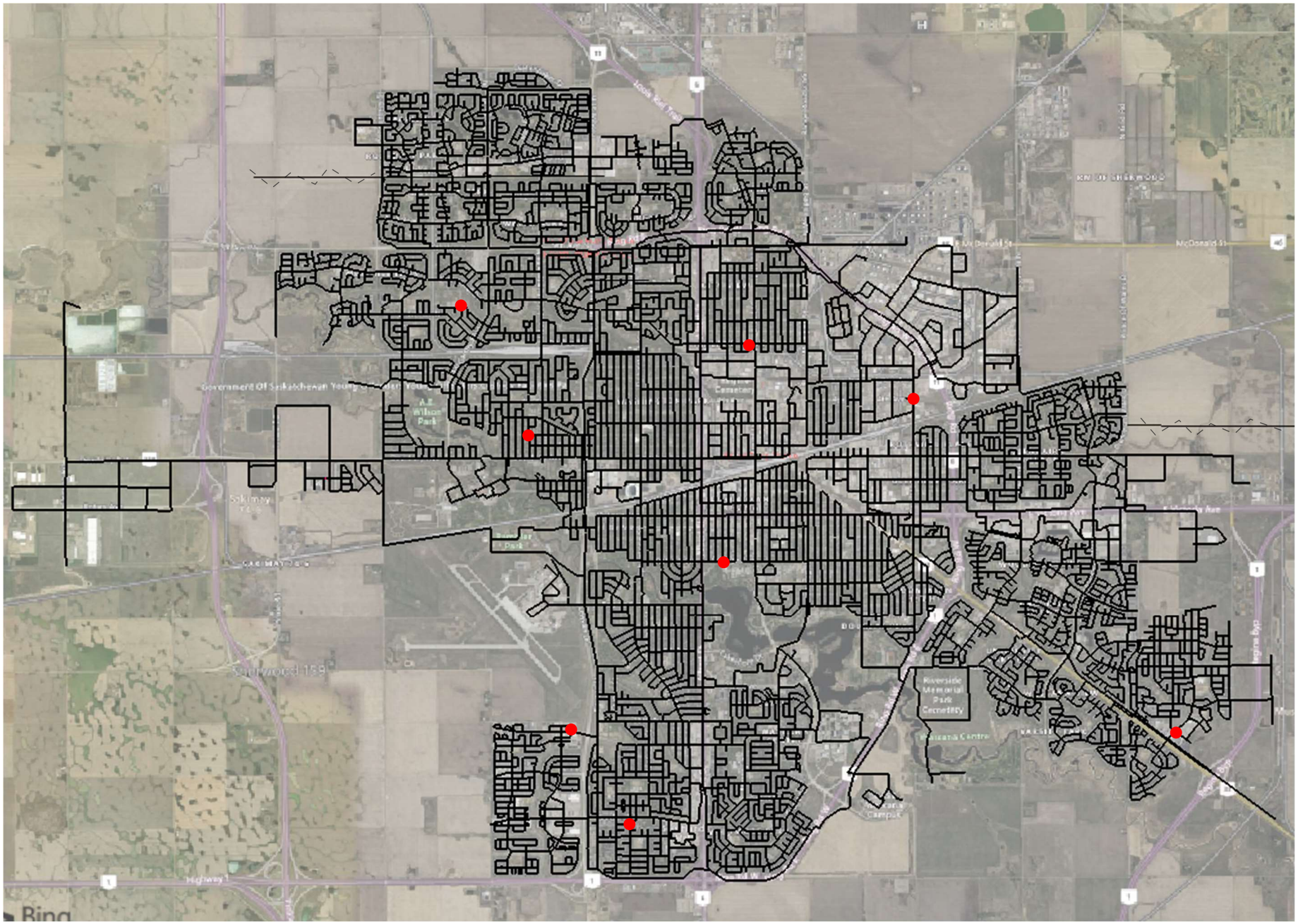


Figure A-23 WWF Comparison at P8 Station for June 1-2, 2023 Rainfall Event

Appendix B Hydrant Test Locations


Government Of Saskatchewan
A.E. Wilson Park
Cemetery
Sokimay
Saskatchewan
Riverside Memorial Park Cemetery
Highway 1
Bing

Appendix C Hydrant Test Comparison

Southeast

Hydrant Test @ Lorne St and College Ave

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
May 21, 2019 at 10 am	Test	006808	Lorne St & College Ave	J-348
	Monitor	006735	Cornwall St & College Ave	J-287

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
413.7	60	90	206.8	30	404.4	58.7	90			1.3	
427.5	62		386.1	56	396.9	57.6		363.8	52.8	4.4	3.2
Test Hydrant pressure loss (static-flow)				6	Model Hydrant pressure loss (static-flow)				4.8	Diff in loss =	1.2

Hydrant Test @ Green Falls Drive and Chuck Blvd

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
June 13, 2018 at 8 am	Test	234331	Green Falls Dr 60m E of Chuka Blvd	J-32675
	Monitor	234330	Green Falls Dr 160m E of Chuka Blvd	J-41695

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
399.9	58	95	289.6	42	380.3	55.2	95			2.8	
386.1	56		358.5	52	404.4	58.7		383.1	55.6	-2.7	-3.6
Test Hydrant pressure loss (static-flow)				4	Model Hydrant pressure loss (static-flow)				3.1	Diff in loss =	0.9

Southwest

Hydrant Test @ Beacon Drive and Beacon Place

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
August 1, 2019 at 9 am	Test	230970	Beacon Dr & Beacon Place	J-31505
	Monitor	231085	Beacon Dr & Fairchild Rd	J-31500

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
413.7	60	110	220.6	32	406.5	59	110	341.7	49.6	1	
427.5	62		303.4	44	407.9	59.2		350.7	50.9	2.8	-6.9
Test Hydrant pressure loss (static-flow)				18	Model Hydrant pressure loss (static-flow)				8.3	Diff in loss =	9.7

Hydrant Test @Wilkie Road and McTavish Street

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
August 17, 2010 at 9 am	Test	011993	Wilkie Road & McTavish Street	J-782
	Monitor	008898	Forbes Place & McTavish Street	J-7360

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
413.7	60	110	234.4	34	413.4	60	110	360.3	52.3	0	
399.96	58		372.3	54	410.6	59.6		378.3	54.9	-1.6	-0.9
Test Hydrant pressure loss (static-flow)				4	Model Hydrant pressure loss (static-flow)				4.7	Diff in loss =	-0.7

Hydrant Test @ Parliament Ave and Habour Landing Drive

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
October 23, 2018 at 9 am	Test	011505	Parliament Avenue 148m E of Harbour Landing D	J-30115
	Monitor	011503	Harbour Landing Drive and Parliament Avenue N	J-30120

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
399.9	58	100	275.8	40	417.5	60.6	100	412.7	59.9	-2.6	
413.7	60		386.1	56	412.7	59.9		407.9	59.2	0.1	-3.2
Test Hydrant pressure loss (static-flow)				4	Model Hydrant pressure loss (static-flow)				0.7	Diff in loss =	3.3

Northeast

Hydrant Test @ Park St. and 4th Ave

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
July 5, 2018 at 8 am	Test	007786	Park St & 4th Ave; 1019 Park St	J-2112
	Monitor	007782	Park St across from 860 Park St	J-1085

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
358.5	52	100	206.8	30	358.3	52	100	332.8	48.3	0	
372.3	54		358.5	52	365.2	53		354.8	51.5	1	0.5
Test Hydrant pressure loss (static-flow)				2	Model Hydrant pressure loss (static-flow)				1.5	Diff in loss =	0.5

Hydrant Test @ Rose Street & 1st Avenue North

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
August 1, 2017 at 8 am	Test	006983	Rose Street & 1st Avenue North	J-1027
	Monitor	007049	1st Avenue North & Broad Street	J-1026

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
399.9	58	90	206.8	30	392.0	56.9	90	368.6	53.5	1.1	
413.7	60		386.1	56	392.0	56.9		376.2	54.6	3.1	1.4
Test Hydrant pressure loss (static-flow)				4	Model Hydrant pressure loss (static-flow)				2.3	Diff in loss =	1.7

Northwest

Hydrant Test @ Dempsey Ave and Stinson Ave

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
June 21, 2018 at 8:10 am	Test	011050	Dempsey Ave & Stinson Ave; 10 Dempsy Ave	J-4067
	Monitor	009318	Dempsey Ave & 7th Ave N	J-42530

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
441.3	64	100	248.2	36	438.2	63.6	100	289.4	42	0.4	
448.1	65		358.5	52	439.6	63.8		340.4	49.4	1.2	2.6
Test Hydrant pressure loss (static-flow)				13	Model Hydrant pressure loss (static-flow)				14.4	Diff in loss =	-1.4

Hydrant Test @ Dempsey Ave and Stinson Ave

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
Sept 10, 2018 at 11:30 am	Test	235405	Argyle Street N and Rochdale, 1181 Argyle	
	Monitor	235407	Argyle Street N - 210m S of Rochdale Blvd	

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
399.9	58	90	220.6	32		59.7	90		58.6	-1.7	
386.1	56		289.6	42		61.4			60.4	-5.4	-18.4
Test Hydrant pressure loss (static-flow)				14	Model Hydrant pressure loss (static-flow)				1	Diff in loss =	13

Hydrant Test @ Grey St and 7th Ave

Date/Time	Hydrant Type	Hydrant ID	Location	Model Node
October 31, 2011 at 10:30	Test	010939	Grey Street & 7th Avenue	J-1301
	Monitor	010937	Grey Street & North West Boulevard	J-1297

Hydrant Test Field Results					ADD Model Results					Pressure Diff	Pressure Diff
Static Pressure		Test Flow	Residual Pressure		Static Pressure		Test Flow	Residual Pressure		Static	Flowing
kPa	psi	L/s	kPa	psi	kPa	psi	L/s	kPa	psi	psi	psi
427.5	62	90	262	38	422.4	61.3	90	366.5	53.2	0.7	
413.7	60		399.96	58	422.4	61.3		414.1	60.1	-1.3	-2.1
Test Hydrant pressure loss (static-flow)				2	Model Hydrant pressure loss (static-flow)				1.2	Diff in loss =	0.8

Appendix D Rainfall Data (May 27-28, 2023 and June 1-2, 2023)

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/25/2023 0:00	0.00	5/25/2023 3:25	0.00	5/25/2023 6:50	0.00	5/25/2023 10:15	0.00	5/25/2023 13:40	0.00
5/25/2023 0:05	0.00	5/25/2023 3:30	0.00	5/25/2023 6:55	0.00	5/25/2023 10:20	0.00	5/25/2023 13:45	0.00
5/25/2023 0:10	0.00	5/25/2023 3:35	0.00	5/25/2023 7:00	0.00	5/25/2023 10:25	0.00	5/25/2023 13:50	0.00
5/25/2023 0:15	0.00	5/25/2023 3:40	0.00	5/25/2023 7:05	0.00	5/25/2023 10:30	0.00	5/25/2023 13:55	0.00
5/25/2023 0:20	0.00	5/25/2023 3:45	0.00	5/25/2023 7:10	0.00	5/25/2023 10:35	0.00	5/25/2023 14:00	0.00
5/25/2023 0:25	0.00	5/25/2023 3:50	0.00	5/25/2023 7:15	0.00	5/25/2023 10:40	0.00	5/25/2023 14:05	0.00
5/25/2023 0:30	0.00	5/25/2023 3:55	0.00	5/25/2023 7:20	0.00	5/25/2023 10:45	0.00	5/25/2023 14:10	0.00
5/25/2023 0:35	0.00	5/25/2023 4:00	0.00	5/25/2023 7:25	0.00	5/25/2023 10:50	0.00	5/25/2023 14:15	0.00
5/25/2023 0:40	0.00	5/25/2023 4:05	0.00	5/25/2023 7:30	0.00	5/25/2023 10:55	0.00	5/25/2023 14:20	0.00
5/25/2023 0:45	0.00	5/25/2023 4:10	0.00	5/25/2023 7:35	0.00	5/25/2023 11:00	0.00	5/25/2023 14:25	0.00
5/25/2023 0:50	0.00	5/25/2023 4:15	0.00	5/25/2023 7:40	0.00	5/25/2023 11:05	0.00	5/25/2023 14:30	0.00
5/25/2023 0:55	0.00	5/25/2023 4:20	0.00	5/25/2023 7:45	2.40	5/25/2023 11:10	0.00	5/25/2023 14:35	0.00
5/25/2023 1:00	0.00	5/25/2023 4:25	0.00	5/25/2023 7:50	4.80	5/25/2023 11:15	0.00	5/25/2023 14:40	0.00
5/25/2023 1:05	0.00	5/25/2023 4:30	0.00	5/25/2023 7:55	2.40	5/25/2023 11:20	0.00	5/25/2023 14:45	0.00
5/25/2023 1:10	0.00	5/25/2023 4:35	0.00	5/25/2023 8:00	4.80	5/25/2023 11:25	0.00	5/25/2023 14:50	0.00
5/25/2023 1:15	0.00	5/25/2023 4:40	0.00	5/25/2023 8:05	0.00	5/25/2023 11:30	0.00	5/25/2023 14:55	0.00
5/25/2023 1:20	0.00	5/25/2023 4:45	0.00	5/25/2023 8:10	2.40	5/25/2023 11:35	0.00	5/25/2023 15:00	0.00
5/25/2023 1:25	0.00	5/25/2023 4:50	0.00	5/25/2023 8:15	0.00	5/25/2023 11:40	0.00	5/25/2023 15:05	0.00
5/25/2023 1:30	0.00	5/25/2023 4:55	0.00	5/25/2023 8:20	0.00	5/25/2023 11:45	0.00	5/25/2023 15:10	0.00
5/25/2023 1:35	0.00	5/25/2023 5:00	0.00	5/25/2023 8:25	0.00	5/25/2023 11:50	0.00	5/25/2023 15:15	0.00
5/25/2023 1:40	0.00	5/25/2023 5:05	0.00	5/25/2023 8:30	0.00	5/25/2023 11:55	0.00	5/25/2023 15:20	0.00
5/25/2023 1:45	0.00	5/25/2023 5:10	0.00	5/25/2023 8:35	0.00	5/25/2023 12:00	0.00	5/25/2023 15:25	0.00
5/25/2023 1:50	0.00	5/25/2023 5:15	0.00	5/25/2023 8:40	0.00	5/25/2023 12:05	0.00	5/25/2023 15:30	0.00
5/25/2023 1:55	0.00	5/25/2023 5:20	0.00	5/25/2023 8:45	0.00	5/25/2023 12:10	0.00	5/25/2023 15:35	0.00
5/25/2023 2:00	0.00	5/25/2023 5:25	0.00	5/25/2023 8:50	0.00	5/25/2023 12:15	0.00	5/25/2023 15:40	0.00
5/25/2023 2:05	0.00	5/25/2023 5:30	0.00	5/25/2023 8:55	0.00	5/25/2023 12:20	0.00	5/25/2023 15:45	0.00
5/25/2023 2:10	0.00	5/25/2023 5:35	0.00	5/25/2023 9:00	0.00	5/25/2023 12:25	0.00	5/25/2023 15:50	0.00
5/25/2023 2:15	0.00	5/25/2023 5:40	0.00	5/25/2023 9:05	0.00	5/25/2023 12:30	0.00	5/25/2023 15:55	0.00
5/25/2023 2:20	0.00	5/25/2023 5:45	0.00	5/25/2023 9:10	0.00	5/25/2023 12:35	0.00	5/25/2023 16:00	0.00
5/25/2023 2:25	0.00	5/25/2023 5:50	0.00	5/25/2023 9:15	0.00	5/25/2023 12:40	0.00	5/25/2023 16:05	0.00
5/25/2023 2:30	0.00	5/25/2023 5:55	0.00	5/25/2023 9:20	0.00	5/25/2023 12:45	0.00	5/25/2023 16:10	0.00
5/25/2023 2:35	0.00	5/25/2023 6:00	0.00	5/25/2023 9:25	0.00	5/25/2023 12:50	0.00	5/25/2023 16:15	0.00
5/25/2023 2:40	0.00	5/25/2023 6:05	0.00	5/25/2023 9:30	0.00	5/25/2023 12:55	0.00	5/25/2023 16:20	0.00
5/25/2023 2:45	0.00	5/25/2023 6:10	0.00	5/25/2023 9:35	0.00	5/25/2023 13:00	0.00	5/25/2023 16:25	0.00
5/25/2023 2:50	0.00	5/25/2023 6:15	0.00	5/25/2023 9:40	0.00	5/25/2023 13:05	0.00	5/25/2023 16:30	0.00
5/25/2023 2:55	0.00	5/25/2023 6:20	0.00	5/25/2023 9:45	0.00	5/25/2023 13:10	0.00	5/25/2023 16:35	0.00
5/25/2023 3:00	0.00	5/25/2023 6:25	0.00	5/25/2023 9:50	0.00	5/25/2023 13:15	0.00	5/25/2023 16:40	0.00
5/25/2023 3:05	0.00	5/25/2023 6:30	0.00	5/25/2023 9:55	0.00	5/25/2023 13:20	0.00	5/25/2023 16:45	0.00
5/25/2023 3:10	0.00	5/25/2023 6:35	0.00	5/25/2023 10:00	0.00	5/25/2023 13:25	0.00	5/25/2023 16:50	0.00
5/25/2023 3:15	0.00	5/25/2023 6:40	0.00	5/25/2023 10:05	0.00	5/25/2023 13:30	0.00	5/25/2023 16:55	0.00
5/25/2023 3:20	0.00	5/25/2023 6:45	0.00	5/25/2023 10:10	0.00	5/25/2023 13:35	0.00	5/25/2023 17:00	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/25/2023 17:05	0.00	5/25/2023 20:30	0.00	5/25/2023 23:55	0.00	5/26/2023 3:20	0.00	5/26/2023 6:45	0.00
5/25/2023 17:10	0.00	5/25/2023 20:35	0.00	5/26/2023 0:00	0.00	5/26/2023 3:25	0.00	5/26/2023 6:50	0.00
5/25/2023 17:15	0.00	5/25/2023 20:40	0.00	5/26/2023 0:05	0.00	5/26/2023 3:30	0.00	5/26/2023 6:55	0.00
5/25/2023 17:20	0.00	5/25/2023 20:45	0.00	5/26/2023 0:10	0.00	5/26/2023 3:35	0.00	5/26/2023 7:00	0.00
5/25/2023 17:25	0.00	5/25/2023 20:50	0.00	5/26/2023 0:15	0.00	5/26/2023 3:40	0.00	5/26/2023 7:05	0.00
5/25/2023 17:30	0.00	5/25/2023 20:55	0.00	5/26/2023 0:20	0.00	5/26/2023 3:45	0.00	5/26/2023 7:10	0.00
5/25/2023 17:35	0.00	5/25/2023 21:00	0.00	5/26/2023 0:25	0.00	5/26/2023 3:50	0.00	5/26/2023 7:15	0.00
5/25/2023 17:40	0.00	5/25/2023 21:05	0.00	5/26/2023 0:30	0.00	5/26/2023 3:55	0.00	5/26/2023 7:20	0.00
5/25/2023 17:45	0.00	5/25/2023 21:10	0.00	5/26/2023 0:35	0.00	5/26/2023 4:00	0.00	5/26/2023 7:25	0.00
5/25/2023 17:50	0.00	5/25/2023 21:15	0.00	5/26/2023 0:40	0.00	5/26/2023 4:05	0.00	5/26/2023 7:30	0.00
5/25/2023 17:55	0.00	5/25/2023 21:20	0.00	5/26/2023 0:45	0.00	5/26/2023 4:10	0.00	5/26/2023 7:35	0.00
5/25/2023 18:00	0.00	5/25/2023 21:25	0.00	5/26/2023 0:50	0.00	5/26/2023 4:15	2.40	5/26/2023 7:40	2.40
5/25/2023 18:05	0.00	5/25/2023 21:30	0.00	5/26/2023 0:55	0.00	5/26/2023 4:20	0.00	5/26/2023 7:45	0.00
5/25/2023 18:10	0.00	5/25/2023 21:35	0.00	5/26/2023 1:00	0.00	5/26/2023 4:25	0.00	5/26/2023 7:50	2.40
5/25/2023 18:15	0.00	5/25/2023 21:40	0.00	5/26/2023 1:05	0.00	5/26/2023 4:30	0.00	5/26/2023 7:55	0.00
5/25/2023 18:20	0.00	5/25/2023 21:45	0.00	5/26/2023 1:10	0.00	5/26/2023 4:35	0.00	5/26/2023 8:00	0.00
5/25/2023 18:25	0.00	5/25/2023 21:50	0.00	5/26/2023 1:15	0.00	5/26/2023 4:40	0.00	5/26/2023 8:05	0.00
5/25/2023 18:30	0.00	5/25/2023 21:55	0.00	5/26/2023 1:20	0.00	5/26/2023 4:45	0.00	5/26/2023 8:10	0.00
5/25/2023 18:35	0.00	5/25/2023 22:00	0.00	5/26/2023 1:25	0.00	5/26/2023 4:50	0.00	5/26/2023 8:15	0.00
5/25/2023 18:40	0.00	5/25/2023 22:05	0.00	5/26/2023 1:30	0.00	5/26/2023 4:55	0.00	5/26/2023 8:20	0.00
5/25/2023 18:45	0.00	5/25/2023 22:10	0.00	5/26/2023 1:35	0.00	5/26/2023 5:00	0.00	5/26/2023 8:25	2.40
5/25/2023 18:50	0.00	5/25/2023 22:15	0.00	5/26/2023 1:40	0.00	5/26/2023 5:05	0.00	5/26/2023 8:30	0.00
5/25/2023 18:55	0.00	5/25/2023 22:20	0.00	5/26/2023 1:45	0.00	5/26/2023 5:10	0.00	5/26/2023 8:35	2.40
5/25/2023 19:00	0.00	5/25/2023 22:25	0.00	5/26/2023 1:50	0.00	5/26/2023 5:15	0.00	5/26/2023 8:40	0.00
5/25/2023 19:05	0.00	5/25/2023 22:30	0.00	5/26/2023 1:55	0.00	5/26/2023 5:20	0.00	5/26/2023 8:45	0.00
5/25/2023 19:10	0.00	5/25/2023 22:35	0.00	5/26/2023 2:00	0.00	5/26/2023 5:25	0.00	5/26/2023 8:50	2.40
5/25/2023 19:15	0.00	5/25/2023 22:40	0.00	5/26/2023 2:05	0.00	5/26/2023 5:30	0.00	5/26/2023 8:55	0.00
5/25/2023 19:20	0.00	5/25/2023 22:45	0.00	5/26/2023 2:10	0.00	5/26/2023 5:35	0.00	5/26/2023 9:00	0.00
5/25/2023 19:25	0.00	5/25/2023 22:50	0.00	5/26/2023 2:15	0.00	5/26/2023 5:40	0.00	5/26/2023 9:05	2.40
5/25/2023 19:30	0.00	5/25/2023 22:55	0.00	5/26/2023 2:20	0.00	5/26/2023 5:45	0.00	5/26/2023 9:10	0.00
5/25/2023 19:35	0.00	5/25/2023 23:00	0.00	5/26/2023 2:25	0.00	5/26/2023 5:50	0.00	5/26/2023 9:15	2.40
5/25/2023 19:40	0.00	5/25/2023 23:05	0.00	5/26/2023 2:30	0.00	5/26/2023 5:55	0.00	5/26/2023 9:20	2.40
5/25/2023 19:45	0.00	5/25/2023 23:10	0.00	5/26/2023 2:35	0.00	5/26/2023 6:00	0.00	5/26/2023 9:25	0.00
5/25/2023 19:50	0.00	5/25/2023 23:15	0.00	5/26/2023 2:40	0.00	5/26/2023 6:05	0.00	5/26/2023 9:30	0.00
5/25/2023 19:55	0.00	5/25/2023 23:20	0.00	5/26/2023 2:45	0.00	5/26/2023 6:10	0.00	5/26/2023 9:35	2.40
5/25/2023 20:00	0.00	5/25/2023 23:25	0.00	5/26/2023 2:50	0.00	5/26/2023 6:15	0.00	5/26/2023 9:40	4.80
5/25/2023 20:05	0.00	5/25/2023 23:30	0.00	5/26/2023 2:55	0.00	5/26/2023 6:20	0.00	5/26/2023 9:45	0.00
5/25/2023 20:10	0.00	5/25/2023 23:35	0.00	5/26/2023 3:00	0.00	5/26/2023 6:25	0.00	5/26/2023 9:50	2.40
5/25/2023 20:15	0.00	5/25/2023 23:40	0.00	5/26/2023 3:05	0.00	5/26/2023 6:30	0.00	5/26/2023 9:55	0.00
5/25/2023 20:20	0.00	5/25/2023 23:45	0.00	5/26/2023 3:10	0.00	5/26/2023 6:35	0.00	5/26/2023 10:00	0.00
5/25/2023 20:25	0.00	5/25/2023 23:50	0.00	5/26/2023 3:15	0.00	5/26/2023 6:40	0.00	5/26/2023 10:05	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/26/2023 10:10	0.00	5/26/2023 13:35	0.00	5/26/2023 17:00	0.00	5/26/2023 20:25	0.00	5/26/2023 23:50	0.00
5/26/2023 10:15	0.00	5/26/2023 13:40	0.00	5/26/2023 17:05	0.00	5/26/2023 20:30	0.00	5/26/2023 23:55	0.00
5/26/2023 10:20	0.00	5/26/2023 13:45	0.00	5/26/2023 17:10	0.00	5/26/2023 20:35	0.00	5/27/2023 0:00	0.00
5/26/2023 10:25	2.40	5/26/2023 13:50	0.00	5/26/2023 17:15	0.00	5/26/2023 20:40	0.00	5/27/2023 0:05	0.00
5/26/2023 10:30	0.00	5/26/2023 13:55	0.00	5/26/2023 17:20	0.00	5/26/2023 20:45	0.00	5/27/2023 0:10	0.00
5/26/2023 10:35	0.00	5/26/2023 14:00	0.00	5/26/2023 17:25	0.00	5/26/2023 20:50	0.00	5/27/2023 0:15	0.00
5/26/2023 10:40	0.00	5/26/2023 14:05	0.00	5/26/2023 17:30	0.00	5/26/2023 20:55	0.00	5/27/2023 0:20	0.00
5/26/2023 10:45	0.00	5/26/2023 14:10	0.00	5/26/2023 17:35	0.00	5/26/2023 21:00	0.00	5/27/2023 0:25	0.00
5/26/2023 10:50	0.00	5/26/2023 14:15	0.00	5/26/2023 17:40	0.00	5/26/2023 21:05	0.00	5/27/2023 0:30	0.00
5/26/2023 10:55	0.00	5/26/2023 14:20	0.00	5/26/2023 17:45	0.00	5/26/2023 21:10	0.00	5/27/2023 0:35	0.00
5/26/2023 11:00	0.00	5/26/2023 14:25	0.00	5/26/2023 17:50	0.00	5/26/2023 21:15	0.00	5/27/2023 0:40	0.00
5/26/2023 11:05	0.00	5/26/2023 14:30	0.00	5/26/2023 17:55	0.00	5/26/2023 21:20	0.00	5/27/2023 0:45	0.00
5/26/2023 11:10	0.00	5/26/2023 14:35	0.00	5/26/2023 18:00	0.00	5/26/2023 21:25	0.00	5/27/2023 0:50	0.00
5/26/2023 11:15	0.00	5/26/2023 14:40	0.00	5/26/2023 18:05	0.00	5/26/2023 21:30	0.00	5/27/2023 0:55	0.00
5/26/2023 11:20	0.00	5/26/2023 14:45	0.00	5/26/2023 18:10	0.00	5/26/2023 21:35	0.00	5/27/2023 1:00	0.00
5/26/2023 11:25	0.00	5/26/2023 14:50	0.00	5/26/2023 18:15	0.00	5/26/2023 21:40	0.00	5/27/2023 1:05	0.00
5/26/2023 11:30	0.00	5/26/2023 14:55	0.00	5/26/2023 18:20	0.00	5/26/2023 21:45	0.00	5/27/2023 1:10	0.00
5/26/2023 11:35	0.00	5/26/2023 15:00	0.00	5/26/2023 18:25	0.00	5/26/2023 21:50	0.00	5/27/2023 1:15	0.00
5/26/2023 11:40	0.00	5/26/2023 15:05	0.00	5/26/2023 18:30	0.00	5/26/2023 21:55	0.00	5/27/2023 1:20	0.00
5/26/2023 11:45	0.00	5/26/2023 15:10	0.00	5/26/2023 18:35	0.00	5/26/2023 22:00	0.00	5/27/2023 1:25	0.00
5/26/2023 11:50	0.00	5/26/2023 15:15	0.00	5/26/2023 18:40	0.00	5/26/2023 22:05	0.00	5/27/2023 1:30	0.00
5/26/2023 11:55	0.00	5/26/2023 15:20	0.00	5/26/2023 18:45	0.00	5/26/2023 22:10	0.00	5/27/2023 1:35	0.00
5/26/2023 12:00	0.00	5/26/2023 15:25	0.00	5/26/2023 18:50	0.00	5/26/2023 22:15	0.00	5/27/2023 1:40	0.00
5/26/2023 12:05	0.00	5/26/2023 15:30	0.00	5/26/2023 18:55	0.00	5/26/2023 22:20	0.00	5/27/2023 1:45	0.00
5/26/2023 12:10	0.00	5/26/2023 15:35	0.00	5/26/2023 19:00	0.00	5/26/2023 22:25	0.00	5/27/2023 1:50	0.00
5/26/2023 12:15	0.00	5/26/2023 15:40	0.00	5/26/2023 19:05	0.00	5/26/2023 22:30	0.00	5/27/2023 1:55	0.00
5/26/2023 12:20	0.00	5/26/2023 15:45	0.00	5/26/2023 19:10	0.00	5/26/2023 22:35	0.00	5/27/2023 2:00	0.00
5/26/2023 12:25	0.00	5/26/2023 15:50	0.00	5/26/2023 19:15	0.00	5/26/2023 22:40	0.00	5/27/2023 2:05	0.00
5/26/2023 12:30	0.00	5/26/2023 15:55	0.00	5/26/2023 19:20	0.00	5/26/2023 22:45	0.00	5/27/2023 2:10	0.00
5/26/2023 12:35	0.00	5/26/2023 16:00	0.00	5/26/2023 19:25	0.00	5/26/2023 22:50	0.00	5/27/2023 2:15	0.00
5/26/2023 12:40	0.00	5/26/2023 16:05	0.00	5/26/2023 19:30	0.00	5/26/2023 22:55	0.00	5/27/2023 2:20	0.00
5/26/2023 12:45	0.00	5/26/2023 16:10	0.00	5/26/2023 19:35	0.00	5/26/2023 23:00	0.00	5/27/2023 2:25	0.00
5/26/2023 12:50	0.00	5/26/2023 16:15	0.00	5/26/2023 19:40	0.00	5/26/2023 23:05	0.00	5/27/2023 2:30	0.00
5/26/2023 12:55	0.00	5/26/2023 16:20	0.00	5/26/2023 19:45	0.00	5/26/2023 23:10	0.00	5/27/2023 2:35	0.00
5/26/2023 13:00	0.00	5/26/2023 16:25	0.00	5/26/2023 19:50	0.00	5/26/2023 23:15	0.00	5/27/2023 2:40	0.00
5/26/2023 13:05	0.00	5/26/2023 16:30	0.00	5/26/2023 19:55	0.00	5/26/2023 23:20	0.00	5/27/2023 2:45	0.00
5/26/2023 13:10	0.00	5/26/2023 16:35	0.00	5/26/2023 20:00	0.00	5/26/2023 23:25	0.00	5/27/2023 2:50	0.00
5/26/2023 13:15	0.00	5/26/2023 16:40	0.00	5/26/2023 20:05	0.00	5/26/2023 23:30	0.00	5/27/2023 2:55	0.00
5/26/2023 13:20	0.00	5/26/2023 16:45	0.00	5/26/2023 20:10	0.00	5/26/2023 23:35	0.00	5/27/2023 3:00	0.00
5/26/2023 13:25	0.00	5/26/2023 16:50	0.00	5/26/2023 20:15	0.00	5/26/2023 23:40	0.00	5/27/2023 3:05	0.00
5/26/2023 13:30	0.00	5/26/2023 16:55	0.00	5/26/2023 20:20	0.00	5/26/2023 23:45	0.00	5/27/2023 3:10	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/27/2023 3:15	0.00	5/27/2023 6:40	0.00	5/27/2023 10:05	0.00	5/27/2023 13:30	0.00	5/27/2023 16:55	0.00
5/27/2023 3:20	0.00	5/27/2023 6:45	0.00	5/27/2023 10:10	0.00	5/27/2023 13:35	0.00	5/27/2023 17:00	0.00
5/27/2023 3:25	0.00	5/27/2023 6:50	0.00	5/27/2023 10:15	0.00	5/27/2023 13:40	0.00	5/27/2023 17:05	0.00
5/27/2023 3:30	0.00	5/27/2023 6:55	0.00	5/27/2023 10:20	0.00	5/27/2023 13:45	0.00	5/27/2023 17:10	0.00
5/27/2023 3:35	0.00	5/27/2023 7:00	0.00	5/27/2023 10:25	0.00	5/27/2023 13:50	0.00	5/27/2023 17:15	0.00
5/27/2023 3:40	0.00	5/27/2023 7:05	0.00	5/27/2023 10:30	0.00	5/27/2023 13:55	0.00	5/27/2023 17:20	0.00
5/27/2023 3:45	0.00	5/27/2023 7:10	0.00	5/27/2023 10:35	0.00	5/27/2023 14:00	0.00	5/27/2023 17:25	0.00
5/27/2023 3:50	0.00	5/27/2023 7:15	0.00	5/27/2023 10:40	0.00	5/27/2023 14:05	0.00	5/27/2023 17:30	0.00
5/27/2023 3:55	0.00	5/27/2023 7:20	0.00	5/27/2023 10:45	0.00	5/27/2023 14:10	0.00	5/27/2023 17:35	0.00
5/27/2023 4:00	0.00	5/27/2023 7:25	0.00	5/27/2023 10:50	0.00	5/27/2023 14:15	0.00	5/27/2023 17:40	0.00
5/27/2023 4:05	0.00	5/27/2023 7:30	0.00	5/27/2023 10:55	0.00	5/27/2023 14:20	0.00	5/27/2023 17:45	0.00
5/27/2023 4:10	0.00	5/27/2023 7:35	0.00	5/27/2023 11:00	0.00	5/27/2023 14:25	0.00	5/27/2023 17:50	0.00
5/27/2023 4:15	0.00	5/27/2023 7:40	0.00	5/27/2023 11:05	0.00	5/27/2023 14:30	0.00	5/27/2023 17:55	0.00
5/27/2023 4:20	0.00	5/27/2023 7:45	0.00	5/27/2023 11:10	0.00	5/27/2023 14:35	0.00	5/27/2023 18:00	0.00
5/27/2023 4:25	0.00	5/27/2023 7:50	0.00	5/27/2023 11:15	0.00	5/27/2023 14:40	0.00	5/27/2023 18:05	0.00
5/27/2023 4:30	0.00	5/27/2023 7:55	0.00	5/27/2023 11:20	0.00	5/27/2023 14:45	0.00	5/27/2023 18:10	0.00
5/27/2023 4:35	0.00	5/27/2023 8:00	0.00	5/27/2023 11:25	0.00	5/27/2023 14:50	0.00	5/27/2023 18:15	0.00
5/27/2023 4:40	0.00	5/27/2023 8:05	0.00	5/27/2023 11:30	0.00	5/27/2023 14:55	0.00	5/27/2023 18:20	0.00
5/27/2023 4:45	0.00	5/27/2023 8:10	0.00	5/27/2023 11:35	0.00	5/27/2023 15:00	0.00	5/27/2023 18:25	0.00
5/27/2023 4:50	0.00	5/27/2023 8:15	0.00	5/27/2023 11:40	0.00	5/27/2023 15:05	0.00	5/27/2023 18:30	0.00
5/27/2023 4:55	0.00	5/27/2023 8:20	0.00	5/27/2023 11:45	0.00	5/27/2023 15:10	0.00	5/27/2023 18:35	0.00
5/27/2023 5:00	0.00	5/27/2023 8:25	0.00	5/27/2023 11:50	0.00	5/27/2023 15:15	0.00	5/27/2023 18:40	0.00
5/27/2023 5:05	0.00	5/27/2023 8:30	0.00	5/27/2023 11:55	0.00	5/27/2023 15:20	0.00	5/27/2023 18:45	0.00
5/27/2023 5:10	0.00	5/27/2023 8:35	0.00	5/27/2023 12:00	0.00	5/27/2023 15:25	0.00	5/27/2023 18:50	0.00
5/27/2023 5:15	0.00	5/27/2023 8:40	0.00	5/27/2023 12:05	0.00	5/27/2023 15:30	0.00	5/27/2023 18:55	0.00
5/27/2023 5:20	0.00	5/27/2023 8:45	0.00	5/27/2023 12:10	0.00	5/27/2023 15:35	0.00	5/27/2023 19:00	0.00
5/27/2023 5:25	0.00	5/27/2023 8:50	0.00	5/27/2023 12:15	0.00	5/27/2023 15:40	0.00	5/27/2023 19:05	0.00
5/27/2023 5:30	0.00	5/27/2023 8:55	0.00	5/27/2023 12:20	0.00	5/27/2023 15:45	0.00	5/27/2023 19:10	0.00
5/27/2023 5:35	0.00	5/27/2023 9:00	0.00	5/27/2023 12:25	0.00	5/27/2023 15:50	0.00	5/27/2023 19:15	0.00
5/27/2023 5:40	0.00	5/27/2023 9:05	0.00	5/27/2023 12:30	0.00	5/27/2023 15:55	0.00	5/27/2023 19:20	0.00
5/27/2023 5:45	0.00	5/27/2023 9:10	0.00	5/27/2023 12:35	0.00	5/27/2023 16:00	0.00	5/27/2023 19:25	0.00
5/27/2023 5:50	0.00	5/27/2023 9:15	0.00	5/27/2023 12:40	0.00	5/27/2023 16:05	0.00	5/27/2023 19:30	0.00
5/27/2023 5:55	0.00	5/27/2023 9:20	0.00	5/27/2023 12:45	0.00	5/27/2023 16:10	0.00	5/27/2023 19:35	0.00
5/27/2023 6:00	0.00	5/27/2023 9:25	0.00	5/27/2023 12:50	0.00	5/27/2023 16:15	0.00	5/27/2023 19:40	0.00
5/27/2023 6:05	0.00	5/27/2023 9:30	0.00	5/27/2023 12:55	0.00	5/27/2023 16:20	0.00	5/27/2023 19:45	0.00
5/27/2023 6:10	0.00	5/27/2023 9:35	0.00	5/27/2023 13:00	0.00	5/27/2023 16:25	0.00	5/27/2023 19:50	2.40
5/27/2023 6:15	0.00	5/27/2023 9:40	0.00	5/27/2023 13:05	0.00	5/27/2023 16:30	0.00	5/27/2023 19:55	0.00
5/27/2023 6:20	0.00	5/27/2023 9:45	0.00	5/27/2023 13:10	0.00	5/27/2023 16:35	0.00	5/27/2023 20:00	0.00
5/27/2023 6:25	0.00	5/27/2023 9:50	0.00	5/27/2023 13:15	0.00	5/27/2023 16:40	0.00	5/27/2023 20:05	0.00
5/27/2023 6:30	0.00	5/27/2023 9:55	0.00	5/27/2023 13:20	0.00	5/27/2023 16:45	0.00	5/27/2023 20:10	2.40
5/27/2023 6:35	0.00	5/27/2023 10:00	0.00	5/27/2023 13:25	0.00	5/27/2023 16:50	0.00	5/27/2023 20:15	4.80

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/27/2023 20:20	4.80	5/27/2023 23:45	0.00	5/28/2023 3:10	0.00	5/28/2023 6:35	0.00	5/28/2023 10:00	0.00
5/27/2023 20:25	12.00	5/27/2023 23:50	0.00	5/28/2023 3:15	0.00	5/28/2023 6:40	0.00	5/28/2023 10:05	0.00
5/27/2023 20:30	7.20	5/27/2023 23:55	0.00	5/28/2023 3:20	0.00	5/28/2023 6:45	0.00	5/28/2023 10:10	0.00
5/27/2023 20:35	12.00	5/28/2023 0:00	0.00	5/28/2023 3:25	0.00	5/28/2023 6:50	0.00	5/28/2023 10:15	0.00
5/27/2023 20:40	9.60	5/28/2023 0:05	0.00	5/28/2023 3:30	0.00	5/28/2023 6:55	0.00	5/28/2023 10:20	0.00
5/27/2023 20:45	19.20	5/28/2023 0:10	0.00	5/28/2023 3:35	0.00	5/28/2023 7:00	0.00	5/28/2023 10:25	0.00
5/27/2023 20:50	60.00	5/28/2023 0:15	0.00	5/28/2023 3:40	0.00	5/28/2023 7:05	0.00	5/28/2023 10:30	0.00
5/27/2023 20:55	86.40	5/28/2023 0:20	0.00	5/28/2023 3:45	0.00	5/28/2023 7:10	0.00	5/28/2023 10:35	0.00
5/27/2023 21:00	124.80	5/28/2023 0:25	0.00	5/28/2023 3:50	0.00	5/28/2023 7:15	0.00	5/28/2023 10:40	0.00
5/27/2023 21:05	40.80	5/28/2023 0:30	0.00	5/28/2023 3:55	0.00	5/28/2023 7:20	0.00	5/28/2023 10:45	0.00
5/27/2023 21:10	4.80	5/28/2023 0:35	0.00	5/28/2023 4:00	0.00	5/28/2023 7:25	0.00	5/28/2023 10:50	0.00
5/27/2023 21:15	0.00	5/28/2023 0:40	0.00	5/28/2023 4:05	0.00	5/28/2023 7:30	0.00	5/28/2023 10:55	0.00
5/27/2023 21:20	0.00	5/28/2023 0:45	2.40	5/28/2023 4:10	0.00	5/28/2023 7:35	0.00	5/28/2023 11:00	0.00
5/27/2023 21:25	0.00	5/28/2023 0:50	0.00	5/28/2023 4:15	0.00	5/28/2023 7:40	0.00	5/28/2023 11:05	0.00
5/27/2023 21:30	0.00	5/28/2023 0:55	0.00	5/28/2023 4:20	0.00	5/28/2023 7:45	0.00	5/28/2023 11:10	0.00
5/27/2023 21:35	0.00	5/28/2023 1:00	0.00	5/28/2023 4:25	0.00	5/28/2023 7:50	0.00	5/28/2023 11:15	0.00
5/27/2023 21:40	0.00	5/28/2023 1:05	2.40	5/28/2023 4:30	0.00	5/28/2023 7:55	0.00	5/28/2023 11:20	0.00
5/27/2023 21:45	0.00	5/28/2023 1:10	0.00	5/28/2023 4:35	0.00	5/28/2023 8:00	0.00	5/28/2023 11:25	0.00
5/27/2023 21:50	0.00	5/28/2023 1:15	4.80	5/28/2023 4:40	0.00	5/28/2023 8:05	0.00	5/28/2023 11:30	0.00
5/27/2023 21:55	0.00	5/28/2023 1:20	7.20	5/28/2023 4:45	0.00	5/28/2023 8:10	0.00	5/28/2023 11:35	0.00
5/27/2023 22:00	0.00	5/28/2023 1:25	9.60	5/28/2023 4:50	0.00	5/28/2023 8:15	0.00	5/28/2023 11:40	0.00
5/27/2023 22:05	0.00	5/28/2023 1:30	12.00	5/28/2023 4:55	0.00	5/28/2023 8:20	0.00	5/28/2023 11:45	0.00
5/27/2023 22:10	0.00	5/28/2023 1:35	2.40	5/28/2023 5:00	0.00	5/28/2023 8:25	0.00	5/28/2023 11:50	0.00
5/27/2023 22:15	0.00	5/28/2023 1:40	9.60	5/28/2023 5:05	0.00	5/28/2023 8:30	0.00	5/28/2023 11:55	0.00
5/27/2023 22:20	0.00	5/28/2023 1:45	7.20	5/28/2023 5:10	0.00	5/28/2023 8:35	0.00	5/28/2023 12:00	0.00
5/27/2023 22:25	0.00	5/28/2023 1:50	4.80	5/28/2023 5:15	0.00	5/28/2023 8:40	0.00	5/28/2023 12:05	0.00
5/27/2023 22:30	0.00	5/28/2023 1:55	2.40	5/28/2023 5:20	0.00	5/28/2023 8:45	0.00	5/28/2023 12:10	0.00
5/27/2023 22:35	0.00	5/28/2023 2:00	7.20	5/28/2023 5:25	0.00	5/28/2023 8:50	0.00	5/28/2023 12:15	0.00
5/27/2023 22:40	0.00	5/28/2023 2:05	2.40	5/28/2023 5:30	0.00	5/28/2023 8:55	0.00	5/28/2023 12:20	0.00
5/27/2023 22:45	0.00	5/28/2023 2:10	2.40	5/28/2023 5:35	0.00	5/28/2023 9:00	0.00	5/28/2023 12:25	0.00
5/27/2023 22:50	0.00	5/28/2023 2:15	4.80	5/28/2023 5:40	0.00	5/28/2023 9:05	0.00	5/28/2023 12:30	0.00
5/27/2023 22:55	0.00	5/28/2023 2:20	0.00	5/28/2023 5:45	0.00	5/28/2023 9:10	0.00	5/28/2023 12:35	0.00
5/27/2023 23:00	0.00	5/28/2023 2:25	2.40	5/28/2023 5:50	0.00	5/28/2023 9:15	0.00	5/28/2023 12:40	0.00
5/27/2023 23:05	0.00	5/28/2023 2:30	0.00	5/28/2023 5:55	0.00	5/28/2023 9:20	0.00	5/28/2023 12:45	0.00
5/27/2023 23:10	0.00	5/28/2023 2:35	2.40	5/28/2023 6:00	0.00	5/28/2023 9:25	0.00	5/28/2023 12:50	0.00
5/27/2023 23:15	0.00	5/28/2023 2:40	0.00	5/28/2023 6:05	0.00	5/28/2023 9:30	0.00	5/28/2023 12:55	0.00
5/27/2023 23:20	0.00	5/28/2023 2:45	0.00	5/28/2023 6:10	0.00	5/28/2023 9:35	0.00	5/28/2023 13:00	0.00
5/27/2023 23:25	0.00	5/28/2023 2:50	0.00	5/28/2023 6:15	0.00	5/28/2023 9:40	0.00	5/28/2023 13:05	0.00
5/27/2023 23:30	0.00	5/28/2023 2:55	0.00	5/28/2023 6:20	0.00	5/28/2023 9:45	0.00	5/28/2023 13:10	0.00
5/27/2023 23:35	0.00	5/28/2023 3:00	0.00	5/28/2023 6:25	0.00	5/28/2023 9:50	0.00	5/28/2023 13:15	0.00
5/27/2023 23:40	0.00	5/28/2023 3:05	0.00	5/28/2023 6:30	0.00	5/28/2023 9:55	0.00	5/28/2023 13:20	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/28/2023 13:25	0.00	5/28/2023 16:50	0.00	5/28/2023 20:15	0.00	5/28/2023 23:40	0.00	5/29/2023 3:05	0.00
5/28/2023 13:30	0.00	5/28/2023 16:55	0.00	5/28/2023 20:20	0.00	5/28/2023 23:45	0.00	5/29/2023 3:10	0.00
5/28/2023 13:35	0.00	5/28/2023 17:00	0.00	5/28/2023 20:25	0.00	5/28/2023 23:50	0.00	5/29/2023 3:15	0.00
5/28/2023 13:40	0.00	5/28/2023 17:05	0.00	5/28/2023 20:30	0.00	5/28/2023 23:55	0.00	5/29/2023 3:20	0.00
5/28/2023 13:45	0.00	5/28/2023 17:10	0.00	5/28/2023 20:35	0.00	5/29/2023 0:00	0.00	5/29/2023 3:25	0.00
5/28/2023 13:50	0.00	5/28/2023 17:15	0.00	5/28/2023 20:40	0.00	5/29/2023 0:05	0.00	5/29/2023 3:30	0.00
5/28/2023 13:55	0.00	5/28/2023 17:20	0.00	5/28/2023 20:45	0.00	5/29/2023 0:10	0.00	5/29/2023 3:35	0.00
5/28/2023 14:00	0.00	5/28/2023 17:25	0.00	5/28/2023 20:50	0.00	5/29/2023 0:15	0.00	5/29/2023 3:40	0.00
5/28/2023 14:05	0.00	5/28/2023 17:30	0.00	5/28/2023 20:55	0.00	5/29/2023 0:20	0.00	5/29/2023 3:45	0.00
5/28/2023 14:10	0.00	5/28/2023 17:35	0.00	5/28/2023 21:00	0.00	5/29/2023 0:25	0.00	5/29/2023 3:50	0.00
5/28/2023 14:15	0.00	5/28/2023 17:40	0.00	5/28/2023 21:05	0.00	5/29/2023 0:30	0.00	5/29/2023 3:55	0.00
5/28/2023 14:20	0.00	5/28/2023 17:45	0.00	5/28/2023 21:10	0.00	5/29/2023 0:35	0.00	5/29/2023 4:00	0.00
5/28/2023 14:25	0.00	5/28/2023 17:50	0.00	5/28/2023 21:15	0.00	5/29/2023 0:40	0.00	5/29/2023 4:05	0.00
5/28/2023 14:30	0.00	5/28/2023 17:55	0.00	5/28/2023 21:20	0.00	5/29/2023 0:45	0.00	5/29/2023 4:10	0.00
5/28/2023 14:35	0.00	5/28/2023 18:00	0.00	5/28/2023 21:25	0.00	5/29/2023 0:50	0.00	5/29/2023 4:15	0.00
5/28/2023 14:40	0.00	5/28/2023 18:05	0.00	5/28/2023 21:30	0.00	5/29/2023 0:55	0.00	5/29/2023 4:20	0.00
5/28/2023 14:45	0.00	5/28/2023 18:10	0.00	5/28/2023 21:35	0.00	5/29/2023 1:00	0.00	5/29/2023 4:25	0.00
5/28/2023 14:50	0.00	5/28/2023 18:15	0.00	5/28/2023 21:40	0.00	5/29/2023 1:05	0.00	5/29/2023 4:30	0.00
5/28/2023 14:55	0.00	5/28/2023 18:20	0.00	5/28/2023 21:45	0.00	5/29/2023 1:10	0.00	5/29/2023 4:35	0.00
5/28/2023 15:00	0.00	5/28/2023 18:25	0.00	5/28/2023 21:50	0.00	5/29/2023 1:15	0.00	5/29/2023 4:40	0.00
5/28/2023 15:05	0.00	5/28/2023 18:30	0.00	5/28/2023 21:55	0.00	5/29/2023 1:20	0.00	5/29/2023 4:45	0.00
5/28/2023 15:10	0.00	5/28/2023 18:35	0.00	5/28/2023 22:00	0.00	5/29/2023 1:25	0.00	5/29/2023 4:50	0.00
5/28/2023 15:15	0.00	5/28/2023 18:40	0.00	5/28/2023 22:05	0.00	5/29/2023 1:30	0.00	5/29/2023 4:55	0.00
5/28/2023 15:20	0.00	5/28/2023 18:45	0.00	5/28/2023 22:10	0.00	5/29/2023 1:35	0.00	5/29/2023 5:00	0.00
5/28/2023 15:25	0.00	5/28/2023 18:50	0.00	5/28/2023 22:15	0.00	5/29/2023 1:40	0.00	5/29/2023 5:05	0.00
5/28/2023 15:30	0.00	5/28/2023 18:55	0.00	5/28/2023 22:20	0.00	5/29/2023 1:45	0.00	5/29/2023 5:10	0.00
5/28/2023 15:35	0.00	5/28/2023 19:00	0.00	5/28/2023 22:25	0.00	5/29/2023 1:50	0.00	5/29/2023 5:15	0.00
5/28/2023 15:40	0.00	5/28/2023 19:05	0.00	5/28/2023 22:30	0.00	5/29/2023 1:55	0.00	5/29/2023 5:20	0.00
5/28/2023 15:45	0.00	5/28/2023 19:10	0.00	5/28/2023 22:35	0.00	5/29/2023 2:00	0.00	5/29/2023 5:25	0.00
5/28/2023 15:50	0.00	5/28/2023 19:15	0.00	5/28/2023 22:40	0.00	5/29/2023 2:05	0.00	5/29/2023 5:30	0.00
5/28/2023 15:55	0.00	5/28/2023 19:20	0.00	5/28/2023 22:45	0.00	5/29/2023 2:10	0.00	5/29/2023 5:35	0.00
5/28/2023 16:00	0.00	5/28/2023 19:25	0.00	5/28/2023 22:50	0.00	5/29/2023 2:15	0.00	5/29/2023 5:40	0.00
5/28/2023 16:05	0.00	5/28/2023 19:30	0.00	5/28/2023 22:55	0.00	5/29/2023 2:20	0.00	5/29/2023 5:45	0.00
5/28/2023 16:10	0.00	5/28/2023 19:35	0.00	5/28/2023 23:00	0.00	5/29/2023 2:25	0.00	5/29/2023 5:50	0.00
5/28/2023 16:15	0.00	5/28/2023 19:40	0.00	5/28/2023 23:05	0.00	5/29/2023 2:30	0.00	5/29/2023 5:55	0.00
5/28/2023 16:20	0.00	5/28/2023 19:45	0.00	5/28/2023 23:10	0.00	5/29/2023 2:35	0.00	5/29/2023 6:00	0.00
5/28/2023 16:25	0.00	5/28/2023 19:50	0.00	5/28/2023 23:15	0.00	5/29/2023 2:40	0.00	5/29/2023 6:05	0.00
5/28/2023 16:30	0.00	5/28/2023 19:55	0.00	5/28/2023 23:20	0.00	5/29/2023 2:45	0.00	5/29/2023 6:10	0.00
5/28/2023 16:35	0.00	5/28/2023 20:00	0.00	5/28/2023 23:25	0.00	5/29/2023 2:50	0.00	5/29/2023 6:15	0.00
5/28/2023 16:40	0.00	5/28/2023 20:05	0.00	5/28/2023 23:30	0.00	5/29/2023 2:55	0.00	5/29/2023 6:20	0.00
5/28/2023 16:45	0.00	5/28/2023 20:10	0.00	5/28/2023 23:35	0.00	5/29/2023 3:00	0.00	5/29/2023 6:25	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/29/2023 6:30	0.00	5/29/2023 9:55	0.00	5/29/2023 13:20	0.00	5/29/2023 16:45	0.00	5/29/2023 20:10	0.00
5/29/2023 6:35	0.00	5/29/2023 10:00	0.00	5/29/2023 13:25	0.00	5/29/2023 16:50	0.00	5/29/2023 20:15	0.00
5/29/2023 6:40	0.00	5/29/2023 10:05	0.00	5/29/2023 13:30	0.00	5/29/2023 16:55	0.00	5/29/2023 20:20	0.00
5/29/2023 6:45	0.00	5/29/2023 10:10	0.00	5/29/2023 13:35	0.00	5/29/2023 17:00	0.00	5/29/2023 20:25	0.00
5/29/2023 6:50	0.00	5/29/2023 10:15	0.00	5/29/2023 13:40	0.00	5/29/2023 17:05	0.00	5/29/2023 20:30	0.00
5/29/2023 6:55	0.00	5/29/2023 10:20	0.00	5/29/2023 13:45	0.00	5/29/2023 17:10	0.00	5/29/2023 20:35	0.00
5/29/2023 7:00	0.00	5/29/2023 10:25	0.00	5/29/2023 13:50	0.00	5/29/2023 17:15	0.00	5/29/2023 20:40	0.00
5/29/2023 7:05	0.00	5/29/2023 10:30	0.00	5/29/2023 13:55	0.00	5/29/2023 17:20	0.00	5/29/2023 20:45	0.00
5/29/2023 7:10	0.00	5/29/2023 10:35	0.00	5/29/2023 14:00	0.00	5/29/2023 17:25	0.00	5/29/2023 20:50	0.00
5/29/2023 7:15	0.00	5/29/2023 10:40	0.00	5/29/2023 14:05	0.00	5/29/2023 17:30	0.00	5/29/2023 20:55	0.00
5/29/2023 7:20	0.00	5/29/2023 10:45	0.00	5/29/2023 14:10	0.00	5/29/2023 17:35	0.00	5/29/2023 21:00	0.00
5/29/2023 7:25	0.00	5/29/2023 10:50	0.00	5/29/2023 14:15	0.00	5/29/2023 17:40	0.00	5/29/2023 21:05	0.00
5/29/2023 7:30	0.00	5/29/2023 10:55	0.00	5/29/2023 14:20	0.00	5/29/2023 17:45	0.00	5/29/2023 21:10	0.00
5/29/2023 7:35	0.00	5/29/2023 11:00	0.00	5/29/2023 14:25	0.00	5/29/2023 17:50	0.00	5/29/2023 21:15	0.00
5/29/2023 7:40	0.00	5/29/2023 11:05	0.00	5/29/2023 14:30	0.00	5/29/2023 17:55	0.00	5/29/2023 21:20	0.00
5/29/2023 7:45	0.00	5/29/2023 11:10	0.00	5/29/2023 14:35	0.00	5/29/2023 18:00	0.00	5/29/2023 21:25	0.00
5/29/2023 7:50	0.00	5/29/2023 11:15	0.00	5/29/2023 14:40	0.00	5/29/2023 18:05	0.00	5/29/2023 21:30	0.00
5/29/2023 7:55	0.00	5/29/2023 11:20	0.00	5/29/2023 14:45	0.00	5/29/2023 18:10	0.00	5/29/2023 21:35	0.00
5/29/2023 8:00	0.00	5/29/2023 11:25	0.00	5/29/2023 14:50	0.00	5/29/2023 18:15	0.00	5/29/2023 21:40	0.00
5/29/2023 8:05	0.00	5/29/2023 11:30	0.00	5/29/2023 14:55	0.00	5/29/2023 18:20	0.00	5/29/2023 21:45	0.00
5/29/2023 8:10	0.00	5/29/2023 11:35	0.00	5/29/2023 15:00	0.00	5/29/2023 18:25	0.00	5/29/2023 21:50	0.00
5/29/2023 8:15	0.00	5/29/2023 11:40	0.00	5/29/2023 15:05	0.00	5/29/2023 18:30	0.00	5/29/2023 21:55	0.00
5/29/2023 8:20	0.00	5/29/2023 11:45	0.00	5/29/2023 15:10	0.00	5/29/2023 18:35	0.00	5/29/2023 22:00	0.00
5/29/2023 8:25	0.00	5/29/2023 11:50	0.00	5/29/2023 15:15	0.00	5/29/2023 18:40	0.00	5/29/2023 22:05	0.00
5/29/2023 8:30	0.00	5/29/2023 11:55	0.00	5/29/2023 15:20	0.00	5/29/2023 18:45	0.00	5/29/2023 22:10	0.00
5/29/2023 8:35	0.00	5/29/2023 12:00	0.00	5/29/2023 15:25	0.00	5/29/2023 18:50	0.00	5/29/2023 22:15	0.00
5/29/2023 8:40	0.00	5/29/2023 12:05	0.00	5/29/2023 15:30	0.00	5/29/2023 18:55	0.00	5/29/2023 22:20	0.00
5/29/2023 8:45	0.00	5/29/2023 12:10	0.00	5/29/2023 15:35	0.00	5/29/2023 19:00	0.00	5/29/2023 22:25	0.00
5/29/2023 8:50	0.00	5/29/2023 12:15	0.00	5/29/2023 15:40	0.00	5/29/2023 19:05	0.00	5/29/2023 22:30	0.00
5/29/2023 8:55	0.00	5/29/2023 12:20	0.00	5/29/2023 15:45	0.00	5/29/2023 19:10	0.00	5/29/2023 22:35	0.00
5/29/2023 9:00	0.00	5/29/2023 12:25	0.00	5/29/2023 15:50	0.00	5/29/2023 19:15	0.00	5/29/2023 22:40	0.00
5/29/2023 9:05	0.00	5/29/2023 12:30	0.00	5/29/2023 15:55	0.00	5/29/2023 19:20	0.00	5/29/2023 22:45	0.00
5/29/2023 9:10	0.00	5/29/2023 12:35	0.00	5/29/2023 16:00	0.00	5/29/2023 19:25	0.00	5/29/2023 22:50	0.00
5/29/2023 9:15	0.00	5/29/2023 12:40	0.00	5/29/2023 16:05	0.00	5/29/2023 19:30	0.00	5/29/2023 22:55	0.00
5/29/2023 9:20	0.00	5/29/2023 12:45	0.00	5/29/2023 16:10	0.00	5/29/2023 19:35	0.00	5/29/2023 23:00	0.00
5/29/2023 9:25	0.00	5/29/2023 12:50	0.00	5/29/2023 16:15	0.00	5/29/2023 19:40	0.00	5/29/2023 23:05	0.00
5/29/2023 9:30	0.00	5/29/2023 12:55	0.00	5/29/2023 16:20	0.00	5/29/2023 19:45	0.00	5/29/2023 23:10	0.00
5/29/2023 9:35	0.00	5/29/2023 13:00	0.00	5/29/2023 16:25	0.00	5/29/2023 19:50	0.00	5/29/2023 23:15	0.00
5/29/2023 9:40	0.00	5/29/2023 13:05	0.00	5/29/2023 16:30	0.00	5/29/2023 19:55	0.00	5/29/2023 23:20	0.00
5/29/2023 9:45	0.00	5/29/2023 13:10	0.00	5/29/2023 16:35	0.00	5/29/2023 20:00	0.00	5/29/2023 23:25	0.00
5/29/2023 9:50	0.00	5/29/2023 13:15	0.00	5/29/2023 16:40	0.00	5/29/2023 20:05	0.00	5/29/2023 23:30	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/29/2023 23:35	0.00	5/30/2023 3:00	0.00	5/30/2023 6:25	0.00	5/30/2023 9:50	0.00	5/30/2023 13:15	0.00
5/29/2023 23:40	0.00	5/30/2023 3:05	0.00	5/30/2023 6:30	0.00	5/30/2023 9:55	0.00	5/30/2023 13:20	0.00
5/29/2023 23:45	0.00	5/30/2023 3:10	0.00	5/30/2023 6:35	0.00	5/30/2023 10:00	0.00	5/30/2023 13:25	0.00
5/29/2023 23:50	0.00	5/30/2023 3:15	0.00	5/30/2023 6:40	0.00	5/30/2023 10:05	0.00	5/30/2023 13:30	0.00
5/29/2023 23:55	0.00	5/30/2023 3:20	0.00	5/30/2023 6:45	0.00	5/30/2023 10:10	0.00	5/30/2023 13:35	0.00
5/30/2023 0:00	0.00	5/30/2023 3:25	0.00	5/30/2023 6:50	0.00	5/30/2023 10:15	0.00	5/30/2023 13:40	0.00
5/30/2023 0:05	0.00	5/30/2023 3:30	0.00	5/30/2023 6:55	0.00	5/30/2023 10:20	0.00	5/30/2023 13:45	0.00
5/30/2023 0:10	0.00	5/30/2023 3:35	0.00	5/30/2023 7:00	0.00	5/30/2023 10:25	0.00	5/30/2023 13:50	0.00
5/30/2023 0:15	0.00	5/30/2023 3:40	0.00	5/30/2023 7:05	0.00	5/30/2023 10:30	0.00	5/30/2023 13:55	0.00
5/30/2023 0:20	0.00	5/30/2023 3:45	0.00	5/30/2023 7:10	0.00	5/30/2023 10:35	0.00	5/30/2023 14:00	0.00
5/30/2023 0:25	0.00	5/30/2023 3:50	0.00	5/30/2023 7:15	0.00	5/30/2023 10:40	0.00	5/30/2023 14:05	0.00
5/30/2023 0:30	0.00	5/30/2023 3:55	0.00	5/30/2023 7:20	0.00	5/30/2023 10:45	0.00	5/30/2023 14:10	0.00
5/30/2023 0:35	0.00	5/30/2023 4:00	0.00	5/30/2023 7:25	0.00	5/30/2023 10:50	0.00	5/30/2023 14:15	0.00
5/30/2023 0:40	0.00	5/30/2023 4:05	0.00	5/30/2023 7:30	0.00	5/30/2023 10:55	0.00	5/30/2023 14:20	0.00
5/30/2023 0:45	0.00	5/30/2023 4:10	0.00	5/30/2023 7:35	0.00	5/30/2023 11:00	0.00	5/30/2023 14:25	0.00
5/30/2023 0:50	0.00	5/30/2023 4:15	0.00	5/30/2023 7:40	0.00	5/30/2023 11:05	0.00	5/30/2023 14:30	0.00
5/30/2023 0:55	0.00	5/30/2023 4:20	0.00	5/30/2023 7:45	0.00	5/30/2023 11:10	0.00	5/30/2023 14:35	0.00
5/30/2023 1:00	0.00	5/30/2023 4:25	0.00	5/30/2023 7:50	0.00	5/30/2023 11:15	0.00	5/30/2023 14:40	0.00
5/30/2023 1:05	0.00	5/30/2023 4:30	0.00	5/30/2023 7:55	0.00	5/30/2023 11:20	0.00	5/30/2023 14:45	0.00
5/30/2023 1:10	0.00	5/30/2023 4:35	0.00	5/30/2023 8:00	0.00	5/30/2023 11:25	0.00	5/30/2023 14:50	0.00
5/30/2023 1:15	0.00	5/30/2023 4:40	0.00	5/30/2023 8:05	0.00	5/30/2023 11:30	0.00	5/30/2023 14:55	0.00
5/30/2023 1:20	0.00	5/30/2023 4:45	0.00	5/30/2023 8:10	0.00	5/30/2023 11:35	0.00	5/30/2023 15:00	0.00
5/30/2023 1:25	0.00	5/30/2023 4:50	0.00	5/30/2023 8:15	0.00	5/30/2023 11:40	0.00	5/30/2023 15:05	0.00
5/30/2023 1:30	0.00	5/30/2023 4:55	0.00	5/30/2023 8:20	0.00	5/30/2023 11:45	0.00	5/30/2023 15:10	0.00
5/30/2023 1:35	0.00	5/30/2023 5:00	0.00	5/30/2023 8:25	0.00	5/30/2023 11:50	0.00	5/30/2023 15:15	0.00
5/30/2023 1:40	0.00	5/30/2023 5:05	0.00	5/30/2023 8:30	0.00	5/30/2023 11:55	0.00	5/30/2023 15:20	0.00
5/30/2023 1:45	0.00	5/30/2023 5:10	0.00	5/30/2023 8:35	0.00	5/30/2023 12:00	0.00	5/30/2023 15:25	0.00
5/30/2023 1:50	0.00	5/30/2023 5:15	0.00	5/30/2023 8:40	0.00	5/30/2023 12:05	0.00	5/30/2023 15:30	0.00
5/30/2023 1:55	0.00	5/30/2023 5:20	0.00	5/30/2023 8:45	0.00	5/30/2023 12:10	0.00	5/30/2023 15:35	0.00
5/30/2023 2:00	0.00	5/30/2023 5:25	0.00	5/30/2023 8:50	0.00	5/30/2023 12:15	0.00	5/30/2023 15:40	0.00
5/30/2023 2:05	0.00	5/30/2023 5:30	0.00	5/30/2023 8:55	0.00	5/30/2023 12:20	0.00	5/30/2023 15:45	0.00
5/30/2023 2:10	0.00	5/30/2023 5:35	0.00	5/30/2023 9:00	0.00	5/30/2023 12:25	0.00	5/30/2023 15:50	0.00
5/30/2023 2:15	0.00	5/30/2023 5:40	0.00	5/30/2023 9:05	0.00	5/30/2023 12:30	0.00	5/30/2023 15:55	0.00
5/30/2023 2:20	0.00	5/30/2023 5:45	0.00	5/30/2023 9:10	0.00	5/30/2023 12:35	0.00	5/30/2023 16:00	0.00
5/30/2023 2:25	0.00	5/30/2023 5:50	0.00	5/30/2023 9:15	0.00	5/30/2023 12:40	0.00	5/30/2023 16:05	0.00
5/30/2023 2:30	0.00	5/30/2023 5:55	0.00	5/30/2023 9:20	0.00	5/30/2023 12:45	0.00	5/30/2023 16:10	0.00
5/30/2023 2:35	0.00	5/30/2023 6:00	0.00	5/30/2023 9:25	0.00	5/30/2023 12:50	0.00	5/30/2023 16:15	0.00
5/30/2023 2:40	0.00	5/30/2023 6:05	0.00	5/30/2023 9:30	0.00	5/30/2023 12:55	0.00	5/30/2023 16:20	0.00
5/30/2023 2:45	0.00	5/30/2023 6:10	0.00	5/30/2023 9:35	0.00	5/30/2023 13:00	0.00	5/30/2023 16:25	0.00
5/30/2023 2:50	0.00	5/30/2023 6:15	0.00	5/30/2023 9:40	0.00	5/30/2023 13:05	0.00	5/30/2023 16:30	0.00
5/30/2023 2:55	0.00	5/30/2023 6:20	0.00	5/30/2023 9:45	0.00	5/30/2023 13:10	0.00	5/30/2023 16:35	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/30/2023 16:40	0.00	5/30/2023 20:05	0.00	5/30/2023 23:30	0.00	5/31/2023 2:55	0.00	5/31/2023 6:20	0.00
5/30/2023 16:45	0.00	5/30/2023 20:10	0.00	5/30/2023 23:35	0.00	5/31/2023 3:00	0.00	5/31/2023 6:25	0.00
5/30/2023 16:50	0.00	5/30/2023 20:15	0.00	5/30/2023 23:40	0.00	5/31/2023 3:05	0.00	5/31/2023 6:30	0.00
5/30/2023 16:55	0.00	5/30/2023 20:20	0.00	5/30/2023 23:45	0.00	5/31/2023 3:10	0.00	5/31/2023 6:35	0.00
5/30/2023 17:00	0.00	5/30/2023 20:25	0.00	5/30/2023 23:50	0.00	5/31/2023 3:15	0.00	5/31/2023 6:40	0.00
5/30/2023 17:05	0.00	5/30/2023 20:30	0.00	5/30/2023 23:55	0.00	5/31/2023 3:20	0.00	5/31/2023 6:45	0.00
5/30/2023 17:10	0.00	5/30/2023 20:35	0.00	5/31/2023 0:00	0.00	5/31/2023 3:25	0.00	5/31/2023 6:50	0.00
5/30/2023 17:15	0.00	5/30/2023 20:40	0.00	5/31/2023 0:05	0.00	5/31/2023 3:30	0.00	5/31/2023 6:55	0.00
5/30/2023 17:20	0.00	5/30/2023 20:45	0.00	5/31/2023 0:10	0.00	5/31/2023 3:35	0.00	5/31/2023 7:00	0.00
5/30/2023 17:25	0.00	5/30/2023 20:50	0.00	5/31/2023 0:15	0.00	5/31/2023 3:40	0.00	5/31/2023 7:05	0.00
5/30/2023 17:30	0.00	5/30/2023 20:55	0.00	5/31/2023 0:20	0.00	5/31/2023 3:45	0.00	5/31/2023 7:10	0.00
5/30/2023 17:35	0.00	5/30/2023 21:00	0.00	5/31/2023 0:25	0.00	5/31/2023 3:50	0.00	5/31/2023 7:15	0.00
5/30/2023 17:40	0.00	5/30/2023 21:05	0.00	5/31/2023 0:30	0.00	5/31/2023 3:55	0.00	5/31/2023 7:20	0.00
5/30/2023 17:45	0.00	5/30/2023 21:10	0.00	5/31/2023 0:35	0.00	5/31/2023 4:00	0.00	5/31/2023 7:25	0.00
5/30/2023 17:50	0.00	5/30/2023 21:15	0.00	5/31/2023 0:40	0.00	5/31/2023 4:05	0.00	5/31/2023 7:30	0.00
5/30/2023 17:55	0.00	5/30/2023 21:20	0.00	5/31/2023 0:45	0.00	5/31/2023 4:10	0.00	5/31/2023 7:35	0.00
5/30/2023 18:00	0.00	5/30/2023 21:25	0.00	5/31/2023 0:50	0.00	5/31/2023 4:15	0.00	5/31/2023 7:40	0.00
5/30/2023 18:05	0.00	5/30/2023 21:30	0.00	5/31/2023 0:55	0.00	5/31/2023 4:20	0.00	5/31/2023 7:45	0.00
5/30/2023 18:10	0.00	5/30/2023 21:35	0.00	5/31/2023 1:00	0.00	5/31/2023 4:25	0.00	5/31/2023 7:50	0.00
5/30/2023 18:15	0.00	5/30/2023 21:40	0.00	5/31/2023 1:05	0.00	5/31/2023 4:30	0.00	5/31/2023 7:55	0.00
5/30/2023 18:20	0.00	5/30/2023 21:45	0.00	5/31/2023 1:10	0.00	5/31/2023 4:35	0.00	5/31/2023 8:00	0.00
5/30/2023 18:25	0.00	5/30/2023 21:50	0.00	5/31/2023 1:15	0.00	5/31/2023 4:40	0.00	5/31/2023 8:05	0.00
5/30/2023 18:30	0.00	5/30/2023 21:55	0.00	5/31/2023 1:20	0.00	5/31/2023 4:45	0.00	5/31/2023 8:10	0.00
5/30/2023 18:35	0.00	5/30/2023 22:00	0.00	5/31/2023 1:25	0.00	5/31/2023 4:50	0.00	5/31/2023 8:15	0.00
5/30/2023 18:40	0.00	5/30/2023 22:05	0.00	5/31/2023 1:30	0.00	5/31/2023 4:55	0.00	5/31/2023 8:20	0.00
5/30/2023 18:45	0.00	5/30/2023 22:10	0.00	5/31/2023 1:35	0.00	5/31/2023 5:00	0.00	5/31/2023 8:25	0.00
5/30/2023 18:50	0.00	5/30/2023 22:15	0.00	5/31/2023 1:40	0.00	5/31/2023 5:05	0.00	5/31/2023 8:30	0.00
5/30/2023 18:55	0.00	5/30/2023 22:20	0.00	5/31/2023 1:45	0.00	5/31/2023 5:10	0.00	5/31/2023 8:35	0.00
5/30/2023 19:00	0.00	5/30/2023 22:25	0.00	5/31/2023 1:50	0.00	5/31/2023 5:15	0.00	5/31/2023 8:40	0.00
5/30/2023 19:05	0.00	5/30/2023 22:30	0.00	5/31/2023 1:55	0.00	5/31/2023 5:20	0.00	5/31/2023 8:45	0.00
5/30/2023 19:10	0.00	5/30/2023 22:35	0.00	5/31/2023 2:00	0.00	5/31/2023 5:25	0.00	5/31/2023 8:50	0.00
5/30/2023 19:15	0.00	5/30/2023 22:40	0.00	5/31/2023 2:05	0.00	5/31/2023 5:30	0.00	5/31/2023 8:55	0.00
5/30/2023 19:20	0.00	5/30/2023 22:45	0.00	5/31/2023 2:10	0.00	5/31/2023 5:35	0.00	5/31/2023 9:00	0.00
5/30/2023 19:25	0.00	5/30/2023 22:50	0.00	5/31/2023 2:15	0.00	5/31/2023 5:40	0.00	5/31/2023 9:05	0.00
5/30/2023 19:30	0.00	5/30/2023 22:55	0.00	5/31/2023 2:20	0.00	5/31/2023 5:45	0.00	5/31/2023 9:10	0.00
5/30/2023 19:35	0.00	5/30/2023 23:00	0.00	5/31/2023 2:25	0.00	5/31/2023 5:50	0.00	5/31/2023 9:15	0.00
5/30/2023 19:40	0.00	5/30/2023 23:05	0.00	5/31/2023 2:30	0.00	5/31/2023 5:55	0.00	5/31/2023 9:20	0.00
5/30/2023 19:45	0.00	5/30/2023 23:10	0.00	5/31/2023 2:35	0.00	5/31/2023 6:00	0.00	5/31/2023 9:25	0.00
5/30/2023 19:50	0.00	5/30/2023 23:15	0.00	5/31/2023 2:40	0.00	5/31/2023 6:05	0.00	5/31/2023 9:30	0.00
5/30/2023 19:55	0.00	5/30/2023 23:20	0.00	5/31/2023 2:45	0.00	5/31/2023 6:10	0.00	5/31/2023 9:35	0.00
5/30/2023 20:00	0.00	5/30/2023 23:25	0.00	5/31/2023 2:50	0.00	5/31/2023 6:15	0.00	5/31/2023 9:40	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
5/31/2023 9:45	0.00	5/31/2023 13:10	0.00	5/31/2023 16:35	0.00	5/31/2023 20:00	0.00	5/31/2023 23:25	0.00
5/31/2023 9:50	0.00	5/31/2023 13:15	0.00	5/31/2023 16:40	0.00	5/31/2023 20:05	0.00	5/31/2023 23:30	0.00
5/31/2023 9:55	0.00	5/31/2023 13:20	0.00	5/31/2023 16:45	0.00	5/31/2023 20:10	0.00	5/31/2023 23:35	0.00
5/31/2023 10:00	0.00	5/31/2023 13:25	0.00	5/31/2023 16:50	0.00	5/31/2023 20:15	0.00	5/31/2023 23:40	0.00
5/31/2023 10:05	0.00	5/31/2023 13:30	0.00	5/31/2023 16:55	0.00	5/31/2023 20:20	0.00	5/31/2023 23:45	0.00
5/31/2023 10:10	0.00	5/31/2023 13:35	0.00	5/31/2023 17:00	0.00	5/31/2023 20:25	0.00	5/31/2023 23:50	0.00
5/31/2023 10:15	0.00	5/31/2023 13:40	0.00	5/31/2023 17:05	0.00	5/31/2023 20:30	0.00	5/31/2023 23:55	0.00
5/31/2023 10:20	0.00	5/31/2023 13:45	0.00	5/31/2023 17:10	0.00	5/31/2023 20:35	0.00	6/1/2023 0:00	0.00
5/31/2023 10:25	0.00	5/31/2023 13:50	0.00	5/31/2023 17:15	0.00	5/31/2023 20:40	0.00	6/1/2023 0:05	0.00
5/31/2023 10:30	0.00	5/31/2023 13:55	0.00	5/31/2023 17:20	0.00	5/31/2023 20:45	0.00	6/1/2023 0:10	0.00
5/31/2023 10:35	0.00	5/31/2023 14:00	0.00	5/31/2023 17:25	0.00	5/31/2023 20:50	0.00	6/1/2023 0:15	0.00
5/31/2023 10:40	0.00	5/31/2023 14:05	0.00	5/31/2023 17:30	0.00	5/31/2023 20:55	0.00	6/1/2023 0:20	0.00
5/31/2023 10:45	0.00	5/31/2023 14:10	0.00	5/31/2023 17:35	0.00	5/31/2023 21:00	0.00	6/1/2023 0:25	0.00
5/31/2023 10:50	0.00	5/31/2023 14:15	0.00	5/31/2023 17:40	0.00	5/31/2023 21:05	0.00	6/1/2023 0:30	0.00
5/31/2023 10:55	0.00	5/31/2023 14:20	0.00	5/31/2023 17:45	0.00	5/31/2023 21:10	0.00	6/1/2023 0:35	0.00
5/31/2023 11:00	0.00	5/31/2023 14:25	0.00	5/31/2023 17:50	0.00	5/31/2023 21:15	0.00	6/1/2023 0:40	0.00
5/31/2023 11:05	0.00	5/31/2023 14:30	0.00	5/31/2023 17:55	0.00	5/31/2023 21:20	0.00	6/1/2023 0:45	0.00
5/31/2023 11:10	0.00	5/31/2023 14:35	0.00	5/31/2023 18:00	0.00	5/31/2023 21:25	0.00	6/1/2023 0:50	0.00
5/31/2023 11:15	0.00	5/31/2023 14:40	0.00	5/31/2023 18:05	0.00	5/31/2023 21:30	0.00	6/1/2023 0:55	0.00
5/31/2023 11:20	0.00	5/31/2023 14:45	0.00	5/31/2023 18:10	0.00	5/31/2023 21:35	0.00	6/1/2023 1:00	0.00
5/31/2023 11:25	0.00	5/31/2023 14:50	0.00	5/31/2023 18:15	0.00	5/31/2023 21:40	0.00	6/1/2023 1:05	0.00
5/31/2023 11:30	0.00	5/31/2023 14:55	0.00	5/31/2023 18:20	0.00	5/31/2023 21:45	0.00	6/1/2023 1:10	0.00
5/31/2023 11:35	0.00	5/31/2023 15:00	0.00	5/31/2023 18:25	0.00	5/31/2023 21:50	0.00	6/1/2023 1:15	0.00
5/31/2023 11:40	0.00	5/31/2023 15:05	0.00	5/31/2023 18:30	0.00	5/31/2023 21:55	0.00	6/1/2023 1:20	0.00
5/31/2023 11:45	0.00	5/31/2023 15:10	0.00	5/31/2023 18:35	0.00	5/31/2023 22:00	0.00	6/1/2023 1:25	0.00
5/31/2023 11:50	0.00	5/31/2023 15:15	0.00	5/31/2023 18:40	0.00	5/31/2023 22:05	0.00	6/1/2023 1:30	0.00
5/31/2023 11:55	0.00	5/31/2023 15:20	0.00	5/31/2023 18:45	0.00	5/31/2023 22:10	0.00	6/1/2023 1:35	0.00
5/31/2023 12:00	0.00	5/31/2023 15:25	0.00	5/31/2023 18:50	0.00	5/31/2023 22:15	0.00	6/1/2023 1:40	0.00
5/31/2023 12:05	0.00	5/31/2023 15:30	0.00	5/31/2023 18:55	0.00	5/31/2023 22:20	0.00	6/1/2023 1:45	0.00
5/31/2023 12:10	0.00	5/31/2023 15:35	0.00	5/31/2023 19:00	0.00	5/31/2023 22:25	0.00	6/1/2023 1:50	0.00
5/31/2023 12:15	0.00	5/31/2023 15:40	0.00	5/31/2023 19:05	0.00	5/31/2023 22:30	0.00	6/1/2023 1:55	0.00
5/31/2023 12:20	0.00	5/31/2023 15:45	0.00	5/31/2023 19:10	0.00	5/31/2023 22:35	0.00	6/1/2023 2:00	0.00
5/31/2023 12:25	0.00	5/31/2023 15:50	0.00	5/31/2023 19:15	0.00	5/31/2023 22:40	0.00	6/1/2023 2:05	0.00
5/31/2023 12:30	0.00	5/31/2023 15:55	0.00	5/31/2023 19:20	0.00	5/31/2023 22:45	0.00	6/1/2023 2:10	0.00
5/31/2023 12:35	0.00	5/31/2023 16:00	0.00	5/31/2023 19:25	0.00	5/31/2023 22:50	0.00	6/1/2023 2:15	0.00
5/31/2023 12:40	0.00	5/31/2023 16:05	0.00	5/31/2023 19:30	0.00	5/31/2023 22:55	0.00	6/1/2023 2:20	0.00
5/31/2023 12:45	0.00	5/31/2023 16:10	0.00	5/31/2023 19:35	0.00	5/31/2023 23:00	0.00	6/1/2023 2:25	0.00
5/31/2023 12:50	0.00	5/31/2023 16:15	0.00	5/31/2023 19:40	0.00	5/31/2023 23:05	0.00	6/1/2023 2:30	0.00
5/31/2023 12:55	0.00	5/31/2023 16:20	0.00	5/31/2023 19:45	0.00	5/31/2023 23:10	0.00	6/1/2023 2:35	0.00
5/31/2023 13:00	0.00	5/31/2023 16:25	0.00	5/31/2023 19:50	0.00	5/31/2023 23:15	0.00	6/1/2023 2:40	0.00
5/31/2023 13:05	0.00	5/31/2023 16:30	0.00	5/31/2023 19:55	0.00	5/31/2023 23:20	0.00	6/1/2023 2:45	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
6/1/2023 2:50	0.00	6/1/2023 6:15	0.00	6/1/2023 9:40	0.00	6/1/2023 13:05	0.00	6/1/2023 16:30	0.00
6/1/2023 2:55	0.00	6/1/2023 6:20	0.00	6/1/2023 9:45	0.00	6/1/2023 13:10	0.00	6/1/2023 16:35	0.00
6/1/2023 3:00	0.00	6/1/2023 6:25	0.00	6/1/2023 9:50	0.00	6/1/2023 13:15	0.00	6/1/2023 16:40	0.00
6/1/2023 3:05	0.00	6/1/2023 6:30	0.00	6/1/2023 9:55	0.00	6/1/2023 13:20	0.00	6/1/2023 16:45	0.00
6/1/2023 3:10	0.00	6/1/2023 6:35	0.00	6/1/2023 10:00	0.00	6/1/2023 13:25	0.00	6/1/2023 16:50	0.00
6/1/2023 3:15	0.00	6/1/2023 6:40	0.00	6/1/2023 10:05	0.00	6/1/2023 13:30	0.00	6/1/2023 16:55	0.00
6/1/2023 3:20	0.00	6/1/2023 6:45	0.00	6/1/2023 10:10	0.00	6/1/2023 13:35	0.00	6/1/2023 17:00	0.00
6/1/2023 3:25	0.00	6/1/2023 6:50	0.00	6/1/2023 10:15	0.00	6/1/2023 13:40	0.00	6/1/2023 17:05	0.00
6/1/2023 3:30	0.00	6/1/2023 6:55	0.00	6/1/2023 10:20	0.00	6/1/2023 13:45	0.00	6/1/2023 17:10	0.00
6/1/2023 3:35	0.00	6/1/2023 7:00	0.00	6/1/2023 10:25	0.00	6/1/2023 13:50	0.00	6/1/2023 17:15	0.00
6/1/2023 3:40	0.00	6/1/2023 7:05	0.00	6/1/2023 10:30	0.00	6/1/2023 13:55	0.00	6/1/2023 17:20	0.00
6/1/2023 3:45	0.00	6/1/2023 7:10	0.00	6/1/2023 10:35	0.00	6/1/2023 14:00	0.00	6/1/2023 17:25	0.00
6/1/2023 3:50	0.00	6/1/2023 7:15	0.00	6/1/2023 10:40	0.00	6/1/2023 14:05	0.00	6/1/2023 17:30	0.00
6/1/2023 3:55	0.00	6/1/2023 7:20	0.00	6/1/2023 10:45	0.00	6/1/2023 14:10	0.00	6/1/2023 17:35	0.00
6/1/2023 4:00	0.00	6/1/2023 7:25	0.00	6/1/2023 10:50	0.00	6/1/2023 14:15	0.00	6/1/2023 17:40	0.00
6/1/2023 4:05	0.00	6/1/2023 7:30	0.00	6/1/2023 10:55	0.00	6/1/2023 14:20	0.00	6/1/2023 17:45	0.00
6/1/2023 4:10	0.00	6/1/2023 7:35	0.00	6/1/2023 11:00	0.00	6/1/2023 14:25	0.00	6/1/2023 17:50	0.00
6/1/2023 4:15	0.00	6/1/2023 7:40	0.00	6/1/2023 11:05	0.00	6/1/2023 14:30	0.00	6/1/2023 17:55	0.00
6/1/2023 4:20	0.00	6/1/2023 7:45	0.00	6/1/2023 11:10	0.00	6/1/2023 14:35	0.00	6/1/2023 18:00	0.00
6/1/2023 4:25	0.00	6/1/2023 7:50	0.00	6/1/2023 11:15	0.00	6/1/2023 14:40	0.00	6/1/2023 18:05	2.40
6/1/2023 4:30	0.00	6/1/2023 7:55	0.00	6/1/2023 11:20	0.00	6/1/2023 14:45	0.00	6/1/2023 18:10	4.80
6/1/2023 4:35	0.00	6/1/2023 8:00	0.00	6/1/2023 11:25	0.00	6/1/2023 14:50	0.00	6/1/2023 18:15	2.40
6/1/2023 4:40	0.00	6/1/2023 8:05	0.00	6/1/2023 11:30	0.00	6/1/2023 14:55	0.00	6/1/2023 18:20	2.40
6/1/2023 4:45	0.00	6/1/2023 8:10	0.00	6/1/2023 11:35	0.00	6/1/2023 15:00	0.00	6/1/2023 18:25	7.20
6/1/2023 4:50	0.00	6/1/2023 8:15	0.00	6/1/2023 11:40	0.00	6/1/2023 15:05	0.00	6/1/2023 18:30	4.80
6/1/2023 4:55	0.00	6/1/2023 8:20	0.00	6/1/2023 11:45	0.00	6/1/2023 15:10	0.00	6/1/2023 18:35	0.00
6/1/2023 5:00	0.00	6/1/2023 8:25	0.00	6/1/2023 11:50	0.00	6/1/2023 15:15	0.00	6/1/2023 18:40	0.00
6/1/2023 5:05	0.00	6/1/2023 8:30	0.00	6/1/2023 11:55	0.00	6/1/2023 15:20	0.00	6/1/2023 18:45	4.80
6/1/2023 5:10	0.00	6/1/2023 8:35	0.00	6/1/2023 12:00	0.00	6/1/2023 15:25	0.00	6/1/2023 18:50	9.60
6/1/2023 5:15	0.00	6/1/2023 8:40	0.00	6/1/2023 12:05	0.00	6/1/2023 15:30	0.00	6/1/2023 18:55	2.40
6/1/2023 5:20	0.00	6/1/2023 8:45	0.00	6/1/2023 12:10	0.00	6/1/2023 15:35	0.00	6/1/2023 19:00	0.00
6/1/2023 5:25	0.00	6/1/2023 8:50	0.00	6/1/2023 12:15	0.00	6/1/2023 15:40	0.00	6/1/2023 19:05	2.40
6/1/2023 5:30	0.00	6/1/2023 8:55	0.00	6/1/2023 12:20	0.00	6/1/2023 15:45	0.00	6/1/2023 19:10	7.20
6/1/2023 5:35	0.00	6/1/2023 9:00	0.00	6/1/2023 12:25	0.00	6/1/2023 15:50	0.00	6/1/2023 19:15	4.80
6/1/2023 5:40	0.00	6/1/2023 9:05	0.00	6/1/2023 12:30	0.00	6/1/2023 15:55	0.00	6/1/2023 19:20	4.80
6/1/2023 5:45	0.00	6/1/2023 9:10	0.00	6/1/2023 12:35	0.00	6/1/2023 16:00	0.00	6/1/2023 19:25	7.20
6/1/2023 5:50	0.00	6/1/2023 9:15	0.00	6/1/2023 12:40	0.00	6/1/2023 16:05	0.00	6/1/2023 19:30	4.80
6/1/2023 5:55	0.00	6/1/2023 9:20	0.00	6/1/2023 12:45	0.00	6/1/2023 16:10	0.00	6/1/2023 19:35	0.00
6/1/2023 6:00	0.00	6/1/2023 9:25	0.00	6/1/2023 12:50	0.00	6/1/2023 16:15	0.00	6/1/2023 19:40	0.00
6/1/2023 6:05	0.00	6/1/2023 9:30	0.00	6/1/2023 12:55	0.00	6/1/2023 16:20	0.00	6/1/2023 19:45	2.40
6/1/2023 6:10	0.00	6/1/2023 9:35	0.00	6/1/2023 13:00	0.00	6/1/2023 16:25	0.00	6/1/2023 19:50	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
6/1/2023 19:55	2.40	6/1/2023 23:20	0.00	6/2/2023 2:45	0.00	6/2/2023 6:10	0.00	6/2/2023 9:35	0.00
6/1/2023 20:00	0.00	6/1/2023 23:25	0.00	6/2/2023 2:50	28.80	6/2/2023 6:15	0.00	6/2/2023 9:40	0.00
6/1/2023 20:05	0.00	6/1/2023 23:30	0.00	6/2/2023 2:55	9.60	6/2/2023 6:20	0.00	6/2/2023 9:45	0.00
6/1/2023 20:10	2.40	6/1/2023 23:35	0.00	6/2/2023 3:00	2.40	6/2/2023 6:25	0.00	6/2/2023 9:50	0.00
6/1/2023 20:15	0.00	6/1/2023 23:40	0.00	6/2/2023 3:05	4.80	6/2/2023 6:30	0.00	6/2/2023 9:55	0.00
6/1/2023 20:20	0.00	6/1/2023 23:45	0.00	6/2/2023 3:10	0.00	6/2/2023 6:35	0.00	6/2/2023 10:00	0.00
6/1/2023 20:25	0.00	6/1/2023 23:50	0.00	6/2/2023 3:15	0.00	6/2/2023 6:40	0.00	6/2/2023 10:05	0.00
6/1/2023 20:30	0.00	6/1/2023 23:55	0.00	6/2/2023 3:20	0.00	6/2/2023 6:45	0.00	6/2/2023 10:10	0.00
6/1/2023 20:35	0.00	6/2/2023 0:00	0.00	6/2/2023 3:25	4.80	6/2/2023 6:50	0.00	6/2/2023 10:15	0.00
6/1/2023 20:40	0.00	6/2/2023 0:05	0.00	6/2/2023 3:30	4.80	6/2/2023 6:55	0.00	6/2/2023 10:20	0.00
6/1/2023 20:45	0.00	6/2/2023 0:10	0.00	6/2/2023 3:35	4.80	6/2/2023 7:00	0.00	6/2/2023 10:25	0.00
6/1/2023 20:50	0.00	6/2/2023 0:15	0.00	6/2/2023 3:40	7.20	6/2/2023 7:05	0.00	6/2/2023 10:30	0.00
6/1/2023 20:55	0.00	6/2/2023 0:20	7.20	6/2/2023 3:45	7.20	6/2/2023 7:10	0.00	6/2/2023 10:35	0.00
6/1/2023 21:00	0.00	6/2/2023 0:25	4.80	6/2/2023 3:50	4.80	6/2/2023 7:15	0.00	6/2/2023 10:40	0.00
6/1/2023 21:05	0.00	6/2/2023 0:30	0.00	6/2/2023 3:55	4.80	6/2/2023 7:20	0.00	6/2/2023 10:45	0.00
6/1/2023 21:10	2.40	6/2/2023 0:35	4.80	6/2/2023 4:00	4.80	6/2/2023 7:25	0.00	6/2/2023 10:50	2.40
6/1/2023 21:15	0.00	6/2/2023 0:40	16.80	6/2/2023 4:05	2.40	6/2/2023 7:30	0.00	6/2/2023 10:55	2.40
6/1/2023 21:20	2.40	6/2/2023 0:45	12.00	6/2/2023 4:10	2.40	6/2/2023 7:35	0.00	6/2/2023 11:00	0.00
6/1/2023 21:25	0.00	6/2/2023 0:50	7.20	6/2/2023 4:15	2.40	6/2/2023 7:40	0.00	6/2/2023 11:05	0.00
6/1/2023 21:30	0.00	6/2/2023 0:55	4.80	6/2/2023 4:20	2.40	6/2/2023 7:45	0.00	6/2/2023 11:10	0.00
6/1/2023 21:35	0.00	6/2/2023 1:00	4.80	6/2/2023 4:25	2.40	6/2/2023 7:50	0.00	6/2/2023 11:15	0.00
6/1/2023 21:40	0.00	6/2/2023 1:05	16.80	6/2/2023 4:30	2.40	6/2/2023 7:55	0.00	6/2/2023 11:20	0.00
6/1/2023 21:45	0.00	6/2/2023 1:10	4.80	6/2/2023 4:35	2.40	6/2/2023 8:00	0.00	6/2/2023 11:25	2.40
6/1/2023 21:50	0.00	6/2/2023 1:15	19.20	6/2/2023 4:40	0.00	6/2/2023 8:05	0.00	6/2/2023 11:30	0.00
6/1/2023 21:55	0.00	6/2/2023 1:20	67.20	6/2/2023 4:45	0.00	6/2/2023 8:10	0.00	6/2/2023 11:35	0.00
6/1/2023 22:00	0.00	6/2/2023 1:25	69.60	6/2/2023 4:50	0.00	6/2/2023 8:15	0.00	6/2/2023 11:40	0.00
6/1/2023 22:05	0.00	6/2/2023 1:30	81.60	6/2/2023 4:55	0.00	6/2/2023 8:20	0.00	6/2/2023 11:45	0.00
6/1/2023 22:10	0.00	6/2/2023 1:35	43.20	6/2/2023 5:00	0.00	6/2/2023 8:25	0.00	6/2/2023 11:50	0.00
6/1/2023 22:15	0.00	6/2/2023 1:40	36.00	6/2/2023 5:05	0.00	6/2/2023 8:30	0.00	6/2/2023 11:55	0.00
6/1/2023 22:20	0.00	6/2/2023 1:45	2.40	6/2/2023 5:10	0.00	6/2/2023 8:35	0.00	6/2/2023 12:00	0.00
6/1/2023 22:25	0.00	6/2/2023 1:50	0.00	6/2/2023 5:15	2.40	6/2/2023 8:40	0.00	6/2/2023 12:05	0.00
6/1/2023 22:30	0.00	6/2/2023 1:55	4.80	6/2/2023 5:20	0.00	6/2/2023 8:45	0.00	6/2/2023 12:10	0.00
6/1/2023 22:35	0.00	6/2/2023 2:00	28.80	6/2/2023 5:25	0.00	6/2/2023 8:50	0.00	6/2/2023 12:15	0.00
6/1/2023 22:40	2.40	6/2/2023 2:05	16.80	6/2/2023 5:30	0.00	6/2/2023 8:55	0.00	6/2/2023 12:20	0.00
6/1/2023 22:45	0.00	6/2/2023 2:10	0.00	6/2/2023 5:35	0.00	6/2/2023 9:00	0.00	6/2/2023 12:25	0.00
6/1/2023 22:50	0.00	6/2/2023 2:15	0.00	6/2/2023 5:40	0.00	6/2/2023 9:05	0.00	6/2/2023 12:30	0.00
6/1/2023 22:55	0.00	6/2/2023 2:20	2.40	6/2/2023 5:45	0.00	6/2/2023 9:10	0.00	6/2/2023 12:35	0.00
6/1/2023 23:00	0.00	6/2/2023 2:25	0.00	6/2/2023 5:50	0.00	6/2/2023 9:15	0.00	6/2/2023 12:40	0.00
6/1/2023 23:05	0.00	6/2/2023 2:30	0.00	6/2/2023 5:55	0.00	6/2/2023 9:20	0.00	6/2/2023 12:45	0.00
6/1/2023 23:10	0.00	6/2/2023 2:35	0.00	6/2/2023 6:00	0.00	6/2/2023 9:25	0.00	6/2/2023 12:50	0.00
6/1/2023 23:15	0.00	6/2/2023 2:40	0.00	6/2/2023 6:05	0.00	6/2/2023 9:30	0.00	6/2/2023 12:55	0.00

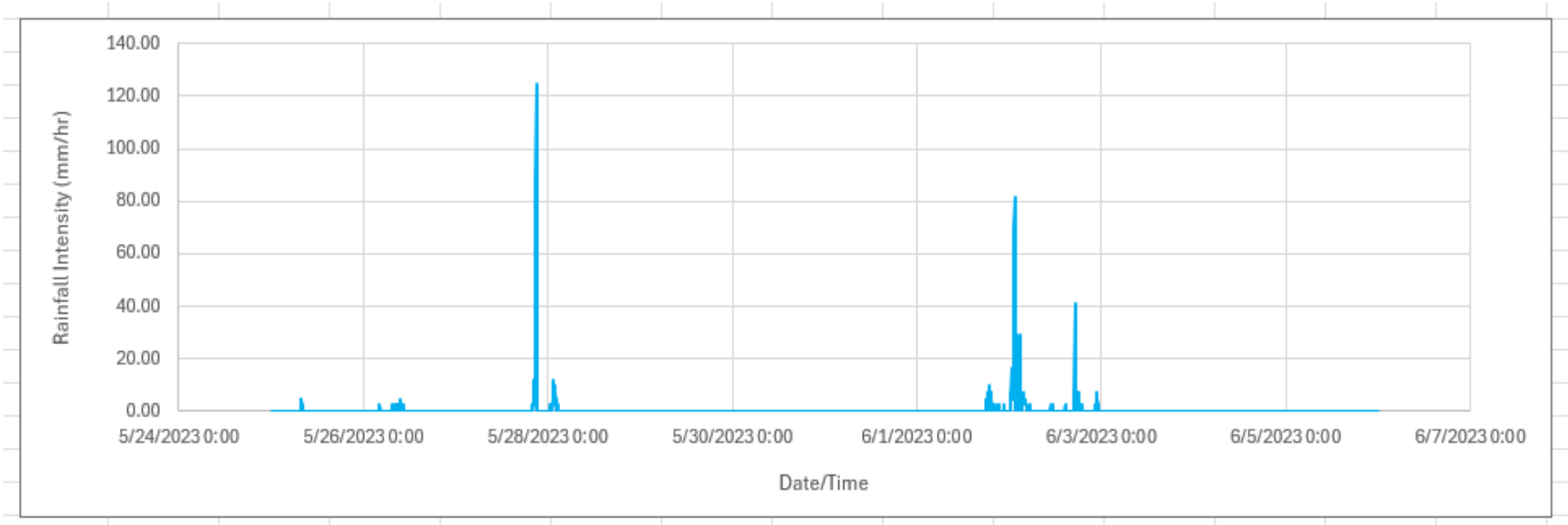
Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
6/2/2023 13:00	0.00	6/2/2023 16:25	0.00	6/2/2023 19:50	0.00	6/2/2023 23:15	0.00	6/3/2023 2:40	0.00
6/2/2023 13:05	0.00	6/2/2023 16:30	0.00	6/2/2023 19:55	0.00	6/2/2023 23:20	0.00	6/3/2023 2:45	0.00
6/2/2023 13:10	0.00	6/2/2023 16:35	0.00	6/2/2023 20:00	0.00	6/2/2023 23:25	0.00	6/3/2023 2:50	0.00
6/2/2023 13:15	0.00	6/2/2023 16:40	0.00	6/2/2023 20:05	0.00	6/2/2023 23:30	0.00	6/3/2023 2:55	0.00
6/2/2023 13:20	0.00	6/2/2023 16:45	0.00	6/2/2023 20:10	0.00	6/2/2023 23:35	0.00	6/3/2023 3:00	0.00
6/2/2023 13:25	0.00	6/2/2023 16:50	0.00	6/2/2023 20:15	0.00	6/2/2023 23:40	0.00	6/3/2023 3:05	0.00
6/2/2023 13:30	0.00	6/2/2023 16:55	0.00	6/2/2023 20:20	0.00	6/2/2023 23:45	0.00	6/3/2023 3:10	0.00
6/2/2023 13:35	0.00	6/2/2023 17:00	0.00	6/2/2023 20:25	0.00	6/2/2023 23:50	0.00	6/3/2023 3:15	0.00
6/2/2023 13:40	0.00	6/2/2023 17:05	4.80	6/2/2023 20:30	0.00	6/2/2023 23:55	0.00	6/3/2023 3:20	0.00
6/2/2023 13:45	0.00	6/2/2023 17:10	40.80	6/2/2023 20:35	0.00	6/3/2023 0:00	0.00	6/3/2023 3:25	0.00
6/2/2023 13:50	0.00	6/2/2023 17:15	24.00	6/2/2023 20:40	0.00	6/3/2023 0:05	0.00	6/3/2023 3:30	0.00
6/2/2023 13:55	0.00	6/2/2023 17:20	4.80	6/2/2023 20:45	0.00	6/3/2023 0:10	0.00	6/3/2023 3:35	0.00
6/2/2023 14:00	0.00	6/2/2023 17:25	2.40	6/2/2023 20:50	0.00	6/3/2023 0:15	0.00	6/3/2023 3:40	0.00
6/2/2023 14:05	0.00	6/2/2023 17:30	4.80	6/2/2023 20:55	0.00	6/3/2023 0:20	0.00	6/3/2023 3:45	0.00
6/2/2023 14:10	0.00	6/2/2023 17:35	0.00	6/2/2023 21:00	0.00	6/3/2023 0:25	0.00	6/3/2023 3:50	0.00
6/2/2023 14:15	0.00	6/2/2023 17:40	2.40	6/2/2023 21:05	0.00	6/3/2023 0:30	0.00	6/3/2023 3:55	0.00
6/2/2023 14:20	0.00	6/2/2023 17:45	0.00	6/2/2023 21:10	0.00	6/3/2023 0:35	0.00	6/3/2023 4:00	0.00
6/2/2023 14:25	0.00	6/2/2023 17:50	2.40	6/2/2023 21:15	0.00	6/3/2023 0:40	0.00	6/3/2023 4:05	0.00
6/2/2023 14:30	0.00	6/2/2023 17:55	7.20	6/2/2023 21:20	0.00	6/3/2023 0:45	0.00	6/3/2023 4:10	0.00
6/2/2023 14:35	2.40	6/2/2023 18:00	7.20	6/2/2023 21:25	0.00	6/3/2023 0:50	0.00	6/3/2023 4:15	0.00
6/2/2023 14:40	0.00	6/2/2023 18:05	2.40	6/2/2023 21:30	0.00	6/3/2023 0:55	0.00	6/3/2023 4:20	0.00
6/2/2023 14:45	0.00	6/2/2023 18:10	2.40	6/2/2023 21:35	0.00	6/3/2023 1:00	0.00	6/3/2023 4:25	0.00
6/2/2023 14:50	0.00	6/2/2023 18:15	0.00	6/2/2023 21:40	0.00	6/3/2023 1:05	0.00	6/3/2023 4:30	0.00
6/2/2023 14:55	0.00	6/2/2023 18:20	2.40	6/2/2023 21:45	0.00	6/3/2023 1:10	0.00	6/3/2023 4:35	0.00
6/2/2023 15:00	0.00	6/2/2023 18:25	2.40	6/2/2023 21:50	0.00	6/3/2023 1:15	0.00	6/3/2023 4:40	0.00
6/2/2023 15:05	0.00	6/2/2023 18:30	0.00	6/2/2023 21:55	0.00	6/3/2023 1:20	0.00	6/3/2023 4:45	0.00
6/2/2023 15:10	0.00	6/2/2023 18:35	0.00	6/2/2023 22:00	0.00	6/3/2023 1:25	0.00	6/3/2023 4:50	0.00
6/2/2023 15:15	0.00	6/2/2023 18:40	0.00	6/2/2023 22:05	0.00	6/3/2023 1:30	0.00	6/3/2023 4:55	0.00
6/2/2023 15:20	0.00	6/2/2023 18:45	0.00	6/2/2023 22:10	0.00	6/3/2023 1:35	0.00	6/3/2023 5:00	0.00
6/2/2023 15:25	0.00	6/2/2023 18:50	2.40	6/2/2023 22:15	0.00	6/3/2023 1:40	0.00	6/3/2023 5:05	0.00
6/2/2023 15:30	0.00	6/2/2023 18:55	0.00	6/2/2023 22:20	0.00	6/3/2023 1:45	0.00	6/3/2023 5:10	0.00
6/2/2023 15:35	0.00	6/2/2023 19:00	0.00	6/2/2023 22:25	2.40	6/3/2023 1:50	0.00	6/3/2023 5:15	0.00
6/2/2023 15:40	0.00	6/2/2023 19:05	0.00	6/2/2023 22:30	2.40	6/3/2023 1:55	0.00	6/3/2023 5:20	0.00
6/2/2023 15:45	0.00	6/2/2023 19:10	0.00	6/2/2023 22:35	0.00	6/3/2023 2:00	0.00	6/3/2023 5:25	0.00
6/2/2023 15:50	0.00	6/2/2023 19:15	0.00	6/2/2023 22:40	2.40	6/3/2023 2:05	0.00	6/3/2023 5:30	0.00
6/2/2023 15:55	0.00	6/2/2023 19:20	0.00	6/2/2023 22:45	7.20	6/3/2023 2:10	0.00	6/3/2023 5:35	0.00
6/2/2023 16:00	0.00	6/2/2023 19:25	0.00	6/2/2023 22:50	2.40	6/3/2023 2:15	0.00	6/3/2023 5:40	0.00
6/2/2023 16:05	0.00	6/2/2023 19:30	0.00	6/2/2023 22:55	4.80	6/3/2023 2:20	0.00	6/3/2023 5:45	0.00
6/2/2023 16:10	0.00	6/2/2023 19:35	0.00	6/2/2023 23:00	4.80	6/3/2023 2:25	0.00	6/3/2023 5:50	0.00
6/2/2023 16:15	0.00	6/2/2023 19:40	0.00	6/2/2023 23:05	2.40	6/3/2023 2:30	0.00	6/3/2023 5:55	0.00
6/2/2023 16:20	0.00	6/2/2023 19:45	0.00	6/2/2023 23:10	2.40	6/3/2023 2:35	0.00	6/3/2023 6:00	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
6/3/2023 6:05	0.00	6/3/2023 9:30	0.00	6/3/2023 12:55	0.00	6/3/2023 16:20	0.00	6/3/2023 19:45	0.00
6/3/2023 6:10	0.00	6/3/2023 9:35	0.00	6/3/2023 13:00	0.00	6/3/2023 16:25	0.00	6/3/2023 19:50	0.00
6/3/2023 6:15	0.00	6/3/2023 9:40	0.00	6/3/2023 13:05	0.00	6/3/2023 16:30	0.00	6/3/2023 19:55	0.00
6/3/2023 6:20	0.00	6/3/2023 9:45	0.00	6/3/2023 13:10	0.00	6/3/2023 16:35	0.00	6/3/2023 20:00	0.00
6/3/2023 6:25	0.00	6/3/2023 9:50	0.00	6/3/2023 13:15	0.00	6/3/2023 16:40	0.00	6/3/2023 20:05	0.00
6/3/2023 6:30	0.00	6/3/2023 9:55	0.00	6/3/2023 13:20	0.00	6/3/2023 16:45	0.00	6/3/2023 20:10	0.00
6/3/2023 6:35	0.00	6/3/2023 10:00	0.00	6/3/2023 13:25	0.00	6/3/2023 16:50	0.00	6/3/2023 20:15	0.00
6/3/2023 6:40	0.00	6/3/2023 10:05	0.00	6/3/2023 13:30	0.00	6/3/2023 16:55	0.00	6/3/2023 20:20	0.00
6/3/2023 6:45	0.00	6/3/2023 10:10	0.00	6/3/2023 13:35	0.00	6/3/2023 17:00	0.00	6/3/2023 20:25	0.00
6/3/2023 6:50	0.00	6/3/2023 10:15	0.00	6/3/2023 13:40	0.00	6/3/2023 17:05	0.00	6/3/2023 20:30	0.00
6/3/2023 6:55	0.00	6/3/2023 10:20	0.00	6/3/2023 13:45	0.00	6/3/2023 17:10	0.00	6/3/2023 20:35	0.00
6/3/2023 7:00	0.00	6/3/2023 10:25	0.00	6/3/2023 13:50	0.00	6/3/2023 17:15	0.00	6/3/2023 20:40	0.00
6/3/2023 7:05	0.00	6/3/2023 10:30	0.00	6/3/2023 13:55	0.00	6/3/2023 17:20	0.00	6/3/2023 20:45	0.00
6/3/2023 7:10	0.00	6/3/2023 10:35	0.00	6/3/2023 14:00	0.00	6/3/2023 17:25	0.00	6/3/2023 20:50	0.00
6/3/2023 7:15	0.00	6/3/2023 10:40	0.00	6/3/2023 14:05	0.00	6/3/2023 17:30	0.00	6/3/2023 20:55	0.00
6/3/2023 7:20	0.00	6/3/2023 10:45	0.00	6/3/2023 14:10	0.00	6/3/2023 17:35	0.00	6/3/2023 21:00	0.00
6/3/2023 7:25	0.00	6/3/2023 10:50	0.00	6/3/2023 14:15	0.00	6/3/2023 17:40	0.00	6/3/2023 21:05	0.00
6/3/2023 7:30	0.00	6/3/2023 10:55	0.00	6/3/2023 14:20	0.00	6/3/2023 17:45	0.00	6/3/2023 21:10	0.00
6/3/2023 7:35	0.00	6/3/2023 11:00	0.00	6/3/2023 14:25	0.00	6/3/2023 17:50	0.00	6/3/2023 21:15	0.00
6/3/2023 7:40	0.00	6/3/2023 11:05	0.00	6/3/2023 14:30	0.00	6/3/2023 17:55	0.00	6/3/2023 21:20	0.00
6/3/2023 7:45	0.00	6/3/2023 11:10	0.00	6/3/2023 14:35	0.00	6/3/2023 18:00	0.00	6/3/2023 21:25	0.00
6/3/2023 7:50	0.00	6/3/2023 11:15	0.00	6/3/2023 14:40	0.00	6/3/2023 18:05	0.00	6/3/2023 21:30	0.00
6/3/2023 7:55	0.00	6/3/2023 11:20	0.00	6/3/2023 14:45	0.00	6/3/2023 18:10	0.00	6/3/2023 21:35	0.00
6/3/2023 8:00	0.00	6/3/2023 11:25	0.00	6/3/2023 14:50	0.00	6/3/2023 18:15	0.00	6/3/2023 21:40	0.00
6/3/2023 8:05	0.00	6/3/2023 11:30	0.00	6/3/2023 14:55	0.00	6/3/2023 18:20	0.00	6/3/2023 21:45	0.00
6/3/2023 8:10	0.00	6/3/2023 11:35	0.00	6/3/2023 15:00	0.00	6/3/2023 18:25	0.00	6/3/2023 21:50	0.00
6/3/2023 8:15	0.00	6/3/2023 11:40	0.00	6/3/2023 15:05	0.00	6/3/2023 18:30	0.00	6/3/2023 21:55	0.00
6/3/2023 8:20	0.00	6/3/2023 11:45	0.00	6/3/2023 15:10	0.00	6/3/2023 18:35	0.00	6/3/2023 22:00	0.00
6/3/2023 8:25	0.00	6/3/2023 11:50	0.00	6/3/2023 15:15	0.00	6/3/2023 18:40	0.00	6/3/2023 22:05	0.00
6/3/2023 8:30	0.00	6/3/2023 11:55	0.00	6/3/2023 15:20	0.00	6/3/2023 18:45	0.00	6/3/2023 22:10	0.00
6/3/2023 8:35	0.00	6/3/2023 12:00	0.00	6/3/2023 15:25	0.00	6/3/2023 18:50	0.00	6/3/2023 22:15	0.00
6/3/2023 8:40	0.00	6/3/2023 12:05	0.00	6/3/2023 15:30	0.00	6/3/2023 18:55	0.00	6/3/2023 22:20	0.00
6/3/2023 8:45	0.00	6/3/2023 12:10	0.00	6/3/2023 15:35	0.00	6/3/2023 19:00	0.00	6/3/2023 22:25	0.00
6/3/2023 8:50	0.00	6/3/2023 12:15	0.00	6/3/2023 15:40	0.00	6/3/2023 19:05	0.00	6/3/2023 22:30	0.00
6/3/2023 8:55	0.00	6/3/2023 12:20	0.00	6/3/2023 15:45	0.00	6/3/2023 19:10	0.00	6/3/2023 22:35	0.00
6/3/2023 9:00	0.00	6/3/2023 12:25	0.00	6/3/2023 15:50	0.00	6/3/2023 19:15	0.00	6/3/2023 22:40	0.00
6/3/2023 9:05	0.00	6/3/2023 12:30	0.00	6/3/2023 15:55	0.00	6/3/2023 19:20	0.00	6/3/2023 22:45	0.00
6/3/2023 9:10	0.00	6/3/2023 12:35	0.00	6/3/2023 16:00	0.00	6/3/2023 19:25	0.00	6/3/2023 22:50	0.00
6/3/2023 9:15	0.00	6/3/2023 12:40	0.00	6/3/2023 16:05	0.00	6/3/2023 19:30	0.00	6/3/2023 22:55	0.00
6/3/2023 9:20	0.00	6/3/2023 12:45	0.00	6/3/2023 16:10	0.00	6/3/2023 19:35	0.00	6/3/2023 23:00	0.00
6/3/2023 9:25	0.00	6/3/2023 12:50	0.00	6/3/2023 16:15	0.00	6/3/2023 19:40	0.00	6/3/2023 23:05	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
6/3/2023 23:10	0.00	6/4/2023 2:35	0.00	6/4/2023 6:00	0.00	6/4/2023 9:25	0.00	6/4/2023 12:50	0.00
6/3/2023 23:15	0.00	6/4/2023 2:40	0.00	6/4/2023 6:05	0.00	6/4/2023 9:30	0.00	6/4/2023 12:55	0.00
6/3/2023 23:20	0.00	6/4/2023 2:45	0.00	6/4/2023 6:10	0.00	6/4/2023 9:35	0.00	6/4/2023 13:00	0.00
6/3/2023 23:25	0.00	6/4/2023 2:50	0.00	6/4/2023 6:15	0.00	6/4/2023 9:40	0.00	6/4/2023 13:05	0.00
6/3/2023 23:30	0.00	6/4/2023 2:55	0.00	6/4/2023 6:20	0.00	6/4/2023 9:45	0.00	6/4/2023 13:10	0.00
6/3/2023 23:35	0.00	6/4/2023 3:00	0.00	6/4/2023 6:25	0.00	6/4/2023 9:50	0.00	6/4/2023 13:15	0.00
6/3/2023 23:40	0.00	6/4/2023 3:05	0.00	6/4/2023 6:30	0.00	6/4/2023 9:55	0.00	6/4/2023 13:20	0.00
6/3/2023 23:45	0.00	6/4/2023 3:10	0.00	6/4/2023 6:35	0.00	6/4/2023 10:00	0.00	6/4/2023 13:25	0.00
6/3/2023 23:50	0.00	6/4/2023 3:15	0.00	6/4/2023 6:40	0.00	6/4/2023 10:05	0.00	6/4/2023 13:30	0.00
6/3/2023 23:55	0.00	6/4/2023 3:20	0.00	6/4/2023 6:45	0.00	6/4/2023 10:10	0.00	6/4/2023 13:35	0.00
6/4/2023 0:00	0.00	6/4/2023 3:25	0.00	6/4/2023 6:50	0.00	6/4/2023 10:15	0.00	6/4/2023 13:40	0.00
6/4/2023 0:05	0.00	6/4/2023 3:30	0.00	6/4/2023 6:55	0.00	6/4/2023 10:20	0.00	6/4/2023 13:45	0.00
6/4/2023 0:10	0.00	6/4/2023 3:35	0.00	6/4/2023 7:00	0.00	6/4/2023 10:25	0.00	6/4/2023 13:50	0.00
6/4/2023 0:15	0.00	6/4/2023 3:40	0.00	6/4/2023 7:05	0.00	6/4/2023 10:30	0.00	6/4/2023 13:55	0.00
6/4/2023 0:20	0.00	6/4/2023 3:45	0.00	6/4/2023 7:10	0.00	6/4/2023 10:35	0.00	6/4/2023 14:00	0.00
6/4/2023 0:25	0.00	6/4/2023 3:50	0.00	6/4/2023 7:15	0.00	6/4/2023 10:40	0.00	6/4/2023 14:05	0.00
6/4/2023 0:30	0.00	6/4/2023 3:55	0.00	6/4/2023 7:20	0.00	6/4/2023 10:45	0.00	6/4/2023 14:10	0.00
6/4/2023 0:35	0.00	6/4/2023 4:00	0.00	6/4/2023 7:25	0.00	6/4/2023 10:50	0.00	6/4/2023 14:15	0.00
6/4/2023 0:40	0.00	6/4/2023 4:05	0.00	6/4/2023 7:30	0.00	6/4/2023 10:55	0.00	6/4/2023 14:20	0.00
6/4/2023 0:45	0.00	6/4/2023 4:10	0.00	6/4/2023 7:35	0.00	6/4/2023 11:00	0.00	6/4/2023 14:25	0.00
6/4/2023 0:50	0.00	6/4/2023 4:15	0.00	6/4/2023 7:40	0.00	6/4/2023 11:05	0.00	6/4/2023 14:30	0.00
6/4/2023 0:55	0.00	6/4/2023 4:20	0.00	6/4/2023 7:45	0.00	6/4/2023 11:10	0.00	6/4/2023 14:35	0.00
6/4/2023 1:00	0.00	6/4/2023 4:25	0.00	6/4/2023 7:50	0.00	6/4/2023 11:15	0.00	6/4/2023 14:40	0.00
6/4/2023 1:05	0.00	6/4/2023 4:30	0.00	6/4/2023 7:55	0.00	6/4/2023 11:20	0.00	6/4/2023 14:45	0.00
6/4/2023 1:10	0.00	6/4/2023 4:35	0.00	6/4/2023 8:00	0.00	6/4/2023 11:25	0.00	6/4/2023 14:50	0.00
6/4/2023 1:15	0.00	6/4/2023 4:40	0.00	6/4/2023 8:05	0.00	6/4/2023 11:30	0.00	6/4/2023 14:55	0.00
6/4/2023 1:20	0.00	6/4/2023 4:45	0.00	6/4/2023 8:10	0.00	6/4/2023 11:35	0.00	6/4/2023 15:00	0.00
6/4/2023 1:25	0.00	6/4/2023 4:50	0.00	6/4/2023 8:15	0.00	6/4/2023 11:40	0.00	6/4/2023 15:05	0.00
6/4/2023 1:30	0.00	6/4/2023 4:55	0.00	6/4/2023 8:20	0.00	6/4/2023 11:45	0.00	6/4/2023 15:10	0.00
6/4/2023 1:35	0.00	6/4/2023 5:00	0.00	6/4/2023 8:25	0.00	6/4/2023 11:50	0.00	6/4/2023 15:15	0.00
6/4/2023 1:40	0.00	6/4/2023 5:05	0.00	6/4/2023 8:30	0.00	6/4/2023 11:55	0.00	6/4/2023 15:20	0.00
6/4/2023 1:45	0.00	6/4/2023 5:10	0.00	6/4/2023 8:35	0.00	6/4/2023 12:00	0.00	6/4/2023 15:25	0.00
6/4/2023 1:50	0.00	6/4/2023 5:15	0.00	6/4/2023 8:40	0.00	6/4/2023 12:05	0.00	6/4/2023 15:30	0.00
6/4/2023 1:55	0.00	6/4/2023 5:20	0.00	6/4/2023 8:45	0.00	6/4/2023 12:10	0.00	6/4/2023 15:35	0.00
6/4/2023 2:00	0.00	6/4/2023 5:25	0.00	6/4/2023 8:50	0.00	6/4/2023 12:15	0.00	6/4/2023 15:40	0.00
6/4/2023 2:05	0.00	6/4/2023 5:30	0.00	6/4/2023 8:55	0.00	6/4/2023 12:20	0.00	6/4/2023 15:45	0.00
6/4/2023 2:10	0.00	6/4/2023 5:35	0.00	6/4/2023 9:00	0.00	6/4/2023 12:25	0.00	6/4/2023 15:50	0.00
6/4/2023 2:15	0.00	6/4/2023 5:40	0.00	6/4/2023 9:05	0.00	6/4/2023 12:30	0.00	6/4/2023 15:55	0.00
6/4/2023 2:20	0.00	6/4/2023 5:45	0.00	6/4/2023 9:10	0.00	6/4/2023 12:35	0.00	6/4/2023 16:00	0.00
6/4/2023 2:25	0.00	6/4/2023 5:50	0.00	6/4/2023 9:15	0.00	6/4/2023 12:40	0.00	6/4/2023 16:05	0.00
6/4/2023 2:30	0.00	6/4/2023 5:55	0.00	6/4/2023 9:20	0.00	6/4/2023 12:45	0.00	6/4/2023 16:10	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
6/4/2023 16:15	0.00	6/4/2023 19:40	0.00	6/4/2023 23:05	0.00	6/5/2023 2:30	0.00	6/5/2023 5:55	0.00
6/4/2023 16:20	0.00	6/4/2023 19:45	0.00	6/4/2023 23:10	0.00	6/5/2023 2:35	0.00	6/5/2023 6:00	0.00
6/4/2023 16:25	0.00	6/4/2023 19:50	0.00	6/4/2023 23:15	0.00	6/5/2023 2:40	0.00	6/5/2023 6:05	0.00
6/4/2023 16:30	0.00	6/4/2023 19:55	0.00	6/4/2023 23:20	0.00	6/5/2023 2:45	0.00	6/5/2023 6:10	0.00
6/4/2023 16:35	0.00	6/4/2023 20:00	0.00	6/4/2023 23:25	0.00	6/5/2023 2:50	0.00	6/5/2023 6:15	0.00
6/4/2023 16:40	0.00	6/4/2023 20:05	0.00	6/4/2023 23:30	0.00	6/5/2023 2:55	0.00	6/5/2023 6:20	0.00
6/4/2023 16:45	0.00	6/4/2023 20:10	0.00	6/4/2023 23:35	0.00	6/5/2023 3:00	0.00	6/5/2023 6:25	0.00
6/4/2023 16:50	0.00	6/4/2023 20:15	0.00	6/4/2023 23:40	0.00	6/5/2023 3:05	0.00	6/5/2023 6:30	0.00
6/4/2023 16:55	0.00	6/4/2023 20:20	0.00	6/4/2023 23:45	0.00	6/5/2023 3:10	0.00	6/5/2023 6:35	0.00
6/4/2023 17:00	0.00	6/4/2023 20:25	0.00	6/4/2023 23:50	0.00	6/5/2023 3:15	0.00	6/5/2023 6:40	0.00
6/4/2023 17:05	0.00	6/4/2023 20:30	0.00	6/4/2023 23:55	0.00	6/5/2023 3:20	0.00	6/5/2023 6:45	0.00
6/4/2023 17:10	0.00	6/4/2023 20:35	0.00	6/5/2023 0:00	0.00	6/5/2023 3:25	0.00	6/5/2023 6:50	0.00
6/4/2023 17:15	0.00	6/4/2023 20:40	0.00	6/5/2023 0:05	0.00	6/5/2023 3:30	0.00	6/5/2023 6:55	0.00
6/4/2023 17:20	0.00	6/4/2023 20:45	0.00	6/5/2023 0:10	0.00	6/5/2023 3:35	0.00	6/5/2023 7:00	0.00
6/4/2023 17:25	0.00	6/4/2023 20:50	0.00	6/5/2023 0:15	0.00	6/5/2023 3:40	0.00	6/5/2023 7:05	0.00
6/4/2023 17:30	0.00	6/4/2023 20:55	0.00	6/5/2023 0:20	0.00	6/5/2023 3:45	0.00	6/5/2023 7:10	0.00
6/4/2023 17:35	0.00	6/4/2023 21:00	0.00	6/5/2023 0:25	0.00	6/5/2023 3:50	0.00	6/5/2023 7:15	0.00
6/4/2023 17:40	0.00	6/4/2023 21:05	0.00	6/5/2023 0:30	0.00	6/5/2023 3:55	0.00	6/5/2023 7:20	0.00
6/4/2023 17:45	0.00	6/4/2023 21:10	0.00	6/5/2023 0:35	0.00	6/5/2023 4:00	0.00	6/5/2023 7:25	0.00
6/4/2023 17:50	0.00	6/4/2023 21:15	0.00	6/5/2023 0:40	0.00	6/5/2023 4:05	0.00	6/5/2023 7:30	0.00
6/4/2023 17:55	0.00	6/4/2023 21:20	0.00	6/5/2023 0:45	0.00	6/5/2023 4:10	0.00	6/5/2023 7:35	0.00
6/4/2023 18:00	0.00	6/4/2023 21:25	0.00	6/5/2023 0:50	0.00	6/5/2023 4:15	0.00	6/5/2023 7:40	0.00
6/4/2023 18:05	0.00	6/4/2023 21:30	0.00	6/5/2023 0:55	0.00	6/5/2023 4:20	0.00	6/5/2023 7:45	0.00
6/4/2023 18:10	0.00	6/4/2023 21:35	0.00	6/5/2023 1:00	0.00	6/5/2023 4:25	0.00	6/5/2023 7:50	0.00
6/4/2023 18:15	0.00	6/4/2023 21:40	0.00	6/5/2023 1:05	0.00	6/5/2023 4:30	0.00	6/5/2023 7:55	0.00
6/4/2023 18:20	0.00	6/4/2023 21:45	0.00	6/5/2023 1:10	0.00	6/5/2023 4:35	0.00	6/5/2023 8:00	0.00
6/4/2023 18:25	0.00	6/4/2023 21:50	0.00	6/5/2023 1:15	0.00	6/5/2023 4:40	0.00	6/5/2023 8:05	0.00
6/4/2023 18:30	0.00	6/4/2023 21:55	0.00	6/5/2023 1:20	0.00	6/5/2023 4:45	0.00	6/5/2023 8:10	0.00
6/4/2023 18:35	0.00	6/4/2023 22:00	0.00	6/5/2023 1:25	0.00	6/5/2023 4:50	0.00	6/5/2023 8:15	0.00
6/4/2023 18:40	0.00	6/4/2023 22:05	0.00	6/5/2023 1:30	0.00	6/5/2023 4:55	0.00	6/5/2023 8:20	0.00
6/4/2023 18:45	0.00	6/4/2023 22:10	0.00	6/5/2023 1:35	0.00	6/5/2023 5:00	0.00	6/5/2023 8:25	0.00
6/4/2023 18:50	0.00	6/4/2023 22:15	0.00	6/5/2023 1:40	0.00	6/5/2023 5:05	0.00	6/5/2023 8:30	0.00
6/4/2023 18:55	0.00	6/4/2023 22:20	0.00	6/5/2023 1:45	0.00	6/5/2023 5:10	0.00	6/5/2023 8:35	0.00
6/4/2023 19:00	0.00	6/4/2023 22:25	0.00	6/5/2023 1:50	0.00	6/5/2023 5:15	0.00	6/5/2023 8:40	0.00
6/4/2023 19:05	0.00	6/4/2023 22:30	0.00	6/5/2023 1:55	0.00	6/5/2023 5:20	0.00	6/5/2023 8:45	0.00
6/4/2023 19:10	0.00	6/4/2023 22:35	0.00	6/5/2023 2:00	0.00	6/5/2023 5:25	0.00	6/5/2023 8:50	0.00
6/4/2023 19:15	0.00	6/4/2023 22:40	0.00	6/5/2023 2:05	0.00	6/5/2023 5:30	0.00	6/5/2023 8:55	0.00
6/4/2023 19:20	0.00	6/4/2023 22:45	0.00	6/5/2023 2:10	0.00	6/5/2023 5:35	0.00	6/5/2023 9:00	0.00
6/4/2023 19:25	0.00	6/4/2023 22:50	0.00	6/5/2023 2:15	0.00	6/5/2023 5:40	0.00	6/5/2023 9:05	0.00
6/4/2023 19:30	0.00	6/4/2023 22:55	0.00	6/5/2023 2:20	0.00	6/5/2023 5:45	0.00	6/5/2023 9:10	0.00
6/4/2023 19:35	0.00	6/4/2023 23:00	0.00	6/5/2023 2:25	0.00	6/5/2023 5:50	0.00	6/5/2023 9:15	0.00

Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)	Date/Time	Rainfall Intensity (mm/hr)
6/5/2023 9:20	0.00	6/5/2023 12:45	0.00	6/5/2023 16:10	0.00	6/5/2023 19:35	0.00	6/5/2023 23:00	0.00
6/5/2023 9:25	0.00	6/5/2023 12:50	0.00	6/5/2023 16:15	0.00	6/5/2023 19:40	0.00	6/5/2023 23:05	0.00
6/5/2023 9:30	0.00	6/5/2023 12:55	0.00	6/5/2023 16:20	0.00	6/5/2023 19:45	0.00	6/5/2023 23:10	0.00
6/5/2023 9:35	0.00	6/5/2023 13:00	0.00	6/5/2023 16:25	0.00	6/5/2023 19:50	0.00	6/5/2023 23:15	0.00
6/5/2023 9:40	0.00	6/5/2023 13:05	0.00	6/5/2023 16:30	0.00	6/5/2023 19:55	0.00	6/5/2023 23:20	0.00
6/5/2023 9:45	0.00	6/5/2023 13:10	0.00	6/5/2023 16:35	0.00	6/5/2023 20:00	0.00	6/5/2023 23:25	0.00
6/5/2023 9:50	0.00	6/5/2023 13:15	0.00	6/5/2023 16:40	0.00	6/5/2023 20:05	0.00	6/5/2023 23:30	0.00
6/5/2023 9:55	0.00	6/5/2023 13:20	0.00	6/5/2023 16:45	0.00	6/5/2023 20:10	0.00	6/5/2023 23:35	0.00
6/5/2023 10:00	0.00	6/5/2023 13:25	0.00	6/5/2023 16:50	0.00	6/5/2023 20:15	0.00	6/5/2023 23:40	0.00
6/5/2023 10:05	0.00	6/5/2023 13:30	0.00	6/5/2023 16:55	0.00	6/5/2023 20:20	0.00	6/5/2023 23:45	0.00
6/5/2023 10:10	0.00	6/5/2023 13:35	0.00	6/5/2023 17:00	0.00	6/5/2023 20:25	0.00	6/5/2023 23:50	0.00
6/5/2023 10:15	0.00	6/5/2023 13:40	0.00	6/5/2023 17:05	0.00	6/5/2023 20:30	0.00	6/5/2023 23:55	0.00
6/5/2023 10:20	0.00	6/5/2023 13:45	0.00	6/5/2023 17:10	0.00	6/5/2023 20:35	0.00		
6/5/2023 10:25	0.00	6/5/2023 13:50	0.00	6/5/2023 17:15	0.00	6/5/2023 20:40	0.00		
6/5/2023 10:30	0.00	6/5/2023 13:55	0.00	6/5/2023 17:20	0.00	6/5/2023 20:45	0.00		
6/5/2023 10:35	0.00	6/5/2023 14:00	0.00	6/5/2023 17:25	0.00	6/5/2023 20:50	0.00		
6/5/2023 10:40	0.00	6/5/2023 14:05	0.00	6/5/2023 17:30	0.00	6/5/2023 20:55	0.00		
6/5/2023 10:45	0.00	6/5/2023 14:10	0.00	6/5/2023 17:35	0.00	6/5/2023 21:00	0.00		
6/5/2023 10:50	0.00	6/5/2023 14:15	0.00	6/5/2023 17:40	0.00	6/5/2023 21:05	0.00		
6/5/2023 10:55	0.00	6/5/2023 14:20	0.00	6/5/2023 17:45	0.00	6/5/2023 21:10	0.00		
6/5/2023 11:00	0.00	6/5/2023 14:25	0.00	6/5/2023 17:50	0.00	6/5/2023 21:15	0.00		
6/5/2023 11:05	0.00	6/5/2023 14:30	0.00	6/5/2023 17:55	0.00	6/5/2023 21:20	0.00		
6/5/2023 11:10	0.00	6/5/2023 14:35	0.00	6/5/2023 18:00	0.00	6/5/2023 21:25	0.00		
6/5/2023 11:15	0.00	6/5/2023 14:40	0.00	6/5/2023 18:05	0.00	6/5/2023 21:30	0.00		
6/5/2023 11:20	0.00	6/5/2023 14:45	0.00	6/5/2023 18:10	0.00	6/5/2023 21:35	0.00		
6/5/2023 11:25	0.00	6/5/2023 14:50	0.00	6/5/2023 18:15	0.00	6/5/2023 21:40	0.00		
6/5/2023 11:30	0.00	6/5/2023 14:55	0.00	6/5/2023 18:20	0.00	6/5/2023 21:45	0.00		
6/5/2023 11:35	0.00	6/5/2023 15:00	0.00	6/5/2023 18:25	0.00	6/5/2023 21:50	0.00		
6/5/2023 11:40	0.00	6/5/2023 15:05	0.00	6/5/2023 18:30	0.00	6/5/2023 21:55	0.00		
6/5/2023 11:45	0.00	6/5/2023 15:10	0.00	6/5/2023 18:35	0.00	6/5/2023 22:00	0.00		
6/5/2023 11:50	0.00	6/5/2023 15:15	0.00	6/5/2023 18:40	0.00	6/5/2023 22:05	0.00		
6/5/2023 11:55	0.00	6/5/2023 15:20	0.00	6/5/2023 18:45	0.00	6/5/2023 22:10	0.00		
6/5/2023 12:00	0.00	6/5/2023 15:25	0.00	6/5/2023 18:50	0.00	6/5/2023 22:15	0.00		
6/5/2023 12:05	0.00	6/5/2023 15:30	0.00	6/5/2023 18:55	0.00	6/5/2023 22:20	0.00		
6/5/2023 12:10	0.00	6/5/2023 15:35	0.00	6/5/2023 19:00	0.00	6/5/2023 22:25	0.00		
6/5/2023 12:15	0.00	6/5/2023 15:40	0.00	6/5/2023 19:05	0.00	6/5/2023 22:30	0.00		
6/5/2023 12:20	0.00	6/5/2023 15:45	0.00	6/5/2023 19:10	0.00	6/5/2023 22:35	0.00		
6/5/2023 12:25	0.00	6/5/2023 15:50	0.00	6/5/2023 19:15	0.00	6/5/2023 22:40	0.00		
6/5/2023 12:30	0.00	6/5/2023 15:55	0.00	6/5/2023 19:20	0.00	6/5/2023 22:45	0.00		
6/5/2023 12:35	0.00	6/5/2023 16:00	0.00	6/5/2023 19:25	0.00	6/5/2023 22:50	0.00		
6/5/2023 12:40	0.00	6/5/2023 16:05	0.00	6/5/2023 19:30	0.00	6/5/2023 22:55	0.00		


140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Rainfall Intensity (mm/hr)
5/24/2023 0:00
5/26/2023 0:00
5/28/2023 0:00
5/30/2023 0:00
6/1/2023 0:00
6/3/2023 0:00
6/5/2023 0:00
6/7/2023 0:00
Date/Time